SENSATIONS OF COMFORT AND PHYSIOLOGICAL REACTIONS TO HEAT AND MOISTURE ON CHANGE IN ENVIRONMENT.

by

Wei-Yung Lee, B.Sc. (Nankai).

Research Assistant at the Henry Lester Institute of Medical Research, Shanghai, China.

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in the Faculty of Medicine

of the University of London

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Department of Industrial Physiology

London School of Hygiene and Tropical Medicine

University of London.

CONTAINS

PULLOUTS

"Our objects in the study of physiology include the description of the chief reactions of the body to changes in its environment, the analysis of these reactions into the simpler reactions of which they are made up, and the assignment to each differentiated structure of the organism its part in every reaction. We must determine the conditions under which each reaction takes place, so that we may learn to evoke any part of it at will by application of the appropriate stimulus, i.e. by effective change of environment."

E. H. STARLING.

"Principles of Human Physiology".

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INTRODUCTION.

Subjective sensations of comfort or discomfort may be felt by individuals on entering artificially cooled buildings in hot climates, and for some years past European residents in India, Malaya and, in particular, in Shanghai, have complained that the control of indoor climate in public buildings by means of air-conditioning systems frequently fails to solve the problem of comfort during hot seasons. Thus, it is common experience that an acute sense of chilling, described as 'cold shock', may be felt on entering an air-conditioned building from the street, while on leaving it overpowering sensations of heat may be encountered.

An examination of the physical characteristics of the outdoor climate and the temperatures and humidities indoors, as maintained by the air-conditioning plants in such places, reveals the fact that, having regard to the type of clothing worn in the tropics and because individuals from more temperate zones develop a certain acclimatisation or adaptation to hot climates, an excessive drop in the dry bulb temperature of the air may have been produced though the actual indoor temperature may still appear to be high in relation to the climate of the country of origin of the foreigner.

Cooling requirements for summer air-conditioning in hot climates have been the subject of extensive investigation by the Research Laboratory of the American Society of Heating and Ventilating Engineers in Pittsburgh, and other American institutions.[1, 2, 3] For the most part, such studies have been carried out by engineers and relatively little attention has been paid to the subject by hygienists, physiologists, or the medical profession in spite of the fact that sensations of heat and cold, of moisture or dryness and the physiological reactions of the human body to such conditions, as for example, sweating and circulatory changes, should provide a scientific basis for standards of indoor temperature and humidity in relation to the outside climate.

In the studies referred to certain definite effective temperatures with considerable variations in relative humidity are laid down for indoor comfort, while minor modifications are suggested according to outdoor climatic variations, or the prevailing atmospheric conditions of a particular locality. While a great deal of stress is laid on the comfort aspect of the problem of air-conditioning insufficient attention appears to have been paid to the effects on the human body arising from the contrast between the artificially cooled environment and the outside hot atmosphere.

Immediate, though in some cases transitory, changes both in respect of sensation and physiological reactions result from a sudden change of environment, as in passing from a hot to a cool place or vice versa. Accurate information both in regard to effects of environmental conditions and clothing on the reactions of the human body, which these factors influence, must be forthcoming if the control of indoor climate by air conditioning is to be placed on a scientific basis in the interests of the comfort and health of dwellers in hot climates. It was with a view to obtaining such information by direct experiment that the present investigation was planned, and accordingly the aims of this study have been to determine or establish:

(1) index scales of gradations of sensation in respect of heat and moisture which may be used separately or in combination for the purpose of defining sensations of thermal comfort due to the physical characteristics of the environment;

(2) the relationship between subjective sensations and objective physiological reactions to different artificially produced climates;

(3) the conditions which determine the occurrence of cold shock on change of environment;

(4) the correlations of the subjective sensations with different physical factors of the atmosphere immediately after the change from one environment to another, and after a prolonged stay in the environment, namely when a state of equilibrium in respect of sensations has been attained; and

(5) the change in objective physiological reactions which takes place under the conditions referred to in (4) and the resulting effects on the body, in particular on the heart and circulation and skin temperature.

EXPERIMENTAL METHOD.

Warm or hot conditions with various humidities were produced by the combination of different dry-bulb and wet-bulb temperatures and air velocities in an air-conditioning room. The atmospheric conditions artificially produced ranged from 86° to 104°F. dry-bulb temperature; from 75° to 95°F wet-bulb temperature and from 20 to 160 feet per minute air velocity. In this way it was possible to reproduce and maintain for the period required for each experiment climatic conditions corresponding to outdoor summer weather met with in various hot countries. The conditions of temperature and humidity in the artificial outdoor climate selected for each experiment or group of experiments were calculated to give rise to such sense impressions as the following: (1) warm and humid; (2) warm and dry; (3) hot and humid; (4) hot and dry; (5) extremely hot and humid; and (6) extremely hot and dry.

A small room or cubicle,having a capacity of approximately 400 cubic feet, was built inside the air-conditioning room. Two windows with an area of 2 ft. by 2 ft. 6 in. each were installed on opposite walls for admitting light and permitting observation from the outside. The walls of the cubicle consisted of two sheets of asbestos boards of 0.2 in. in thickness separated by an air space of 1 inch in the middle of which a sheet or reinforced aluminium foil was mounted in order to provide insulation against external heat. The cubicle was ventilated by air introduced from outside through a duct in the wall, the amount of fresh air being kept at approximately three air changes per hour. An electric lamp was provided for reading instruments and an electric fan was set at one corner of the cubicle to stir up the air in order to avoid stagnation.

By means of a small air-conditioning plant the conditions inside the cubicle were maintained at a level such that persons at rest or doing very light work in this environment for about an hour would feel comfortable, their sensations of warmth ranging from comfortably cool to comfortably warm as indicated in the scales described below. The atmospheric conditions inside the cubicle ranged from 71° to 82°F. dry-bulb, 58° to 74°F. wet-bulb, 8 to 90 feet per minute air velocity, and, owing to the construction of the cubicle, the surface temperature of the inside walls and ceilings remained approximately at the dry-bulb temperature of the air inside it at the time. While the conditions in the outer air-conditioning room corresponded to the tropical climate under investigation, the indoor conditions maintained in the cubicle represented those which might be produced in artificially cooled buildings, and thus it was possible to study in the course of each experimental session the reactions of the subject to both environments, namely on passing from one to the other and on prolonged exposure to each.

Measurement of Sensations of Warmth: Before commencing the intensive study of the reactions of the subject selected for the experiments it was necessary to arrive at a system of faithfully describing the environmental conditions in terms of subjective sensations, and, with this end in view, several subjects were exposed to varying conditions of heat and humidity. As a result of this experience it was found to be possible to appreciate separately the heat sensations and the impressions of humidity or dryness in any particular environment. It should be stated here that the subjects all wore tropical clothing - open shirt and shorts - and this no doubt renders the individual more quickly sensitive particularly to the temperature of the air. Scales of gradations in sensations of heat and of moisture were thus drawn up and it was found that these could be readily used by a subject after a short period of preliminary training and that they did afford not only a means of recording the subjective impressions with a considerable degree of accuracy but also made it possible to ascribe an index or arbitrary numerical value to each sensation level. In view of the effects of both the temperature of the air and moisture on body heat loss, it was decided to give positive signs to warm and hot sensations on the heat-scale and to humid sensations on the moisture scale, while negative signs were ascribed to cool, cold or various gradations in sensation of dryness. The zero point in each scale corresponded to neutral sensations of heat or moisture. The scales of graded sensations as used in the present investigation were as follows:-

Sensation Scales

Heat Scale

Sensation	Index
Unbearably hot	+ 7
Much too hot	+ 6
Too hot	+ 5
Hot	+ 4
Too warm	+ 3
Warm	+ 2
Comfortably warm	+ 1
Neutral	0
Comfortably cool	- 1
Cool	- 2
Too cool	- 3
Cold	- 4
Too cold	- 5
Much too cold	- 6
Unbearably cold	- 7

Moisture Scale

Sensation	Index
Unbearably humid	+ 4
Too humid	+ 3
Humid	+ 2
Comfortably humid	+ 1
Neutral	0
Comfortably dry	- 1
Dry	- 2
Too dry	- 3
Unbearably dry	- 4

<u>Physiological Reactions</u>: The skin temperature at three spots, the forehead, the dorsal surface of the right hand and above the sternum, were measured by means of a thermal couple of the Lewis type retained in close contact with the skin by adhesive tape. The conditions of the skin surface such as clamminess, or the appearance of sweating, were noted. Pulse rates and systolic and diastolic blood pressures were observed.

<u>Environmental Conditions</u>: The physical characteristics of the experimental environments were accurately assessed by means of a variety of instruments, as follows.- Dry-bulb and wet-bulb temperatures were recorded by a whirling psychrometer from which relative humidities and dew point temperatures were computed from hygrometric tables. Dry kata cooling power and wet kata cooling power were determined by either ordinary or high temperature kata-thermometers. Air velocity was computed from kata and dry-bulb temperature readings. When the atmospheric temperature was above 97°F. the kata-thermometer cooling power was expressed as a negative quantity. Vapor pressure was derived from the hygrometric table. Saturation deficiency was calculated as the difference between the vapor pressure in mm. of Hg. of air saturated at the dry-bulb temperature and the actual vapor pressure observed. Mean temperature of surroundings

was arrived at by interpolation on the nomogram of Bedford (1937)[4]. Effective temperature was determined from the chart of Yaglou and Miller (1924)[5]. Effective saturation deficit was calculated as the difference between the vapor pressure of air saturated with water vapor at the skin temperature and the actual vapor pressure observed. Evaporative cooling power was expressed as wet kata cooling power minus dry kata cooling power under the same conditions. Total heat, sensible heat and latent heat of the air were interpolated or calculated from the table of values given in the (1937) Guide of the American Society of Heating and Ventilating Engineers[6].

Routine Experimental Procedure: In view of the limitations of time, space and the large number of variables under investigation, it was necessary to confine the routine experiments to an intensive study of the sensations and reactions of one particular trained subject, though from time to time others were used as controls. The subject was a healthy, athletic young man of nineteen years of age and of good physique. Particular attention was paid to clothing and in all experiments the subject wore garments similar to those which would be used in the Tropics, namely, a khaki shirt open at the neck, short cotton pants, khaki drill shorts, thin socks and ordinary leather shoes.

During the first, or preliminary, stage of each experiment the subject was required to sit resting quietly in a chair in the alcove or air-lock at the entrance to the air-conditioning room for at least half an hour. This period of resting was necessary in order to reach a state of equilibrium from which to assess subsequent reactions to change in environment.

After the preliminary stage the subject entered the experimental chamber according to the plan of the experiment. Throughout each experiment the subject was required to be in a resting condition seated in a chair. No smoking was allowed. Reading and very light work, such as taking readings of the physical instruments were occasionally performed by the subject.

The atmospheric conditions of both the air conditioning room, i.e. the outdoor climate, and of the cubicle, the indoor climate, were decided upon before each experiment. These were maintained at a constant temperature of plus or minus one degree F. for not less than seven hours, and, as previously mentioned, there was but very slight difference in temperature between that of the solid surroundings and the air of the cubicle or air-conditioning room. The change in environment was planned so that it took place either from a higher to a lower temperature and then back again or first from a lower temperature to a higher and then back to the lower temperature, the lower temperatures in every case being maintained in the cubicle. The change in environment was sudden as it was made within one minute. The duration of stay in each experimental environment was usually about one hour, by which time it was found that the sensations of warmth attained a state of equilibrium.

The subject was asked to state his sensations of heat and moisture according to the scale immediately after entering each new environment. This inquiry was repeated a number of times at intervals of ten to fifteen minutes until the steady state of the sensations was reached. Determinations of the physiological reactions were performed either before or after the sensations had been recorded. In each environment the readings of the various physical instruments used for assessing the conditions of warmth were observed.

EXPERIMENTAL FINDINGS.

A. Transitory and Equilibrium Values for Sensations of of Warmth and Physiological Reactions: There are two distinguishable warmth sensations, the transitory and equilibrium sensations, according to the time lapse after each change of environment. The transitory sensation arises as an immediate response to the new environment immediately after entering it, and is succeeded gradually by the equilibrium sensation. The equilibrium sensation is therefore one that is attained after a more or less prolonged exposure to the warmth conditions of the new environment. Its establishment usually requires an exposure of about one hour. The discrepancy between the transitory and equilibrium sensations, which may be quite great, depends upon the magnitude and also the direction of the change of environment. This difference between the two sensations is greater when there is a large diversity in the warmth factors between the two environments and it is more pronounced when the change is made from a higher to a lower temperature. Moreover, the difference between the transitory and equilibrium sensations is more pronounced in the sensations of heat than in impressions of moisture or humidity.

Some slight changes occur in the equilibrium values of physiological reactions as compared with the immediate values. However, they may fluctuate to a certain extent after the sensations have reached a state of equilibrium, when the environmental temperature is extreme, either too hot or too cold.

B. <u>Typical Experiments</u>: The routine experiments carried out in the present investigation involved the exposure of the subject to 62 different sets of conditions and 39 changes of environment, either from a higher to a lower temperature or the reverse. Since there was a wide range of atmospheric conditions to be covered in the air-conditioning room, which represented the outdoor climate, only a few duplicate experiments were done. In the cubicle, which was cooled artificially to represent indoor comfort conditions, the combinations of weather factors were more limited and thus frequently permitted repeated observations of sensations and physiological reactions under the same environmental conditions.

In the following sections there is presented a qualitative description of the sensations experienced under different environments. These conditions, as mentioned previously (on page 5), fall into broad classes.

A Table comprising the physical and physiological data and sensation indices for all experiments is given in Appendix I.

(I) Atmospheric conditions: warm and humid; warm and dry. Warm and humid.- When the outside atmospheric condition, described in general terms as warm and humid, corresponds to an effective temperature of 81°F. (d.b. 87°F.; w.b. 76°F., air velocity 21 ft. per min.) the sensations range from 'comfortably warm' to 'warm' and 'comfortably humid'. The indoor conditions being cooled to an effective temperature of 71°F. (d.b. 76°F.; w.b. 66°F., air velocity 70 ft. per min.) the sensations of warmth experienced are from 'neutral' to 'comfortably cool' and 'neutral' in respect of moisture. There is a difference of eleven degrees in dry-bulb temperature and ten degrees in effective temperature between the two environments (Fig. 1). In Fig. I and in subsequent figures of the same type the stages in the experiment are indicated. Thus, exposure to the outdoor climate is shown in that part of the figure labelled A.C.R. (air-conditioning room) while the indoor climate was experienced during the period marked Cubicle. The direction of change of environment is indicated by an arrow in each case. The variation between the transitory and equilibrium sensations in regard to both heat and moisture after the change of environment is slight.

Warm and dry.- In a case with an environment described as 'warm and dry' but having the same effective temperature as that in the last experiment but with different dry-bulb and wet-bulb temperatures (d.b. 90°F.; w.b. 75°F.; air velocity 80 ft. per min.) the sensations produced are 'warm' and 'neutral' immediately upon entering the environment (Fig. 2). Compared with the previous experiment the effective temperatures are the same but the sensations of heat differ somewhat. 'Too warm' and 'comfortably dry' are found to be the equilibrium sensations in contrast to the 'warm' and 'comfortably humid' sensations of the last experiment. The combined sensations, that is the algebraic sum of the sensations of heat and moisture, would be plus 3 and plus 2 respectively in the two experiments. Regarding a difference in one unit on the scales as within the range of possible experimental error, it can be inferred that different conditions of the same effective temperature give rise to similar summated sensation values. The quantitative aspect of this relationship is dealt with later. (page 42).

(II) <u>Atmospheric conditions: hot and neutral; hot and moist.</u> <u>Hot and neutral.</u> - When the atmospheric conditions reach dry-bulb temperature 95°F. and wet-bulb temperature 77°F. the immediate sensations of heat upon entering are recorded as 'warm' and then gradually evolve into 'hot', the equilibrium sensation. The sensations of moisture experienced are from 'neutral' to 'comfortably dry' (Fig. 3).

Hot and moist.- When the atmosphere is loaded with moisture at the same dry-bulb temperature, i.e. 95°F., but with a wet-bulb temperature of 90°F., the immediate sensations of heat become 'hot' and then develop into the equilibrium sensation 'too hot', and the moisture sensations range from 'humid' to 'too humid' (Fig. 4). The dry-bulb temperatures in the two experiments are the same, but the moisture content in the air is higher in the latter. Consequently the sensations of both heat and moisture vary considerably. It is obvious that the humidity in the air not only affects one's sensations of moisture but it also intensifies the sensations of heat as well through its influence on body heat loss by evaporation of sweat. Therefore it is natural to expect that when the dry-bulb temperature exceeds a certain level, say 85°F., the rôle played by wet-bulb temperature upon the sensations of warmth becomes of increasing importance. The over-all sensation of warmth, namely the combined or summated sensation of heat and moisture, is more highly correlated with the wet-bulb temperature of the air than with its dry-bulb temperature. This will be fully dealt with in a later section.

With the last-mentioned outdoor conditions and the cubicle cooled to dry-bulb temperature of 80°F. and the wet-bulb at 74°F., upon entering, the sensations of heat and moisture experienced are 'comfortably warm' and 'comfortably humid' respectively. The moisture content in the cubicle is rather high for comfort at such a high dry-bulb temperature. If the water vapor were diminished so as to lower the wet-bulb temperature to 67°F., then the sensations would be 'neutral' both to heat and moisture, as shown in Fig. 3. It is clear from these experiments that, in order to ensure a comfortable environment by air-conditioning, it is necessary to produce a drier atmosphere as well as lower the air temperature.

(III) <u>Atmospheric conditions: extremely hot and dry; extremely hot and moist.</u> When the atmospheric temperature is equal to or exceeds that of the human body by even a few degrees, sensations described as 'hot', 'much too hot', or even 'unbearably hot', will be experienced, the actual degree of excessive warmth depending very largely on the moisture content of the air. Thus, with a dry-bulb temperature of 102°F. and a wet-bulb of 78°F. to 80.5°F., a subject in tropical clothing describes his sensation as being 'too hot' and 'dry', Fig. 5. When, however, with substantially the same dry-bulb temperature, the wet-bulb is raised above 90°F. the subject's sensation of heat is increased and is described as 'much too hot' to 'unbearably hot', while he also notices the increased humidity and judges the environment to be 'too humid' or 'unbearably humid', as shown in Fig. 6. These unbearable sensations of heat and humidity combined are experienced under such environmental conditions, even on short exposure, but the sensation of excessive heat tends to increase with the duration of exposure.

C. <u>The Occurrence of Cold Shock:</u> It has been shown that the immediate sensations, particularly the heat sensations, experienced on entering an environment vary according to the actual level of the air temperature and the moisture content of the air in the previous environment. The moisture content of the air is a factor of primary importance in determining the sensations of thermal comfort when the dry-bulb temperature is well above 90°F. The immediate contrast in sensations of warmth will not be too severe on entering an artificially cooled place, if the atmospheric conditions of the previous environment were hot and dry. On the other hand, when the previous condition, namely the outdoor climate, is hot and humid, sudden entry into a cooled place gives rise to immediate sensations of excessive chilling described as 'cool' and 'cold', as indicated in Fig. VI (and in the Table on page 19 (a)). These sensations may, however, be transitory and change, after perhaps half an hour's exposure, to 'comfortably warm' or even 'warm' if the dry-bulb temperature of the air-conditioned apartment is approximately 80°F.

Table showing occurrence and non-occurrence of 'Cold Shock' upon change of environment

PREVIOUS ENVIRONMENT						NEW ENVIRONMENT					CHANGE IN SENSATION INDICES ON CHANGE IN ENVIRONMENT		TEMPERATURE DIFFERENCE BETWEEN THE TWO ENVIRONMENTS °F.		
Equilibrium Sensations*		Skin Condition	Temperature °F.			Immediate Sensations		Temperature °F.							
Heat	Moisture		Dry-Bulb	Wet-Bulb	Effective Temperature	Heat	Moisture	Dry-Bulb	Wet-Bulb	Effective Temperature	Heat	Moisture	Dry-Bulb	Wet-Bulb	Effective Temperature
Experiments in which 'Cold Shock' was felt upon Change of Environment															
+6	+4	Sweating profusely	98.	92.	93.2	-5	0	79.	69.	73.7	11	4	19.	23.	19.5
+7	+3	Sweating profusely	104.	93.	95.	-4	0	82.	72.	76.6	11	3	22.	21.	18.4
+5	+2	Sweating	96.	87.	89.3	-3	0	76.	69.	72.	8	2	20.	18.	17.3
+5	+3	Sweating	96.	90.	90.7	-3	0	76.	70.	73.	8	3	20.	20.	17.7
+6	+3	Sweating	103.	92.	94.	-3	0	80.	73.	75.8	9	3	23.	19.	18.2
Experiments in which 'Cold Shock' was not felt upon Change of Environment															
+5	-2	Clammy	102.	80.5	87.3	-1	0	73.	63.	68.5	6	2	29.	17.5	18.8
+5	-2	Clammy	103.	76.	85.8	-1	0	75.	63.	69.	6	2	28.	13.	16.8
+5	+2	Damp	96.	85.	87.8	-1	0	80.	69.	74.3	6	2	16.	16.	13.5
+4	+2	Clammy and slightly damp.	95.	87.	89.	0	0	80.	73.	76.	4	2	15.	14.	13.

* See the scales given on Page 8 for the heat and moisture sensations corresponding to the values shown in this Table.

It is evident, therefore, that the outdoor atmospheric conditions largely determine the immediate sensations experienced upon entering an air-conditioned building in the summer season and that the moisture content of the outdoor air profoundly influences the intensity of the sensation of excessive chilling which may be felt upon entering a building which has been air-conditioned for comfort. This immediate sensation of excessive chilling, described locally as 'cold shock', is what is complained of by residents in the Tropics and other parts of the world, notably Shanghai, during the hot and wet season. This cold shock is due not only to the temperature difference between the inside and outdoor atmosphere but is caused primarily by the conditions of high humidity in conjunction with a high dry-bulb temperature. No cold shock is felt on entering an air-conditioned building when the outdoor climate is hot and dry although the actual drop in dry-bulb temperature may be the same, or even greater.

Naturally, one expects to feel cooler on entering an air-conditioned building in the Tropics, but it is definitely unpleasant suddenly to feel a sensation of being 'too cool' or 'cold'. The presence or absence of cold shock on change in environment in the experiments which have been carried out was judged on the basis of whether the subject described his immediate sensations as being of this order of chilling. When the outside air was dry no cold shock occurred, even though the drop in dry-bulb temperature encountered on entering the indoor environment of the cubicle was as much as 30°F., as shown in Fig. 5, from which it may be seen that the subject felt 'comfortably cool' on entry. On the other hand, if the outdoor conditions were humid with dry-bulb at the same level as in the previous instance, the individual experienced cold shock and described his sensations as 'too cool' or 'cold' on entering the air-conditioned cubicle although the dry-bulb temperature drop was less than before, namely 26°F., as indicated in Fig. 6.

It is worth while to consider these experimental findings from the physiological point of view and to consider in each instance the factors involved in body heat loss and temperature control. In the case of an individual wearing tropical clothing, air gains ready access to the skin of the body, and, in an atmosphere which is hot and humid, dry-bulb 102°F. and wet-bulb 90°F., the individual depends solely on evaporation of sweat for heat loss and perspires so profusely that his skin and clothing are wet with sweat secreted in the effort of maintaining thermal equilibrium in the environment. On entering the air-conditioned cubicle it immediately becomes possible to lose body heat by radiation as the walls of the enclosure are at a lower.

temperature than that of the body, loss of heat to the air by convection is similarly possible and in addition increased evaporation takes place at once owing to the lower dew point of the air. As the skin and clothing is already wet with excess perspiration it is evident that the rate of heat loss increases above that necessary for body temperature equilibrium with the result that, in comparison with the previous condition, excessive heat loss per unit time and per unit of surface suddenly occurs and this gives rise to the immediate sensation of being 'too cool' or 'cold', in other words of 'cold shock', or chill. After about 20 minutes in the new environment the sense of chilling passes off and it was noticed that the skin surface becomes dry in about that time.

In the case of a hot and dry outdoor climate with dry-bulb over 100°F. and wet-bulb of 80°F., it is true that the individual depends solely on the evaporation of sweat as the mechanism of heat loss but the rate of evaporation is such that his skin and clothing remain practically dry if he is resting or only doing very light work. Hence on entering an air-conditioned room, while he suddenly commences to lose body heat by radiation and convection, there is no possibility of greatly increased loss by evaporation for there is no excess moisture on his skin nor are his clothes soaked in sweat previously secreted in the outdoor environment.

It would appear from these physiological considerations that, in order to avoid cold shock on entering air-conditioned buildings from an outside climate in which the dry-bulb temperature exceeds or is equal to body temperature and the wet-bulb temperature is in the region of 90°F., the conditions inside the building should be very carefully regulated in the sense that excessive drop in dry-bulb temperature coupled with a high degree of dehumidification should be avoided. Probably a drop in the dry-bulb of 10°F. coupled with a wet-bulb fall of 15° to 20°F. would be satisfactory. On the other hand, the putting on of a wrap on entering such a room after excessive sweating outside might prove of value, while the gradual entry to the air-conditioned room through passages, as is now done in some public buildings, prevents the sudden contrast between the outdoor and indoor conditions being felt so acutely.

D. <u>Statistical Correlation of Subjective Sensations with Physical Environment:</u> Subjective sensations of heat and moisture in relation to the physical environment or to change of environment in each experiment were recorded as

(a) transitory or immediate sensations, and (b) equilibrium sensations. In both groups the sensations experienced were defined in terms of gradations given in the two scales (see page 8), the indices with the appropriate signs being used as these enabled the data to be treated statistically. In the following sections the subjective sensations of heat and of moisture and also of the combined sensations are correlated with many physical characteristics of the environment.

(I) Equilibrium Sensations of Heat.

(a) Correlation with physical data of the environment: The warmth of the environment having been measured according to a number of different indices, it was of interest to test which of these measures of warmth was most closely related to the sensations of heat experienced by the subject. This point has been tested by correlating the physical data with the sensations of heat experienced after the equilibrium state had been reached, usually after about an hour's exposure to the environment. The physical characteristics of the environment are expressed either in single measures or in combined indices which are readily calculated from standard tables or nomograms. Each of the correlation coefficients is based on 62 observations. The correlation coefficients and standard errors are shown in Table I.

TABLE I.

Correlation of equilibrium sensations of heat with physical measures of the environmental warmth.

Equilibrium Sensations of Heat correlated with	Correlation Coefficients and Standard Errors	
* Sensible Heat of the Air	+0.954	±0.012
Dry-bulb Temperature	+0.951	±0.012
Effective Temperature	+0.940	±0.015
Mean Temperature of Surroundings.	+0.936	±0.016
Globe Thermometer Temperature	+0.929	±0.018
Wet-bulb Temperature	+0.885	±0.028
* Total Heat of the Air	+0.875	±0.030
Dry Kata Cooling Power	-0.823	±0.041
* Latent Heat of the Air	+0.794	±0.047
Dew Point Temperature	+0.787	±0.049
Wet Kata Cooling Power	-0.700	±0.065
Effective Saturation Deficit	-0.623	±0.078
Saturation Deficiency	+0.558	±0.088
Moisture Sensations	+0.318	±0.115
Relative Humidity	+0.051	±0.128

* See page 25(a) for definition.

+ Reference Table I, page 25. The correlation coefficients for Total Heat, Latent Heat and Sensible Heat were calculated from the data given in the standard tables used in air conditioning engineering referred to in the following note.

Definitions.

The terms Total Heat of the Air, Sensible Heat and Latent Heat referred to in this thesis are used in the sense adopted in air conditioning engineering. Thus the Total Heat of Air is composed of the sensible heat, or heat due to the temperature of the air, and the latent heat, or the heat of vaporization of the moisture it contains.

The definition of Sensible Heat and Latent Heat as adopted by American engineers is as follows:- The heat necessary to raise the temperature of one pound of water from 32 F to the boiling point is known as the heat of the liquid or sensible heat. When more heat is added, the water begins to evaporate and expand at constant temperature until the water is entirely changed into steam. The heat thus added is known as the latent heat of evaporation. (Page 31, Guide of the American Society of Heating and Ventilating Engineers, 1937 Edition).

In standard tables used by air conditioning engineers, e.g. Table 6, page 12, of the Guide of the American Society of Heating and Ventilating Engineers, 1937

Edition, the quantity of heat representing the Total Heat of Air, at the wet bulb temperature recorded, is given in British Thermal Units per pound of air as above Zero degree Fahrenheit. This quantity does not represent the heat content as above Absolute Zero: 0°F. datum was apparently adopted by pioneers in air conditioning for the sake of convenience.

There is a discrepancy in the concept of sensible heat of the air from the standpoint of physics, as molecular physics reveals that the nil point of kinetic energy of all forms of molecules should be at Absolute Zero, that is -273°C. The practice of air conditioning engineers in taking 0°F. as the Zero point for sensible heat of the air, therefore, is not in agreement with that of physicists.

W.H. Carrier showed that this quantity (Total Heat of Air) is a constant for any given Wet Bulb Temperature irrespective of the Dry Bulb Temperature. (Page 1005, Transactions American Society of Mechanical Engineers, 1911, Vol. 33, "Rational Psychrometric Formulae".).

TABLE II

Differences and Standard Errors of Differences between Correlations of Heat Sensations with Various Physical Measures.

Correlation of Heat Sensations with	Difference and standard error of difference from correlation of heat sensations with													
	Sensible Heat of the Air	Dry Bulb Temperature	Effective Temperature	Mean Temperature of Surroundings	Globe Thermometer Temperature	Wet Bulb Temperature	Total Heat of the Air	Dry Kata Cooling Power	Latent Heat of the Air	Dew Point Temperature	Wet Kata Cooling Power	Effective Saturation Deficit	Saturation Deficiency	Moisture Sensations
Sensible Heat of the Air	-													
Dry Bulb Temperature	0.003 ±0.017													
Effective Temperature	0.014 ±0.019	0.011 ±0.019												
Mean Temp. of Surroundings	0.018 ±0.020	0.015 ±0.020	0.004 ±0.022											
Globe Thermo. Temperature	0.025 ±0.022	0.022 ±0.022	0.011 ±0.023	0.007 ±0.024										
Wet Bulb Temperature	0.069 ±0.030	0.066 ±0.030	0.055 ±0.032	0.051 ±0.032	0.044 ±0.033									
Total Heat of the Air	0.079 ±0.032	0.076 ±0.032	0.065 ±0.034	0.061 ±0.034	0.054 ±0.035	0.010 ±0.041								
Dry Kata Cooling Power	0.131 ±0.043	0.128 ±0.043	0.117 ±0.044	0.113 ±0.044	0.106 ±0.045	0.062 ±0.050	0.052 ±0.051							
Latent Heat of the Air	0.160 ±0.048	0.157 ±0.049	0.146 ±0.049	0.142 ±0.050	0.135 ±0.050	0.091 ±0.055	0.081 ±0.056	0.029 ±0.062						
Dew Point Temperature	0.167 ±0.050	0.164 ±0.050	0.153 ±0.051	0.149 ±0.051	0.142 ±0.052	0.098 ±0.056	0.088 ±0.058	0.036 ±0.064	0.007 ±0.068					
Wet Kata Cooling Power	0.254 ±0.066	0.251 ±0.066	0.240 ±0.067	0.240 ±0.067	0.229 ±0.067	0.185 ±0.071	0.175 ±0.072	0.123 ±0.077	0.094 ±0.080	0.087 ±0.081				
Eff. Saturation Deficit	0.331 ±0.079	0.328 ±0.079	0.317 ±0.079	0.313 ±0.080	0.306 ±0.080	0.262 ±0.083	0.252 ±0.084	0.200 ±0.088	0.171 ±0.091	0.164 ±0.092	0.077 ±0.102			
Saturation Deficiency	0.396 ±0.089	0.393 ±0.089	0.382 ±0.089	0.378 ±0.089	0.371 ±0.090	0.327 ±0.092	0.317 ±0.093	0.265 ±0.097	0.236 ±0.100	0.229 ±0.101	0.142 ±0.109	0.065 ±0.118		
Moisture Sensations	0.636 ±0.116	0.633 ±0.116	0.622 ±0.116	0.618 ±0.116	0.611 ±0.116	0.567 ±0.118	0.557 ±0.119	0.505 ±0.122	0.476 ±0.124	0.475 ±0.125	0.382 ±0.132	0.305 ±0.139	0.240 ±0.145	
Relative Humidity	0.903 ±0.129	0.900 ±0.129	0.889 ±0.129	0.890 ±0.129	0.878 ±0.129	0.834 ±0.131	0.834 ±0.131	0.772 ±0.134	0.743 ±0.136	0.736 ±0.137	0.649 ±0.144	0.572 ±0.153	0.507 ±0.155	0.267 ±0.172

The majority of the correlations are high, and, with the exception of that between sensations of heat and relative humidity, all are much greater than twice their standard errors and are therefore significant. To test the significance of the difference between the correlation coefficients shown in Table I, it is necessary to know the standard errors of these differences. These have been calculated and together with the differences are shown to three places of decimals in Table II. The differences, which are larger than twice their standard errors, and which may therefore be considered significant, are underlined. There is no significant difference between the correlations of sensations of heat with sensible heat of the air, dry-bulb temperature, effective temperature, mean temperature of surroundings and globe thermometer temperature. It appears that the subjective sensations of heat are as closely related to the simple dry-bulb temperature of the air as to the compounded index of several physical factors, known as effective temperature, which takes into consideration humidity and air movement as well as the temperature of the air. Mean temperature of surroundings is a measure of the radiation from the walls of the enclosure, and globe thermometer temperature takes account of the radiation effect and the air temperature. Their correlation coefficients with the sensations of heat did not surpass that with dry bulb temperature which is a measure of the sensible heat of the air only. Therefore it may be concluded that dry-bulb temperature is a good, and at the same time a simple, index of the sensations of heat over the range of atmospheric conditions studied in these experiments in which, as previously stated, the subject wore tropical clothing.

Much stress has been laid on the importance of the wet-bulb temperature in relation to comfort and other bodily reactions in hot atmospheres, and it has been found that the limit of endurance is largely governed by this temperature. This subject is dealt with more fully in a later section, but it may be pointed out here that in these observations the correlation of the sensations of heat with wet-bulb temperature, although reasonably high, is still just significantly lower than the correlation with dry-bulb temperature. Wet-bulb temperature is influenced both by the sensible heat of the air and the heat of vaporization of the water vapor it contains. The difference between the correlations of sensations of heat with dry-bulb and wet-bulb temperatures respectively demonstrates that the graded scale drawn for measuring heat sensations is more closely related to the sensible heat of the air than to the sum of sensible and latent heat which closely follows wet-bulb temperature, and which is defined as total heat. In other words, the graded heat scale drawn up for this investigation is a reasonably accurate assessment of heat sensations experienced in different environments when tropical clothing is worn.

Table II shows the inferiority of the dry kata cooling power as an index of heat sensations. This finding is in agreement with that of Bedford[7]. for a lower range of temperatures. Dry kata cooling power gives a correlation significantly lower than those yielded by dry-bulb temperature, effective temperature, mean temperature of surroundings and globe thermometer temperature, while all these, and also wet-bulb temperature, are superior to the wet kata cooling power, effective saturation deficit and saturation deficiency. These latter three measures are concerned much more with the vapor content than with the actual temperature of the air, so that they correspond in a lesser degree with the sensations of heat than they do with sensations of moisture. It is interesting to note that there is a relationship between the sensations of heat and the sensations of moisture of the subject. As the sensations of heat increase there is a concomitant increment of the sensation of moisture and *vice versa*. The correlation coefficient of heat sensations with relative humidity is statistically insignificant. (Fig. 7b).

It is not, of course, suggested that the numerical scale of heat sensations adopted does actually measure the sensations. These cannot be measured quantitatively but the regression diagram shows that there is an approximate linear relationship between the arbitrary numerical values assigned to the sensations and the dry-bulb temperature as a measure of environmental warmth. (Fig. 7a).

(b) The relative importance of air temperature and humidity: Air temperature and the absolute humidity of the air, as measured by the dew point temperature, are both highly correlated with sensations of heat, but the correlation with air temperature is the higher. There is, in these observations, a fairly high correlation between air temperature and dew point temperature (r = +0.76), so in the attempt to trace the relative effects of temperature and humidity on the sensations of heat partial correlations have been calculated. These are shown in Table III.

TABLE III

Partial correlation of sensations of heat with air temperature and dew point temperature.

Sensations of Heat correlated with	Kept constant	Partial correlation coefficient
Dry-bulb temperature	Dew point temperature	+0.88 ±0.03
Dew point temperature	Dry-bulb temperature	+0.34 ±0.12

Sensations of heat are much more closely related to the air temperature than to dew point temperature, but the partial correlation of sensations with dew point temperature is nearly three times as great as its standard error, and is therefore significant. The total correlation of sensations of heat with dry-bulb temperature and dew point temperature together is 0.96, as compared with a correlation with dry-bulb temperature alone of 0.95. This means that the prediction of individual sensations from a knowledge of the dry-bulb temperature alone is very nearly as good as that based on both dry-bulb and dew point temperatures.

The regression equation calculated from these coefficients is as follows:-

Sensations of heat = 0.193 dry-bulb temperature plus 0.033 dew point temperature minus 16.69.............Equation (1)

A change of one degree in dry-bulb temperature has as much effect as a change of six degrees in dew point temperature. A sensation of 'neutral' to heat, namely zero in the scale, is given with the following combinations of temperature and humidity.

Dry-bulb temperature °F.	Dew point Temperature °F.	Relative Humidity %
73.8	73.8	100
74.5	70.0	86
76.2	60.0	57
77.9	50.0	39

(II) Equilibrium Sensations of Moisture.

(a) Correlation with physical factors of the environment: Since the sensations of moisture are obviously related to the moisture of the air, it seemed of interest to ascertain which measure of humidity was most closely associated with those sensations. To this end sensations of moisture have been correlated with the relative and absolute humidity of the air and many other measures as well. These correlations, which are based on 62 observations, are shown in Table IV.

TABLE IV.

Correlation of equilibrium sensations of moisture with physical measures of the environmental warmth.

Equilibrium Sensations of Moisture correlated with	Correlation Coefficients and Standard Errors
Relative Humidity	+0.796 ±0.047
Effective Saturation Deficit	-0.791 ±0.048
Evaporative Cooling Power	-0.787 ±0.049
Vapor Pressure of the Air	+0.768 ±0.052
Latent Heat of the Air	+0.763 ±0.053
Dew Point Temperature	+0.712 ±0.063
Total Heat of the Air	+0.640 ±0.075
Wet Kata Cooling Power	-0.605 ±0.081
Wet-bulb Temperature	+0.597 ±0.082
Saturation Deficiency	-0.499 ±0.096
Effective Temperature	+0.430 ±0.104
Heat Sensations	+0.318 ±0.115
Dry-bulb Temperature	+0.219 ±0.112
Sensible Heat	+0.213 ±0.112

TABLE V

Differences and Standard Errors of Differences between Correlations of Moisture Sensations with Various Physical Measures

Correlation of Moisture Sensations with	Difference and standard error of difference from correlation of moisture sensations with											
	Relative Humidity	Effective Saturation Deficit	Evaporative Cooling Power	Vapor Pressure of the Air	Latent Heat of the Air	Dew Point Temperature	Total Heat of the Air	Wet Kata Cooling Power	Wet Bulb Temperature	Saturation Deficiency	Effective Temperature	Heat Sensations
Relative Humidity	-											
Effective Saturation Deficit	0.005 ±0.067											
Evaporative Cooling Power	0.009 ±0.068	0.004 ±0.069										
Vapor Pressure of the Air	0.028 ±0.070	0.023 ±0.071	0.019 ±0.071									
Latent Heat of the Air	0.033 ±0.071	0.028 ±0.072	0.024 ±0.072	0.005 ±0.074								
Dew Point Temperature	0.084 ±0.079	0.079 ±0.079	0.075 ±0.080	0.056 ±0.082	0.051 ±0.082							
Total Heat of the Air	0.156 ±0.089	0.151 ±0.089	0.148 ±0.090	0.128 ±0.091	0.123 ±0.092	0.072 ±0.098						
Wet Kata Cooling Power	0.191 ±0.094	0.186 ±0.094	0.182 ±0.095	0.163 ±0.096	0.158 ±0.097	0.107 ±0.103	0.035 ±0.110					
Wet Bulb Temperature	0.199 ±0.095	0.194 ±0.095	0.190 ±0.096	0.171 ±0.097	0.166 ±0.098	0.115 ±0.103	0.043 ±0.111	0.008 ±0.115				
Saturation Deficiency	0.297 ±0.107	0.292 ±0.107	0.288 ±0.108	0.269 ±0.109	0.264 ±0.110	0.213 ±0.115	0.141 ±0.122	0.106 ±0.126	0.098 ±0.126			
Effective Temperature	0.366 ±0.114	0.361 ±0.115	0.357 ±0.115	0.338 ±0.116	0.333 ±0.117	0.282 ±0.122	0.210 ±0.128	0.175 ±0.132	0.167 ±0.132	0.069 ±0.142		
Heat Sensations	0.478 ±0.124	0.473 ±0.125	0.469 ±0.125	0.450 ±0.126	0.445 ±0.127	0.394 ±0.131	0.322 ±0.138	0.287 ±0.141	0.279 ±0.141	0.181 ±0.150	0.112 ±0.155	
Dry Bulb Temperature (Sensible Heat of the Air)	0.577 ±0.131	0.572 ±0.131	0.568 ±0.132	0.549 ±0.133	0.544 ±0.133	0.500 ±0.138	0.421 ±0.142	0.386 ±0.146	0.378 ±0.147	0.280 ±0.155	0.211 ±0.160	0.099 ±0.168

The highest correlations with equilibrium sensations of moisture are given by relative humidity, effective saturation deficit and evaporative cooling power. With the exception of dry-bulb temperature, all the correlations of the sensations of moisture with other physical factors of the environment are statistically significant. The regression lines of moisture sensations and relative humidity and dry-bulb temperature are shown in Fig. 8 (a), (b). The differences between these coefficients and the standard errors of the differences are shown in Table V.

Those differences which are larger than twice their standard errors and which may therefore be considered significant are underlined. There is no significant difference between the sensations of moisture with relative humidity, effective saturation deficit, evaporative cooling power, vapor pressure of the air, latent heat of the air, dew point temperature and total heat of the air. That is, these indices are all equally well related to moisture sensations. The sensations of moisture will be increased with a rise in the relative humidity or vapor pressure of the air, which express the amount of moistness in relative and in absolute units respectively. Increase of latent heat, which is a measure of the heat of vaporization of the moisture in the air, or of total heat, which is the sum of sensible heat and latent of the air, is also accompanied by an increase in the sensation. Rise in dew point temperature or wet-bulb temperature also results in increase in the sensation of moisture. Sensations of moisture show an inverse relationship to evaporative cooling power and effective saturation deficit.

Effective saturation deficit is defined and calculated as the difference between the actual vapor pressure of the air as indicated by the dry-bulb and wet-bulb temperatures and the vapor pressure of air saturated at the mean skin temperature of the subject when exposed to the particular environment. The mean skin temperature in this investigation was taken as the average of the readings for the forehead, sternum and dorsal side of the right hand. Evaporative cooling power is computed as the difference between the wet kata and dry kata cooling powers under similar atmospheric conditions. On physical grounds both wet kata cooling power and wet-bulb temperature are measures which are influenced considerably by the moisture content of the air, but it is shown here that they are inferior to relative humidity of the air as an index of moisture sensations within the range of conditions studied. While it appears that effective temperature is superior only to dry-bulb temperature in its relation to moisture sensations, the correlation between the sensation and dry-bulb temperature of the air is statistically insignificant.

Saturation deficiency is the difference between the absolute amount of water vapour which the air could hold at its dry-bulb temperature, and the actual vapor pressure of the moisture it contains. Marsh and Buxton[8] have shown that the saturation deficiency of the air between the skin and clothing of the body varies very little over a wide range of environmental conditions. This observation tends to explain the finding of the present investigation that the relation between sensations of moisture and saturation deficiency is inferior to that with effective saturation deficit which, as already indicated, takes into account the skin temperature of exposed as well as covered areas of the body (page36). It is of interest to note that sensations of moisture bear an inverse relationship to saturation deficiency.

(b) Partial correlation of sensations of moisture with air temperature and humidity: The highest correlation in Table IV is with relative humidity and the importance of this factor receives confirmation when partial correlations are examined. Two such calculations have been made: (a) the partial correlation of sensations of moisture with dry-bulb temperature and with dew point temperature; and (b) that with dry-bulb temperature and relative humidity. The partial correlation coefficients are shown in Table VI. With constant dry-bulb temperature an increase in the dew point temperature (and therefore in the relative humidity) is accompanied by a feeling of greater humidity. Conversely, with a constant dew point temperature, an increase in the dry-bulb temperature (and consequently a fall in the relative humidity) is accompanied by a feeling of less humidity.

TABLE VI.

Partial correlation of sensations of moisture with air temperature and humidity.

Sensations of moisture correlated with	Kept constant	Partial correlation coefficient
Dew point temperature	Dry-bulb temperature	+0.86 ±0.035
Dry-bulb temperature	Dew point temperature	-0.70 ±0.067
Relative humidity	Dry-bulb temperature	+0.83 ±0.040
Dry-bulb temperature	Relative humidity	+0.43 ±0.105

When the dry-bulb temperature is kept constant sensations of moisture run parallel with the relative humidity. It is interesting to note that according to these figures, when relative humidity is constant, a rise in dry-bulb temperature is accompanied by a sensation of increased humidity, and in this connection it may be pointed out that constant relative humidity with rising dry-bulb temperature entails also a rise in dew point temperature.

The regression equation for sensations of moisture in terms of dry-bulb and dew point temperatures is as follows:-

Sensations of moisture = 0.151 dew point temperature minus
0.099 dry-bulb temperature
minus 1.32. .... Equation (ii)

Thus, a change of one degree in the dew point temperature has as much effect as a change of one and a half degrees in the dry bulb temperature, but in the reverse direction, upon the sensations of moisture. From this equation it can be calculated that the sensations of moisture would be neutral (neither dry nor moist) with the following combinations of conditions. The combinations shown for temperatures lower than those studied experimentally in the present investigation have been extrapolated.

TABLE VII.

Conditions giving a sensation of moisture 'neutral' in the scale (neither dry nor moist) based on dry-bulb temperature and dew point temperature.

Dry-bulb temperature °F.	Wet-bulb temperature °F.	Dew point temperature °F.	Relative humidity %
100	81.7	74.3	44
90	75.0	67.7	48
80	68.4	61.2	53
70	61.2	54.6	58
+ 60	54.0	48.0	65
+ 50	46.0	41.5	73
+ 40	38.0	35.0	82

+ Extrapolated.

Thus, at higher temperatures the relative humidity must be reduced if the same sensation of moisture is to be experienced. This is shown also by the following partial regression equation using dry-bulb temperature and relative humidity:-

Sensations of moisture = 0.035 dry-bulb temperature plus 0.079 relative humidity minus 7.07. ..... Equation (iii)

According to this equation a sensation of moisture corresponding to 'neutral' in the scale (neither dry nor moist) would be felt at the air temperatures and humidities shown in Table VIII.

TABLE VIII

Conditions giving a sensation of moisture 'neutral' on the scale (neither dry nor moist) based on dry-bulb temperature and relative humidity.

Dry-bulb temperature °F.	Relative humidity %
100	45
90	50
80	54
70	58

Comparison of Tables VII and VIII shows that the two methods of computation give remarkably similar results. The significance of these figures for relative humidity over a range of dry-bulb temperatures is discussed in a later section dealing with air-conditioning standards for indoor comfort. (page 55)

(III) Equilibrium Sensations of Warmth. (Summated Sensations of Heat and Moisture) and the Physical Environment: In the previous sections equilibrium sensations of heat and moisture have been examined separately and analytically and correlated with different physical characteristics of the environment. It has been shown that various physical factors of the atmosphere affect sensations of heat and moisture quite differently. In the present section these sensations are summated or combined in order to obtain for any particular environment a single index of the over-all sensation of warmth comfort, as an expression of the influence of the two factors temperature and humidity which were, under the conditions of the experiments, the principal variables affecting body heat loss and the mechanism of body temperature control. In such a process of synthesis from the two partial sensations the algebraic signs of the values arbitrarily given to different sensations in reference to zero or neutral level are taken into account. It is worth while to ascertain which physical factors of the atmosphere most influence the summated sensations. For this purpose the summated sensations of heat and moisture have been correlated with different physical factors and the correlation coefficients are shown in Table IX. The differences and standard errors of the differences between these correlations are given in Table X.

With the exception of saturation deficiency, all the correlations are statistically significant. The highest correlations are those with total heat of the air, latent heat of the air, dew point temperature, wet-bulb temperature and effective temperature. There is no statistically significant difference between the correlations of summated sensations with these five physical measures of the environmental conditions. All these five physical characteristics of the air take into account the moisture content of the air as well as its temperature. The superiority of the correlation of the summated sensations with total heat of the air[+] to the other indices lies in the fact that it is a direct measure of the sensible and latent heat of the air, (Fig. 9a).

[+] In this paper the Fahrenheit scale is used and total heat of the air is expressed in terms of British Thermal Units, as this is the practice in technical papers dealing with heating, ventilation and air-conditioning.

TABLE IX

Correlation of equilibrium sensations of warmth (the summated sensations of heat and moisture) with physical measures of the environmental warmth.

Equilibrium Sensations of Warmth correlated with	Correlation Coefficients and Standard Errors
Total Heat of the Air	+0.949 ±0.013
Latent Heat of the Air	+0.946 ±0.013
Dew Point Temperature	+0.918 ±0.020
Wet-bulb Temperature	+0.912 ±0.022
Effective Temperature	+0.912 ±0.022
Effective Saturation Deficit	-0.837 ±0.038
Sensible Heat of the Air	+0.827 ±0.041
Dry-bulb Temperature	+0.826 ±0.041
Mean Temperature of Surroundings	+0.825 ±0.041
Dry Kata Cooling Power	-0.802 ±0.046
Wet Kata Cooling Power	-0.792 ±0.048
Relative Humidity	+0.390 ±0.108
Saturation Deficiency	+0.209 ±0.122

TABLE X

Differences and Standard Errors of Differences between Correlations
of Warmth Sensations with Various Physical Measures

Correlation of Warmth Sensations with	Difference and standard error of difference from correlation of warmth sensations with										
	Total Heat of the Air	Latent Heat of the Air	Dew Point Temperature	Wet Bulb Temperature	Effective Temperature	Effective Saturation Deficit	Dry Bulb Temperature	Mean Temperature of Surroundings	Dry Kata Cooling Power	Wet Kata Cooling Power	Relative Humidity
Total Heat of the Air											
Latent Heat of the Air	0.003 ±0.018										
Dew Point Temperature	0.031 ±0.024	0.028 ±0.024									
Wet Bulb Temperature	0.037 ±0.026	0.034 ±0.026	0.006 ±0.030								
Effective Temperature	0.037 ±0.026	0.034 ±0.026	0.006 ±0.030	-							
Effective Saturation Deficit	0.112 ±0.040	0.109 ±0.040	0.081 ±0.043	0.075 ±0.044	0.075 ±0.044						
Sensible Heat of the Air (Dry Bulb Temperature)	0.123 ±0.043	0.120 ±0.043	0.092 ±0.046	0.086 ±0.047	0.086 ±0.047	0.011 ±0.056					
Mean Temperature of Surroundings	0.124 ±0.043	0.121 ±0.043	0.093 ±0.046	0.087 ±0.047	0.087 ±0.047	0.012 ±0.056	0.001 ±0.058				
Dry Kata Cooling Power	0.147 ±0.048	0.144 ±0.048	0.116 ±0.050	0.110 ±0.051	0.110 ±0.051	0.035 ±0.060	0.024 ±0.062	0.023 ±0.062			
Wet Kata Cooling Power	0.157 ±0.050	0.154 ±0.050	0.126 ±0.052	0.120 ±0.053	0.120 ±0.053	0.045 ±0.061	0.034 ±0.063	0.033 ±0.063	0.010 ±0.067		
Relative Humidity	0.559 ±0.109	0.556 ±0.109	0.528 ±0.110	0.522 ±0.110	0.522 ±0.110	0.447 ±0.115	0.436 ±0.115	0.435 ±0.115	0.412 ±0.117	0.402 ±0.118	
Saturation Deficiency	0.740 ±0.123	0.737 ±0.123	0.709 ±0.124	0.703 ±0.124	0.703 ±0.124	0.628 ±0.128	0.617 ±0.129	0.616 ±0.129	0.593 ±0.130	0.583 ±0.131	0.181 ±0.163

Seeing that the partial sensations of heat and moisture are highly correlated with the sensible heat and latent heat of the air respectively, it is to be expected that the correlation between summated sensations and total heat of the air will be high, and this is the case. It is to be noticed that these physical measurements of the air, namely sensible heat, latent heat and total heat, appear to be qualitatively related to the corresponding highly correlated sensations, heat sensations, moisture sensations and summated sensations. The regression line affords an accurate quantitative measure of the relationship between the sensation on the one hand and its physical determinant on the other. Figs 7 (a), 8 (a) and 9(a) show this approximate linear relationship for the three sensation indices, in each case with the highest correlated physical factor.

The difference between the correlations of the summated sensations with dry-bulb temperature, mean temperature of surroundings and effective saturation deficit and with total heat of the air are significant. This is the case probably because effective saturation deficit emphasizes too much, while dry-bulb temperature and mean temperature of surroundings do not take into consideration the humidity of the air. Although both the dry and wet kata cooling powers are fairly good indices for summated sensations, as shown by their high correlations, yet they are significantly inferior even to effective temperature, as shown in Tables IX and X. Although the summated sensations are significantly correlated with the relative humidity of the air, the imperfection of relative humidity as an index of warmth is shown by its low correlation coefficient which is significantly different from those of all other measures. The correlation of the summated sensation values with saturation deficiency is statistically insignificant although sensations of heat and moisture separately are fairly well correlated with this factor.

In order to show the relative effects of total heat of the air upon the sensations of heat and moisture, partial correlations have been calculated between total heat of the air and sensations of heat and of moisture. They are shown in Table XI.

TABLE XI.

Partial correlations of total heat of the air with sensations of heat and sensations of moisture.

Total Heat of the Air correlated with	Kept constant	Partial correlation coefficient
Sensations of Heat	Sensations of Moisture	+0.92 ±0.019
Sensations of Moisture	Sensations of Heat	+0.79 ±0.048

These correlations indicate that with an increase in the total heat of the air there results an augmentation both in the sensations of heat and in the sensations of moisture. But the effect of the change on sensations of heat is rather higher than that on the sensations of moisture, or in other words, a change of total heat in the air has a greater effect on the heat sensations than on the moisture sensations.

(IV) Sensations of Heat immediately on changing Environment (Transitory Sensations). It seems probable that the transitory sensations experienced on exposure to different conditions would be influenced more by the direction and magnitude of the change in the warmth of the environment than by the actual level of temperature of the new environment. Therefore immediate sensations of heat have been correlated with (a) the dry-bulb or the effective temperatures of the new environment (that is to say if the change was from room A to B, the temperature of room B was taken), and (b) with the temperature difference between the two environments, a change from cool to hot being taken as positive and one from hot to cool as negative. The correlations calculated in each case from 39 pairs of observations are:-

TABLE XII

Transitory sensations of heat correlated with temperatures.

Transitory sensations of heat correlated with	Correlation coefficient
Difference between effective temperatures	+0.93 ±0.02
Difference between dry-bulb temperatures	+0.91 ±0.03
Actual effective temperature of the new environment	+0.84 ±0.05
Actual dry-bulb temperature of the new environment	+0.87 ±0.04

It is of interest to note that the transitory sensations of heat, namely those experienced on entering a new environment, are more highly correlated with the temperature difference between the two conditions than with the actual levels of temperature or effective temperature in the new environment.

When partial correlations are calculated for the range of conditions covered in this investigation it is found that if the change in temperature between environments is kept constant the actual temperature (dry-bulb or effective) of the new environment has no influence on the sensations of heat, Table XIII. It is the extent of the change which has just been experienced which determines the transitory sensations evoked.

TABLE XIII.

Partial correlations of transitory sensations of heat with temperature of new environment and temperature difference between environments.

Sensations of heat correlated with	Kept constant	Partial correlation coefficient
Change in effective temperature	Effective temperature of new environment	+0.75 ±0.07
Effective temperature of new environment	Change in effective temperature	-0.07 ±0.16
Change in dry-bulb temperature	Dry-bulb temperature in new environment	+0.53 ±0.12
Dry-bulb temperature of new environment	Change in dry-bulb temperature	-0.07 ±0.16

The partial correlation of sensations of heat with change in effective temperature (actual effective temperature in the new environment kept constant) is rather higher than that with change in dry-bulb temperature (actual dry-bulb temperature in the new environment kept constant). This finding would be expected since effective temperature makes due allowance for humidity and air movement. However, the difference between these partial correlation coefficients is not statistically significant, and therefore cannot be claimed as establishing the opinion that effective temperature is the better index of such changes.

(V) Warmth Sensation Charts.

The equations which have been derived for the data obtained in the present investigation have been used as a basis for the construction of charts which relate heat sensations, moisture sensations and the combination of both with various physical factors of the environment. These charts are of a theoretical rather than practical interest and value, but as they do enable the present findings to be compared with those of other workers, particularly of the American Society of Heating and Ventilating Engineers, they are given in Appendix No.II. As indicated in the Appendix close agreement is apparent between the general results of researches carried out in the United States and the deductions drawn from the data obtained in the present investigation.

(VI) <u>The Air Temperatures and Humidities in the Comfort Zone.</u> Under ordinary room temperature conditions the air velocity is usually of the order of 20 feet per minute. With this assumption, the effective temperature and combined indices of the physical characteristics of the air can be calculated from the regression equation (i) (page 31) relating sensations of heat with dry-bulb and dew point temperatures. When neutral sensations of heat are experienced by a resting subject wearing tropical clothing, the corresponding conditions are as follows:-

Dry-bulb °F.	Wet-Bulb °F.	Relative Humidity %	Dew Point °F.	Effective Temperature °F.
73.8	73.8	100	73.8	73.8
74.5	71.0	86	70.0	72.8
76.2	66.0	57	60.0	71.7
77.9	62.5	39	50.0	71.2

Thus, for neutral sensations of heat to be experienced any particular dry-bulb temperature must be associated with a definite wet-bulb temperature, dew point temperature or relative humidity.

According to American standards the summer comfort zone for an exposure of about three hours extends from 64° to 79°F. effective temperature with a mean at 71°F., when the prevailing outdoor temperatures range from 70° to 99.5°F. (Yaglou and Drinker, 1929).[9] Houghten and Gutberlet (1935)[1] found that with effective temperatures between 70° to 75°F., no appreciable impairment of comfort with relative humidity occurred up to levels as high as 80 per cent. The comfort zones, as derived from the regression equation evolved from data collected in the present investigation, are well in accordance with standards advocated in the United States.

The optimum range of humidity is not clearly defined in existing publications. In the experiments on comfort conducted in the Research Laboratories of the American Society of Heating and Ventilating Engineers, the relative humidity was varied between the limits of 30 and 70 per cent. over the range of temperature covered by the comfort zone. The significance of relative humidity to comfort at each dry-bulb temperature in the comfort zone does not appear to have been ascertained. In experiments at Harvard School of Public Health the majority of the subjects were unable to detect the difference in sensations of humidity when the relative humidity was maintained between 30 and 60 per cent. at ordinary room temperatures. Owing to the fact that in the present investigation the range of air temperature was at a higher level, the influence of humidity in relation to dry-bulb temperature was intensified, and thus it has been possible to determine a more exact relationship between these physical factors and the sensations to which they give rise. In the present investigation, humidities producing neutral sensations of moisture over a range of temperature from 71° to 104°F. have been calculated on the basis of the regression equation which expresses the relationship between sensations of moisture and dry-bulb and dew point temperature. These data have already been shown in Table VII. The calculated figures indicate that for higher temperatures a lower relative humidity would be required in order to produce the same sensation of moisture as that experienced at higher humidities but at lower temperatures. It is common experience that the moistness of the air on a hot summer day is more noticeable than the same relative humidity encountered at ordinary room temperatures of say 60° - 70°F.

(VII) Comparison with Indoor Comfort Standards advocated by the American Society of Heating and Ventilating Engineers. The desirable indoor air conditions in summer in relation to outdoor temperatures are set forth as follows in the American Society of Heating and Ventilating Engineers' Guide (1937)(6):-

Desirable Indoor Air Conditions in Summer
Corresponding to Outdoor Temperatures

Applicable to Exposures Less than 3 Hours.

Outdoor Temperature (Deg Fahr)	Indoor Air Conditions		
		Constant Dew-Point 57 F	
Dry-Bulb	Effective Temp.	Dry-Bulb	Wet-Bulb
95	73	80.0	65.0
90	72	78.0	64.5
85	71	76.5	64.0
80	70	75.0	63.5
75	69	73.5	63.0
70	68	72.0	62.5

It will be noted that this table of standards allows only a single moisture content or dew point temperature for the air regardless of variations in the outdoor conditions. A definite indoor dry-bulb temperature is suggested for each outdoor air temperature. For instance, when the outdoor temperature is 95°F., the table gives 80°F. dry-bulb as the desirable inside temperature, and that while an 80°F. outdoor temperature requires 75°F. dry-bulb to be maintained indoors only one dew point temperature, namely 57°F., is laid down for both conditions.

It is of interest to examine the data given in the American Table in the light of values calculated from the equation (page 31) No.(i) derived from observations on sensations of heat over a wide range of dry-bulb temperatures in the experiments carried out in the present investigation. Thus, at a constant dew point temperature of 57°F. a neutral sensation of heat is experienced when the dry-bulb temperature is 76.7°F., the wet-bulb 65.0°F. and at an effective temperature of 71.5°F. These values, calculated on the basis of this equation, lie well within the limits indicated as desirable for indoor comfort according to the American standards above mentioned.

Again, if 57°F. is taken as the constant dew point temperature in equation (page 39) No. (ii) expressing sensations of moisture in terms of dew point temperature and dry bulb temperature, then it may be calculated that a neutral sensation of moisture will be experienced at dry-bulb temperature 73.6°F., wet bulb temperature 63.5°F., and effective temperature 69.6°F. This means that the occupants will feel 'neutral' (neither dry nor humid) under these air conditions when the dew point temperature is 57°F. These dry-bulb and wet-bulb temperatures, as calculated from the equation of moisture sensations, also correspond well with the range given in the table of American standards for indoor comfort.

E. Physiological Reactions in relation to the Physical Environment. It is well known that the skin temperature varies with the warmth of the environment; that in an over-heated room the skin is flushed and warm, while on a cold day, outside, exposed areas are chilled. In addition, it is also well recognized that different parts of the body surface may be at very different temperatures. Various workers have made observations of skin temperature (usually that of the forehead) in relation to air temperature. Phelps and Vold (1934)[10] have summarized the published results and have revealed considerable differences in the forehead temperatures observed at a given air temperature. A great many of these variations are probably due to the methods employed by different observers in measuring the skin temperature (Bedford and Warner, 1934).[11] Recently Winslow et al. (1937)[12,13] have intensively studied the skin temperature of different spots on the body in relation to the environmental temperatures and humidities and assessed the results on a physiological basis.

In the present study, the skin temperatures of the forehead, dorsal side of the hand and sternum were measured in various physical environments and at regular intervals during exposure to each set of conditions.

In addition to measurements of skin temperature and observations on subjective sensations at the time, the systolic and diastolic blood pressures were taken and the pulse rate noted in each environment. These data are presented and discussed in the following sections as they serve to indicate the nature of physiological adjustment to the various environments and changes in environment studied.

(I) General Description of Physiological Reactions in relation to Change of Environment: The physiological reactions in relation to change of environment are illustrated in the composite diagrams, Figs. 10 and 11. The curves shown apply to one group of experiments in which the maximum change in environment was experienced and are based on average values for skin temperature, blood pressure and pulse rate observed at regular intervals. In Fig. 10 the new environment encountered at time 0 had an effective temperature 20°F. lower than the previous environment, while Fig. 11 shows the reactions to a change in the reverse direction, namely a rise of 22°F. in effective temperature.

The variations in the physiological responses with change of environment are presented in relation to effective temperature because the statistical correlation of these reactions is greater with effective temperature than with dry-bulb temperature. These curves give the equilibrium values in the first (or previous) environment for comparison with the immediate and equilibrium values in the second (or new) environment. Detailed records of skin temperatures in typical experiments are shown in Figs. 1-6.

(a) Changes from higher to lower temperatures: Fig. 10, and also Figs. 1-6, show that the immediate reactions are as follows: there is a fall in skin temperature which is most noticeable on the forehead; in most cases pulse rate decreases; both systolic and diastolic pressures increase.

On remaining in the new environment for about an hour, these reactions tend to reach equilibrium, unless the atmospheric conditions are too cold in which case skin temperature may still continue to fall (Fig. 2). The attainment of equilibrium, in most cases, involves an alteration of its immediate value. Equilibrium skin temperature shows a slight recovery after its initial fall. Systolic blood pressure attains a stationary level below the initial increase. Diastolic blood pressure tends to rise slightly above the immediate response. Pulse rate, as a rule, shows a slight secondary decrease.

(b) Changes from lower to higher temperatures: Fig. 11 and also Figs. 1-6 illustrate the findings of experiments in which the change was made from a lower to a higher temperature.

It was found that, in almost every case, the physiological responses proceeded in the reverse direction to that observed when the new environment had a lower temperature. The only exception in this general trend appeared to be the response in respect of change in diastolic pressure, but even in this, when a marked difference (22°F. effective temperature) existed between the two environments the change took place in the opposite direction.

On entering an environment at a materially higher effective temperature there is a sudden rise in the skin temperature, the average rise on the sternum being less than that of the forehead or of the back of the hand. A lowering of the systolic blood pressure occurs. Diastolic blood pressure behaves in an irregular manner except in the case of a large difference between the two environments, when a lowering is observed. There is a slight rise in pulse rate. This small average change in pulse rate even with wide differences in temperature merits attention. Detailed examination of the data of individual experiments reveals the fact that in the early experiments the pulse rate increase is more noticeable than in the later ones. This may be due to the effects of acclimatisation to high temperatures and has been recorded in an investigation carried out by Vernon and Warner[14].

The attainment of equilibrium when there is a marked difference between the environments, such as 22°F. effective temperature, is associated with a slight fall in skin temperature after an initial rise; a recovery in both systolic and diastolic pressures, and little change in pulse rate (Fig. 11).

In the case of a comparable change of environment in the reverse direction, namely a drop in effective temperature of approximately 20°F., the physiological responses are also reversed and of similar magnitude. Changes in subjective sensations are, however, more noticeable in the case of passing from an environment with a higher effective temperature to one in which it is lower, than when the change of environment is reversed but of the same extent.

With the exception of systolic blood pressure, circulatory responses to the changes of environment which have been investigated are less definite than skin temperature reactions.

(II) Correlations of Physiological Reactions to Change of Environment: In order to show the degree of variation of physiological reactions in relation to the change of environment experienced, the data have been treated statistically. The changes in these reactions as a result of change in environment have been correlated with the changes in environmental warmth (a) in terms of dry-bulb temperature and (b) in terms of effective temperature, and are shown in Tables XIV and XV.

TABLE XIV

Correlation of physiological reactions with change in dry-bulb temperature (36 observations).

Change in dry-bulb temperature correlated with change in	Correlation coefficient
Skin temperature (forehead)	+0.883 ±0.037
Skin temperature (hand)	+0.841 ±0.049
Skin temperature (sternum)	+0.775 ±0.068
Systolic pressure	-0.719 ±0.082
Diastolic pressure	-0.119 ±0.167
Pulse pressure	-0.545 ±0.119
Pulse rate	+0.245 ±0.159

TABLE XV.

Correlation of skin temperature and systolic pressure with change in effective temperature (36 observations).

Change in effective temperature correlated with change in	Correlation coefficient
Skin temperature (forehead)	+0.892 ±0.035
Skin temperature (hand)	+0.853 ±0.046
Skin temperature (sternum)	+0.828 ±0.053
Systolic pressure	-0.736 ±0.077

The correlations of dry-bulb temperature change, with changes in diastolic pressure and in pulse rate are not statistically significant, all the remaining coefficients shown in both Tables are significant.

From a comparison of the four coefficients in Table XV with the corresponding values in Table XIV, it can be seen that the correlations of physiological reactions with effective temperature change were in each case higher than with dry-bulb temperature changes. These differences are not statistically significant but the consistently higher coefficients in the case of effective temperature suggest that physiological reactions are more closely related to changes in effective temperature than to changes in dry-bulb temperature. This indication supports the opinion that bodily reactions change not only with dry-bulb temperature but are also influenced by the moisture content and the movement of the air. It may be mentioned similarly that Lee and Mulder (1935)[15] in the study of the effects of reduced cooling power on human subjects, found that various physiological functions respond in an equivalent manner to two environments of the same effective temperature, one being humid and the other dry. In other words, dry-bulb temperature in their experiments was less significant than effective temperature in determining physiological reactions.

In a previous section it has been shown that the extent of the change in sensations depends only upon the difference between the warmth of the two environments and not on the actual level of the physical factors characterising them. In order to compare change of physiological responses to change of environment regression diagrams have been constructed, (Fig. 12). The effective temperature differences were used rather than those of dry-bulb temperatures, since the former bears a higher relationship to these changes. Although the correlations are fairly high, it is evident that there is much variation around the regression line, and the individual observations differ by a considerable amount from the values indicated by that line. Calculated from the regression coefficients, a rise of 10°F. in the dry-bulb temperature is accompanied by a rise of 1.04°F. in the forehead temperature, of 1.08°F. in the temperature of the dorsal surface of the hand, and of 0.73°F. in the temperature of the skin at the level of the sternum. For a similar rise in the effective temperature, namely 10°F., the rise in skin temperature is 1.39°F. on the forehead, 1.44°F. on the hand, and 1.02°F. on the sternum. There appears to be a fall of 3.7 mm. Hg. in the systolic pressure for a rise of 10°F. dry-bulb temperature, while the fall is 5.06 mm. Hg. for a similar rise in effective temperature.

(III) <u>Equilibrium Physiological Reactions in relation to Physical Environment.</u>

(a) <u>Skin temperature</u>: The skin temperatures of the forehead, dorsal side of the right hand and the sternum cease to rise after the environmental warmth reaches a dry-bulb temperature of about 85-86°F. or an effective temperature of about 80°F. (Fig. 13(a)). Below these levels the skin temperature rises in accordance with the degree of warmth of the surroundings. This observed increase in skin temperature in relation to air temperatures below dry-bulb 86°F. is in close agreement with the findings of Winslow et al. (1937)[12] and of Hardy and Du Bois (1937)[16]. In the experiments carried out in the present investigation wall temperatures were practically the same as that of the air. Hence dry-bulb temperature in the present experiments is equivalent to the operative temperatures of Winslow et al. The temperature of the dorsal side of the hand cools more quickly than in the case of the skin of either the forehead or the sternum.

Since the skin temperature of the three spots all cease to increase when the air temperature reaches approximately 86°F. dry-bulb or 80°F. effective temperature, it is clear that below this temperature the rate of body heat loss by a subject wearing tropical clothing is largely governed by change in skin temperature. Consequently in cooler surroundings heat loss by radiation and convection will not increase in proportion to the drop in air temperature because the surface of the body will also become cooled (Gagge et al. 1937).[17] Above 86°F. dry-bulb or 80°F. effective temperature, as a result of increased sensible perspiration, the skin temperature remains at a more or less constant level, body heat loss being achieved by increased evaporation from the surface.

With regard to the relationship between the comfort sensations and the skin temperatures, it has been found that neutral sensations in both scales correspond to skin temperatures of 91-95°F., 88-94°F. and 91-95°F. for forehead, dorsal side of hand and sternum respectively.

(b) <u>Blood pressures and pulse rate</u>: As the environmental warmth rises, both the systolic and diastolic pressures tend to reach equilibrium at lower values (Fig. 15 b), though the change in the latter is less definite. Pulse rate shows a uniform increase as the temperature rises. These values observed for blood pressures and pulse rate have been correlated with the effective temperature of the environment, as shown in Table XVI.

TABLE XVI.

Correlation of effective temperature of the environment with the equilibrium values of blood pressures and pulse rate (59 observations).

Effective temperature of the environment correlated with the equilibrium values of	Correlation coefficients
Systolic blood pressure	-0.36 ±0.11
Diastolic blood pressure	-0.20 ±0.12
Pulse rate	+0.38 ±0.11

The correlation of effective temperature with the equilibrium values of diastolic pressure is not statistically significant. The other two correlations are significant. The regression coefficients show that for a rise of 10°F. effective temperature there is a depression of systolic blood pressure of 3.3 mm. Hg. and an increase of 2.3 beats in the pulse rate.

(c) <u>Wetness of skin surface</u>: The general condition of skin surface as regards wetness or dryness in a particular environment was recorded qualitatively. Variations in the wetness of the skin surface were broadly distinguished as dry, clammy, damp and sweating. It has been proved that the degree of wetness due to perspiration on the skin is affected by the combination of the temperature and moisture of the air and also air movement, (Gagge et al, 1937)[17]. It is therefore reasonable to consider the effective temperature of the environment in relation to the degree of wetness of the skin surface.

Below 80°F. effective temperature the skin is generally dry in the resting subject, even when the heat sensation corresponds to 'warm'. The skin surface begins to feel clammy on an exposure of about ten minutes in an environment of effective temperature approximately 82°F., when the heat sensation corresponds to 'hot'. It has been shown that the skin temperature ceases to rise when the effective temperature exceeds 80°F. Thus the onset of clamminess of the skin surface corresponds roughly to the cessation of rise in skin temperature resulting from increase in environmental warmth. In other words, evaporation from the skin surface compensates for the cessation of the rise in skin temperature as a means of dissipation of the body heat when the effective temperature is above 80°F.

Dampness on the skin surface may be detected after an exposure of ten minutes when the effective temperature is 88°F. Beads of sweat may be apparent on a resting subject after exposure of twenty to thirty minutes in an environment at an effective temperature of 90°F., but sweating of this degree will appear earlier, for example, in ten minutes, when the effective temperature is above 92°F. After entering a comfortable air-conditioned room from a hot environment in which the body has perspired profusely, the unclothed skin surface usually dries in about ten minutes.

DISCUSSION.

In the course of everyday life the human body is frequently subjected to environmental conditions which vary in respect of several physical factors, and often the change from one environment to another takes place in a few seconds, as on entering a dwelling from the outside air. Under such circumstances, it is the custom in some climates to doff or don garments which prevent an excessive sensation of contrast being experienced, but in the tropics, where in recent years the artificial production of indoor climate by air-conditioning has been introduced, such personal adjustment to conditions has not yet become a practice, nor is it certain that it would solve the problem of discomfort on change of environment.

The present investigation comprises an experimental study of the effects on the human body of such changes of environment as may be experienced in hot countries, but it does not cover conditions met with in temperate climates.

The observations made in a series of experiments in which, on each occasion, the subject was required to pass from one environment to another, show that the immediate sensations of heat, which are transitory in character, are more closely related to the difference in effective temperature between the two environments than to their actual temperature levels.

Since the body shows certain definite reactions to each new physical environment and subsequently develops a state of equilibrium, it may be inferred that it had acquired a measure of temporary acclimatisation to the previous environment. If the time of exposure to any set of conditions is sufficiently long the observed values for various physiological reactions will remain steady and indicate the measure of adaptation evoked by those conditions.

While the temperature of the air and its moisture content affect body heat loss, it has been found that sensations of heat are most closely correlated with the dry-bulb temperature of the air but not at all with relative humidity. Sensations of moisture, on the other hand, are most highly correlated with relative humidity and least with dry-bulb temperature. The summated sensations of heat and moisture, that is, the algebraic sum of the arbitrary values ascribed to various gradations in those sensations, have been found to be most highly correlated with the total heat of the air, which is the term used for the sum of the sensible heat and the latent heat of unit quantity of air possessing the physical characteristics of the particular environment. Taken separately, heat sensations and moisture sensations were found to be most closely correlated with sensible heat and latent heat of the air respectively. Thus, it was not surprising to find that the summated sensations were in highest correlation with the sum of the physical values for sensible and latent heat, namely the total heat per unit mass of air expressed in units of energy.

The latent heat of the air appears to exert a relatively greater influence upon moisture sensations and summated sensations of heat and moisture than upon sensations of heat alone, but the sensible heat of the air shows no relation to moisture sensations. When the total heat of the air increases then both heat sensations and moisture sensations are augmented but the effect is more marked in respect of the former.

The validity of the deduction from the experimentally determined data, that the summated sensations of heat and moisture which taken together indicate the subjective impressions of warmth evoked by the environment, stand in highest correlation with the total heat of the air, receives confirmation from air conditioning engineering practice. Thus, in order to produce a comfortable thermal environment by artificial means it is the practice first of all to determine the amount of heat which has to be removed from the air or added to the air and this quantity is the difference between the total heat per unit mass of the air at the two conditions. The present investigation shows that the total heat in unit mass of air determines the over-all warmth sensations of comfort or discomfort experienced by the body under conditions which do not involve great variation in air movement or material differences in temperature between the air and the solid surroundings.

On change of environment there is a sudden disturbance of the previous equilibrium of bodily reactions which had become adapted to the first environment. This gives rise to immediate and new sensations related to the responses of the body to the physical stimuli, the intensity of which depends on the conditions in the new environment.

The effect on subjective sensations of change in environment has been found to be more pronounced on passing from a higher to a lower temperature than an equal change in the reverse direction. This observation would appear to indicate that the human mechanism for temperature regulation adjusts itself more readily to conditions which call for physiological reactions calculated to promote heat loss than those which necessitate a reduction of heat dissipation in various ways as determined by the physical characteristics of the environment.

The changes in bodily reactions, both in respect of immediate responses and of equilibrium values following change of environment, have been investigated. Among the adjustments which the body makes to high environmental temperature are:- the dilatation of peripheral blood vessels, a rise in skin temperature and an increase in sweat secretion, while its reactions to low atmospheric temperatures consist chiefly in a constriction of the peripheral blood vessels with a consequent lowering of skin temperature and a decrease in perspiration. The mechanism of this bodily adjustment to the external environment is assumed to be gradual rather than sudden, but the speed of response will depend upon the degree of environmental warmth experienced and the contrast between the environments.

The conditions investigated covered an extensive range as well as a wide contrast in different environmental factors. Close study of the physiological data referred to above indicates the onset and extent of circulatory reactions resulting from change in the physical environment. Thus, regression coefficients given in a previous section show that immediately on changing from a lower to a higher environmental temperature there is a drop of systolic pressure averaging 5.1 mm. Hg. for a rise of 10°F. effective temperature. Regression coefficients for the equilibrium values show that for a rise of 10°F. effective temperature the fall of systolic pressure is only 3.3 mm.Hg. These facts appear to indicate that on changing from a cool to a hot environment there is an immediate drop in blood pressure and then a recovery - the recovery being roughly one-third of the original fall. The curve shown in Fig. 11 for the average values of systolic blood pressure change illustrates these findings.

The skin temperature rises to almost its equilibrium values immediately after the change from a cool to a hot environment, but change in pulse rate does not occur so rapidly (Fig. 11). The correlation between the change in air temperature and the change in pulse rate is not statistically significant but there is a significant correlation between effective temperature and the values of equilibrium pulse rates. This correlation indicates an increase of 2.3 beats in pulse rate for a rise of 10°F. effective temperature under the conditions of these experiments.

These is some lag in the adjustment of the pulse rate on changing to a hot environment. The almost instantaneous rise of skin temperature,coupled with a sudden drop in blood pressure on entering a hot atmosphere, indicates an increase in the circulation of blood through the peripheral vessels. It seems that the reason for the sudden drop in blood pressures is the onset of dilatation of the peripheral vessels as an immediate reaction of the skin to intense heat, while the heart rate remains unchanged for a time.

A practical problem which has to be faced in dwellings in hot climates is that of ensuring that discomfort shall not be caused by excessive contrast between the outdoor and artificially controlled indoor climates. It would appear from the experimental findings of the present investigation that if the outdoor climate causes sensible perspiration or excessive sweating in the resting subject then the avoidance of a sensation of chilling or 'cold shock' is possible provided the drop in dry-bulb temperature is not excessive. A comfortably cool' sensation can readily be produced by dehumidifying the air and producing a much greater fall in wet-bulb temperature than in dry-bulb temperature.

SUMMARY.

This study deals with the immediate and equilibrium reactions of the human subject to change in environment as may be experienced on entering or leaving air-conditioned dwellings in the tropics.

Artificial outdoor and indoor climates were produced in air-conditioned rooms and the effects of exposure to 62 different sets of conditions ranging in sensation from extremely hot and humid to comfortable were investigated. The physical characteristics of the environments varied between 71°- 104°F. dry-bulb, 58°- 95°F. wet-bulb and 8-160 feet per minute air velocity. On each occasion determinations were made of relative and absolute humidity, dew point, vapour pressure, saturation deficiency, dry and wet kata cooling powers, evaporative cooling power, effective temperature, globe thermometer temperature, mean temperature of the surroundings and the sensible, latent and total heat of the air.

On entry and again after prolonged exposure to each environment records were made of subjective sensations of heat and moisture, skin temperature, sweating,

systolic and diastolic blood pressure and pulse rate. These data have been treated statistically and correlations between subjective sensations and many physical factors have been determined. Physiological reactions to change of environment were found to be more highly correlated with effective temperature than with dry-bulb temperature. The equilibrium sensations of heat, of moisture and of the combination of both stand in highest correlation with the sensible heat, latent heat and total heat of the air respectively. The attainment of equilibrium, after changing from a lower to a higher temperature, was associated with a rise in skin temperature, an increase in pulse rate and recovery in systolic pressure. The significance of the experimental findings is discussed from the point of view of comfort and standards of temperature and humidity for air-conditioned rooms in relation to the outside climate.

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APPENDIX I.

Experimental Data

The following Table gives the actual data for the physical characteristics of the experimental environments, together with immediate and equilibrium values for physiological reactions and sensations of heat and moisture.

In the Table the columns are numbered from 1-17, and, as will be seen from the following list an indication is also given as to the direction of change of environment in each case.

Column Number	Description of Data
1.	Reference number of experiment.
2.	Description of environment: indoor or outdoor
3.	Arrow indicating direction of change of environment.
4.	Dry-bulb temperature.
5.	Wet-bulb temperature.
6.	Globe thermometer temperature, °F.
7.	Dry kata cooling power.
8.	Wet kata cooling power.
9.	Air velocity, feet per minute.
10.	Heat sensations (immediate and equilibrium).
11.	Moisture sensations (immediate and equilibrium)
12.	Forehead skin temperature, °F. (immediate and equilibrium).
13.	Back of hand skin temperature, °F. (immediate and equilibrium).
14.	Sternum skin temperature, °F. (immediate and equilibrium).
15.	Pulse rate (immediate and equilibrium).
16.	Systolic blood pressure, mm. Hg (immediate and equilibrium).
17.	Diastolic blood pressure, mm.Hg (immediate and equilibrium).

1	2	3	4	5	6	7	8	9	10		11		12		13		14		15		16		17	
1	Outdoor	↓	87	76	87.5	2.3	8.9	73	+1	+1	+1	0	95.4	95.2	94.6	94.6	95.4	96.1	60	66	98	98	64	64
2	Indoor		76	70	75	4.7	11.0	50	-2	-1	0	0	93.9	91.9	93.0	89.2	94.6	91.0	60	59	102	106	70	84
3	Outdoor	↓	87	76	87	1.9	7.7	21	+2	+1	+2	+1	95.4	95.7	95.9	96.7	95.8	97.0	67	69	92	96	58	64
4	Indoor		76	66	76	5.0	13.2	62	0	-1	0	0	94.5	93.2	95.7	89.2	95.2	93.3	67	62	102	102	58	72
5	Outdoor	↑	86	76	87.5	2.3	8.9	43	+2	+1	+2	+1	95.0	95.7	94.5	95.4	95.4	96.4	60	63	100	100	66	70
6	Indoor		78	69	77	4.5	11.2	62	0	+1	+1	+1	92.7	94.1	90.0	92.7	94.3	94.3	63	63	112	114	82	68
7	Outdoor	↑	87	77	88.2	2.0	9.2	28	+1	+2	+2	+1	95.7	96.4	94.5	96.1	96.2	96.6	60	59	100	98	64	64
8	Indoor		76	66	76	5.5	15.2	90	-1	-2	0	0	94.0	93.2	94.9	89.2	95.6	93.1	66	58	106	108	50	58
9	Indoor	↓	73	63	73.8	4.8	13.5	28	-1	0	0	0	92.8	93.7	92.8	93.7	92.4	93.7	67	63	100	106	62	58
10	Outdoor	↓	90	75	89.2	1.8	14.9	80	+2	+3	0	-1	94.6	95.3	94.6	95.2	93.8	95.5	63	61	98	92	60	60
11	Indoor		73	62.5	74.1	4.7	13.7	24	-1	-1	0	0	94.5	91.6	93.6	90.1	94.5	91.4	64	59	100	94	56	60
12	Outdoor	↓	92.5	79	92	1.4	12.7	128	+2	+4	0	0	97.1	96.8	96.5	96.5	96.8	96.5	72	72	106	98	66	66
13	Indoor	↓	75	65	75	5.4	15.5	72	-1	0	0	0	95.2	94.0	94.0	91.9	94.0	93.0	64	62	110	90	68	58
14	Outdoor		94	80	94.4	1.1	12.0	160	+3	+4	+1	+1	96.8	96.8	96.5	96.3	96.5	96.8	67	65	86	90	52	64
15	Outdoor	↓	90	79	91.2	2.1	12.1	130	+3	+3	+1	+1	96.9	97.7	97.6	97.6	97.8	97.3	75	66	90	104	50	58
16	Indoor		77	64	77.2	4.1	13.2	34	-1	0	0	0	96.2	96.0	94.7	93.9	96.2	96.2	68	63	104	98	60	58
17	Outdoor	↓	95	87	94.8	0.4	5.6	44	+2	+4	+2	+2	96.9	97.6	96.7	97.6	96.6	97.6	69	71	84	94	50	66
18	Indoor		80	73	80.2	2.5	9.7	21	0	+2	0	0	96.4	96.1	96.7	95.5	97.2	95.5	71	71	104	100	72	62
19	Outdoor	↑ ↓	95	90	96.2	0.3	3.5	37	+4	+5	+2	+3	98.3	99.1	97.8	98.8	97.8	97.9	71	71	102	98	56	60
20	Indoor		80	74	80.8	3.2	10.3	17	+1	+2	+1	+1	95.7	96.8	96.0	96.6	96.3	96.6	75	72	112	106	66	60
21	Outdoor	↓	96	87	97.8	0.2	5.0	40	+3	+5	+3	+2	92.1	92.6	92.1	92.3	91.8	92.3	76	80	96	96	64	54
22	Indoor		76	69	77	4.6	11.7	42	-3	0	0	0	92.0	91.2	91.2	90.9	92.0	90.7	77	70	102	102	60	68
23	Indoor	↓	76	68	78.1	3.7	10.5	10	0	+1	+1	+1	92.4	92.4	91.0	92.4	93.0	92.6	73	69	120	114	66	58
24	Outdoor	↓	96	90	96.8	0.1	4.3	43	+4	+5	+3	+3	93.2	92.8	93.4	92.6	92.8	92.0	73	62	100	98	60	60
25	Indoor		76	70	78.1	3.7	10.5	10	-3	0	0	0	92.6	92.4	92.8	91.6	92.8	92.2	69	66	114	106	62	66
26	Outdoor	↓	95	81	95.6	0.4	8.6	47	+1	+4	+1	0	92.6	93.0	90.6	92.6	92.2	93.3	70	75	88	102	58	58
27	Indoor	↓	74	65	76.8	3.9	11.5	8	0	0	0	0	92.4	92.3	92.6	90.6	93.3	92.0	71	66	104	106	64	72
28	Outdoor		96	78	96	0.2	10.6	52	+2	+4	0	0	93.7	93.6	93.7	93.3	93.3	93.3	69	71	108	100	50	50
29	Indoor	↓	75	65	76.8	4.1	11.3	20	0	0	0	0	92.8	92.8	92.8	92.5	92.5	92.8	72	66	108	98	50	60
30	Outdoor	↓	95	77	96.2	0.3	10.3	32	+2	+4	0	-1	97.6	98.9	95.9	97.9	97.5	98.7	73	73	104	96	64	62
31	Indoor		80	67	80	4.0	12.8	60	-1	+1	0	0	95.5	94.5	94.6	94.7	95.7	95.7	64	68	102	94	68	66
32	Outdoor		95	75	95.6	0.2	11.0	57	+4	+5	-2	-2	98.6	98.8	98.4	98.4	98.6	98.6	70	75	98	94	58	60
33	Indoor	↑	80	66	79.6	4.2	14.2	73	+1	+1	0	0	97.0	95.3	96.4	96.6	97.2	96.8	82	69	112	98	40	58
34	Indoor	↓	71.5	59	72.8	5.0	13.7	28	-2	-1	0	0	93.8	93.0	93.8	92.3	93.0	93.0	69	63	118	118	46	50
35	Outdoor	↓	95	74	96.1	0.2	11.2	50	+3	+4	-1	-1	94.3	94.8	94.3	94.7	93.7	94.6	62	62	100	96	50	60
36	Indoor		70.5	58	72.7	4.7	12.7	13	-1	-2	0	0	91.9	91.2	91.3	88.2	92.2	91.1	61	55	114	106	64	70
37	Indoor	↓	79	66.5	78.9	3.7	12.3	30	0	+1	0	0	94.9	95.1	95.1	94.5	95.1	95.1	72	66	118	112	46	56
38	Outdoor	↓	96	85	95.8	0.9	8.4	92	+4	+5	+2	+2	98.0	97.1	98.0	96.1	97.7	95.2	74	68	98	98	60	60
39	Indoor		80	69	80.1	3.5	11.3	33	-1	+1	0	0	96.3	95.2	95.2	94.7	95.2	95.2	64	62	98	88	60	56
40	Indoor	↓	78	66	78.1	3.9	13.7	30	+1	0	0	0	94.6	93.9	93.9	94.0	93.9	93.9	71	64	108	104	60	60
41	Outdoor	↓	104	93	104.2	-1.4	1.6	50	+5	+7	+3	+3	97.9	96.7	97.0	96.8	96.7	96.4	68	68	88	94	64	58
42	Indoor		82	72	82.4	3.1	10.9	40	-4	+1	0	0	92.7	94.7	93.8	94.2	93.8	93.8	62	62	108	104	44	58
43	Indoor	↓	77.5	67	76.3	4.7	13.3	60	0	0	0	0	93.8	93.8	94.9	93.8	93.8	93.8	73	70	112	114	44	58
44	Outdoor	↓	98	92	99	-0.1	2.7	45	+5	+6	+3	+4	97.2	96.9	97.2	96.3	96.1	95.8	68	66	98	108	34	60
45	Indoor		79	69	78.7	3.9	12.7	40	-5	+1	0	0	92.0	94.7	91.8	94.2	91.6	92.8	65	65	110	106	34	60
46	Outdoor		92	85	91	1.8	8.7	163	+3	+4	+1	+2	97.4	97.3	96.8	96.8	96.8	96.8	72	66	98	108	68	64
47	Indoor	↓ ↓	80	68	79.3	3.8	11.9	50	-2	+1	0	0	96.2	95.9	94.1	95.9	95.9	95.9	74	68	98	90	62	62
48	Outdoor		91	87	91	1.9	7.9	130	+3	+4	+2	+3	96.8	96.8	96.8	96.8	96.8	96.8	64	62	90	90	66	56
49	Outdoor		102	80.5	101	-0.9	7.9	44	+4	+5	-2	-2	93.1	94.6	92.4	94.1	92.3	93.8	68	71	98	96	62	54
50	Indoor	↓ ↓	73	63	73.8	5.6	16.2	61	-1	+1	0	0	91.4	91.4	91.7	91.2	91.7	91.2	66	61	116	104	64	68
51	Outdoor		103	78	104.5	-0.9	8.7	16	+4	+5	-2	-2	94.0	94.4	93.4	92.4	92.5	93.9	62	70	100	96	56	58
52	Indoor		74	62	75.5	5.8	17.6	83	0	0	0	0	90.3	91.4	89.8	90.9	91.6	91.6	70	62	116	98	46	54
53	Outdoor	↓ ↓	103	76	104.8	-1.1	9.5	33	+4	+5	-2	-2	94.4	94.6	94.4	94.4	92.5	94.6	64	64	108	94	58	56
54	Indoor		75	63	76	5.4	15.8	75	-1	0	0	0	92.1	92.1	90.9	91.8	92.3	90.9	68	65	112	104	50	64
55	Indoor	↓	76	63	75.6	4.8	15.0	53	0	0	0	0	94.0	94.5	91.6	94.5	94.5	94.5	72	66	124	110	50	58
56	Outdoor	↓	103	77	103.3	-1.1	11.0	43	+4	+5	-2	-2	97.2	97.6	96.9	96.9	96.6	96.9	64	63	106	100	64	58
57	Indoor		76.5	63.5	77	4.7	14.3	47	-2	0	0	0	94.5	95.4	93.6	93.1	95.4	94.0	62	58	100	98	62	60
58	Outdoor		100	90	102	-0.5	4.3	48	+5	+6	+3	+3	94.7	93.4	94.5	93.1	94.5	93.1	76	78	92	102	56	62
59	Indoor	↓	77	70	78	4.2	9.5	37	-2	+1	0	+1	92.2	92.0	92.2	92.2	92.8	92.8	74	72	112	108	62	68
60	Indoor	↓	78.3	71	79.2	4.1	11.3	43	+1	+1	+1	+1	90.8	93.1	91.7	92.6	93.1	93.2	80	81	124	120	60	58
61	Outdoor	↓	103	92	102.6	-1.1	2.8	44	+5	+6	+3	+3	94.7	94.9	94.2	94.2	94.0	94.0	76	81	108	110	56	58
62	Indoor		80	73	81.5	3.7	12.8	41	-3	+2	0	+1	93.4	93.7	93.7	93.7	92.7	93.9	75	75	114	104	62	68

Note: The data for physiological reactions in environments 56, 58 and 61 were not used in the statistical analysis referred to in the body of the Thesis.

APPENDIX II.

Comfort Sensation Charts

In the present investigation the main physical variables in the experimental environments were those of dry-bulb temperature and humidity. Air movement varied little and the walls of the rooms were kept practically at the dry-bulb temperature of the air. It is of theoretical interest to examine the data collected in respect of the heat and moisture sensations of the subject and correlate the sensations experienced with dry-bulb temperature and dew point temperature. It has been possible to construct charts showing the relation between these physical factors and the sensations to which they give rise when acting in various combinations. The range of conditions covered by the actual experiments is shown in Appendix I.

Heat Sensations: Chart I, relating heat sensations to dry-bulb and dew point temperatures and other physical indices derived from these, has been constructed on the basis of the regression equation derived from observed data, namely:-

Sensations of Heat = 0.193 dry-bulb temperature plus 0.033 dew point temperature minus 16.69 ...... Equation (i).

In Chart I dry-bulb and dew point temperatures are plotted on the ordinate and abscissa respectively. Relative humidity and wet-bulb temperature curves have been calculated from hygrometric tables and superimposed on the chart. The sensations of heat may be evaluated in terms of the appropriate index on the heat sensations scale provided any pair of physical factors are known.

Curves of heat sensations in the chart are parallel straight lines. They are nearly parallel to the dry-bulb temperature curves with a slight uprising towards lower humidity or lower dew point temperatures. This means that for a constant dry-bulb temperature, changes in relative humidity or in dew point temperature have little effect on the heat sensations alone. Different levels of heat sensation follow rather closely changes in dry-bulb temperature. It may be calculated from the above equation that the unbearably hot and unbearably cold sensations will be encountered about 104°F. and 43°F. respectively for saturated air in the case of a resting subject wearing tropical clothing for an exposure of approximately one hour.

Moisture Sensations: Chart II, which relates moisture sensations to physical factors, is constructed on the same principle as Chart I but based upon the following regression equation derived from experimental data:-

Sensations of Moisture = 0.151 dew point temperature minus 0.099 dry bulb temperature minus 1.32 .... Equation (ii)

The curves of moisture sensations are parallel straight lines. They follow fairly closely the direction of the relative humidity curves. Changes in dew point temperature have a greater effect (1.5:1) on the moisture sensations than changes in dry-bulb temperature. The chart shows that the intensity of moisture sensations increases as a result of elevation of dry-bulb temperature with constant relative humidity. Similarly, moisture sensation decreases with a lowering of dew point temperature at constant dry-bulb temperature. With the same dry-bulb temperature the sensation of moisture will be increased if relative humidity is raised, and decreased if it is lowered. It would appear from the chart that the unbearably humid sensation would be experienced at 103°F. saturated air, which conditions also give rise to unbearably hot sensations on the heat scale as in Chart I. Although unbearably dry sensations were not experienced in the experiments carried out it would appear from the chart that these might arise at various temperatures provided the relative humidity is below 20 per cent. for temperatures above 80°F.

Summated Sensations of Heat and Moisture: Chart III relates the summated sensations of heat and moisture to various physical factors and is based on the regression equation:-

Summated Sensations = 0.093 dry-bulb temperature plus
0.184 dew point temperature
minus 17.897 ..... Equation (iv)

The summated sensation curves are parallel straight lines. They are more or less perpendicular to the curves of relative humidity. It would appear that with a constant dew point temperature temperature a rise of x degrees in dry-bulb produces half the effect on the summated sensations as would be caused by a rise of x degrees in the dew point with constant dry-bulb temperature.

In general, it may be said that the effects of identical increments in dry-bulb or wet-bulb temperatures are most pronounced in the case of the summated sensations in Chart III and to lesser degrees in the case of heat sensations and moisture sensations respectively.

The extreme conditions for heat and moisture described as 'unbearably hot' and 'unbearably humid' are, according to Chart III, produced when the air is saturated at 104°F., but this is of purely theoretical interest. Such conditions lie outside the range of indoor or outdoor climate which it was possible to study experimentally.

These charts, derived purely from data collected in the course of the present investigation, appear to show ranges of conditions compatible with comfort which are not widely divergent from the American comfort zones based on effective temperature. This fact tends to lend support to the general deductions which have been drawn from the observations made.

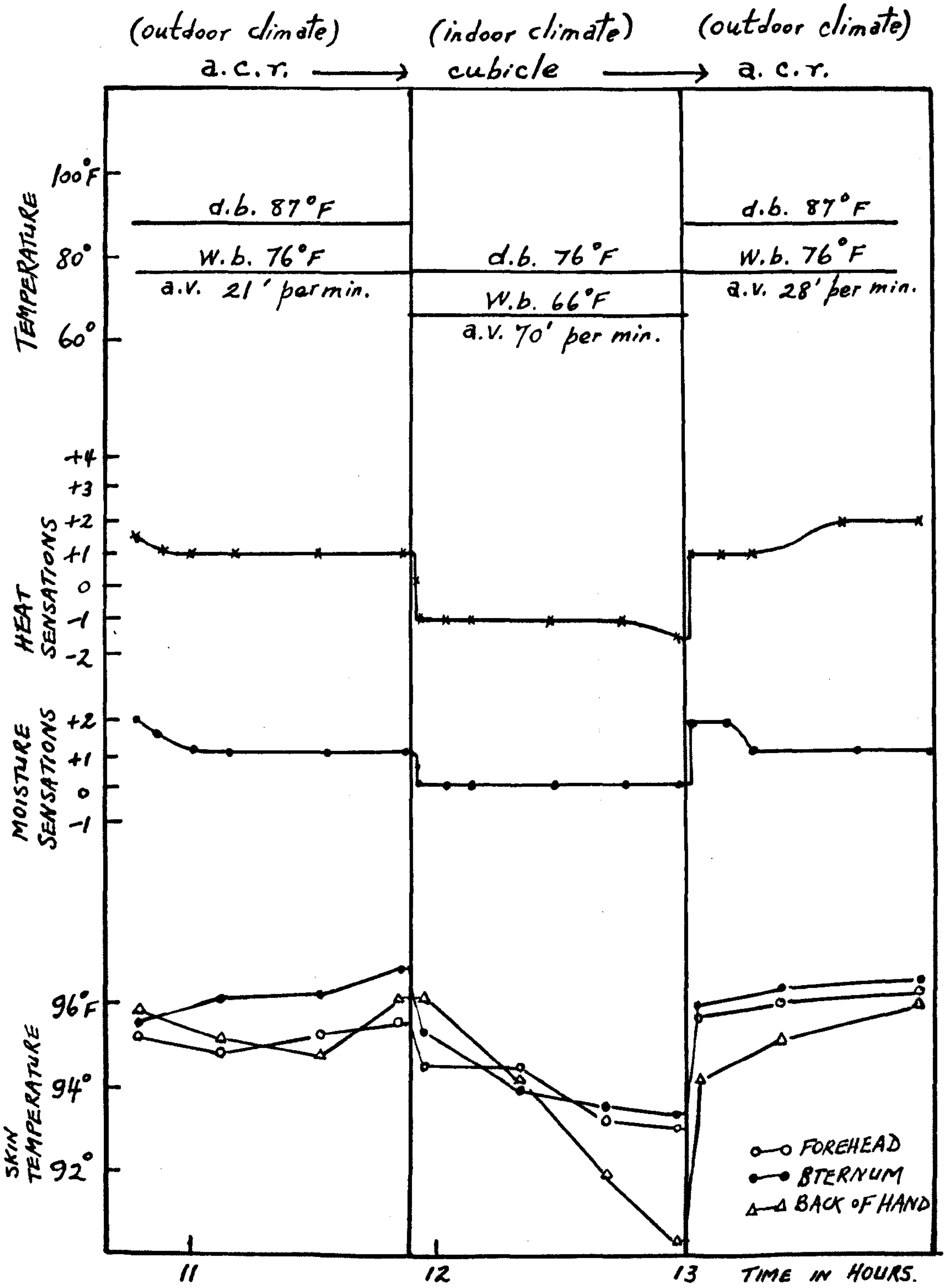


Fig. I. A.C.R. comfortably warm or warm and comfortably humid or humid; cubicle comfortably cool and neutral.

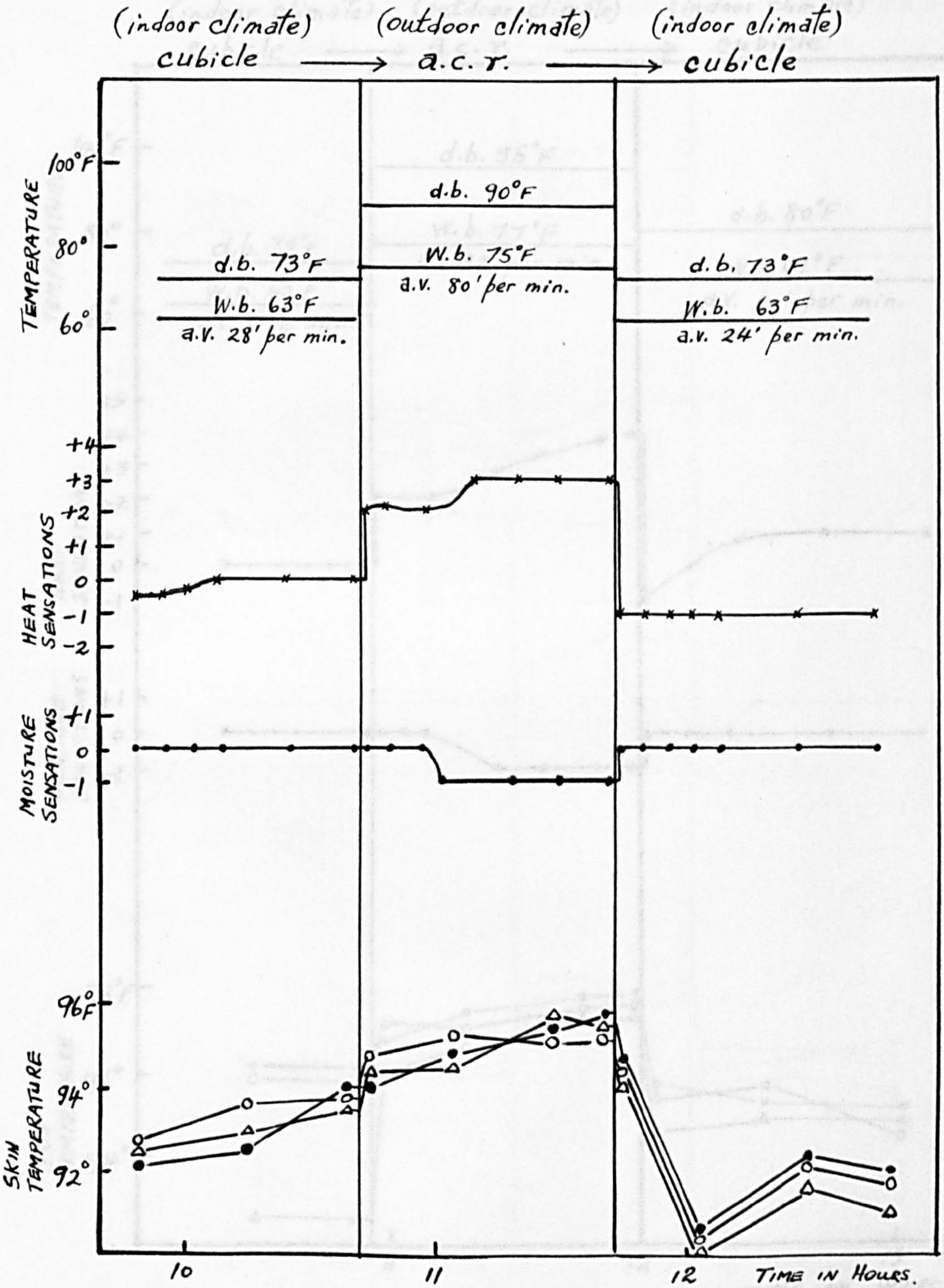


Fig. II. A.C.R. warm and comfortably dry; cubicle comfortable or comfortably cool and neutral.

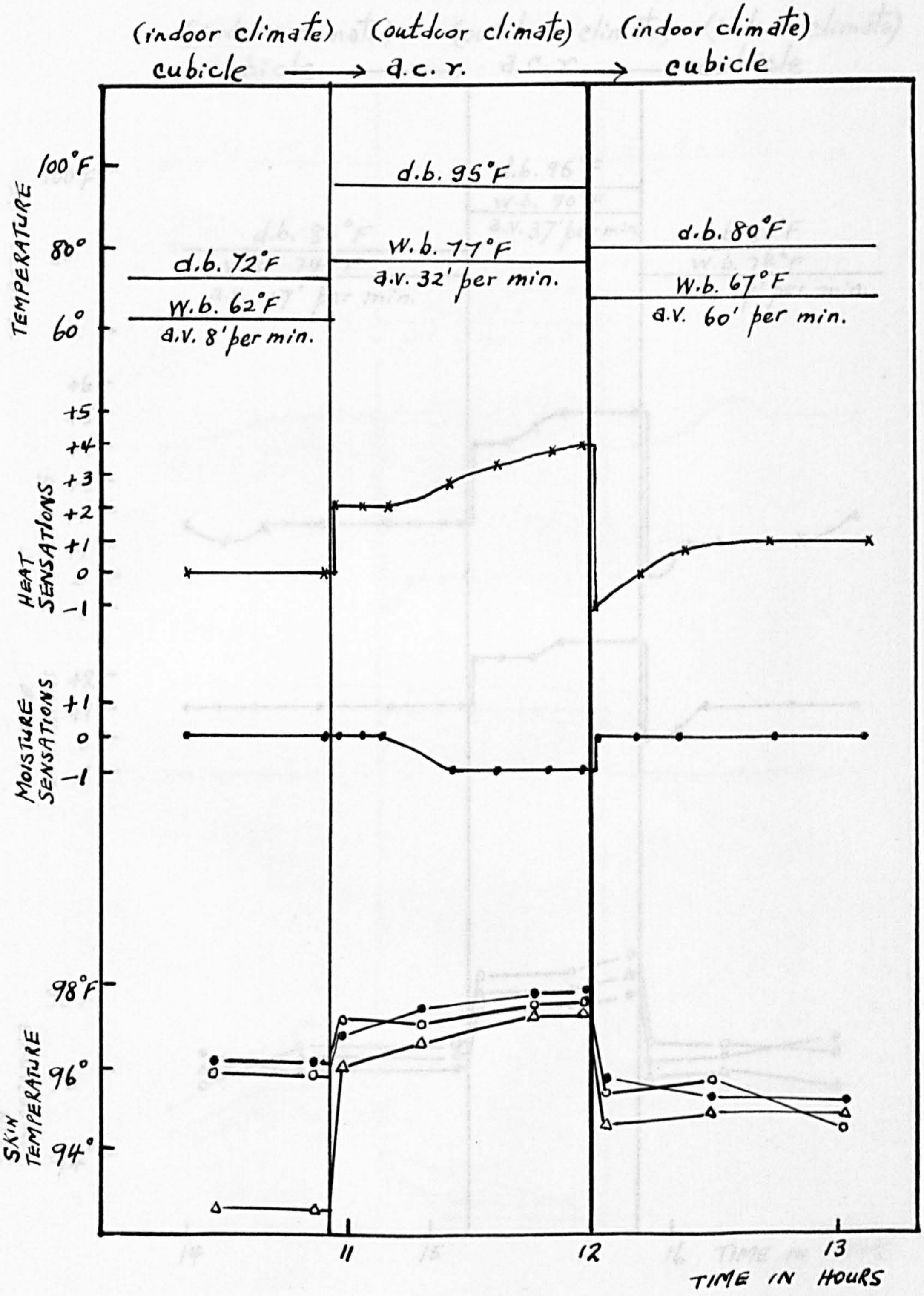


Fig. III. A.C.R. warm to hot and comfortably dry; cubicle comfortable to comfortably warm and neutral.

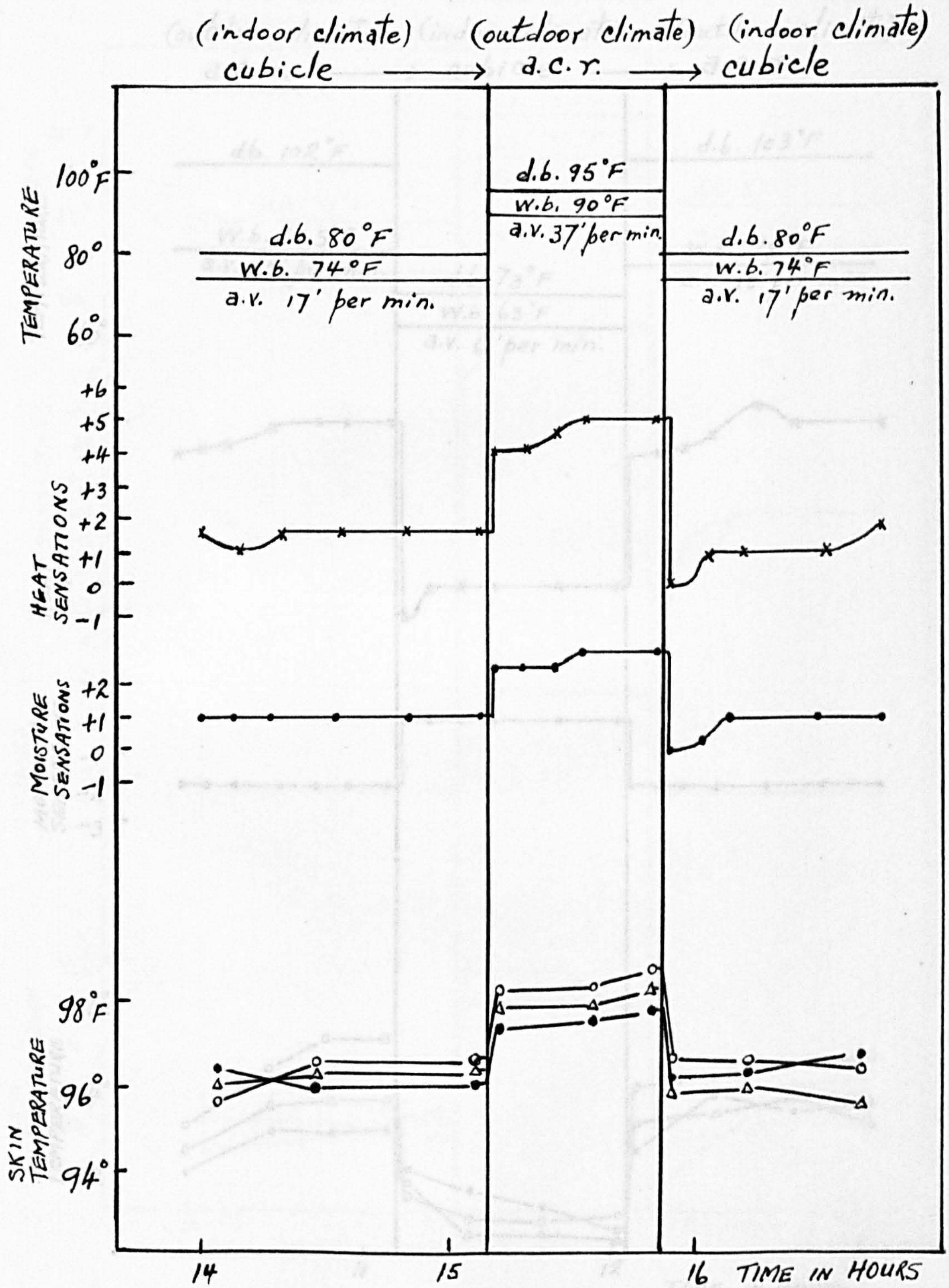


Fig. IV. A.C.R. hot and humid; cubicle comfortably warm and comfortably humid.

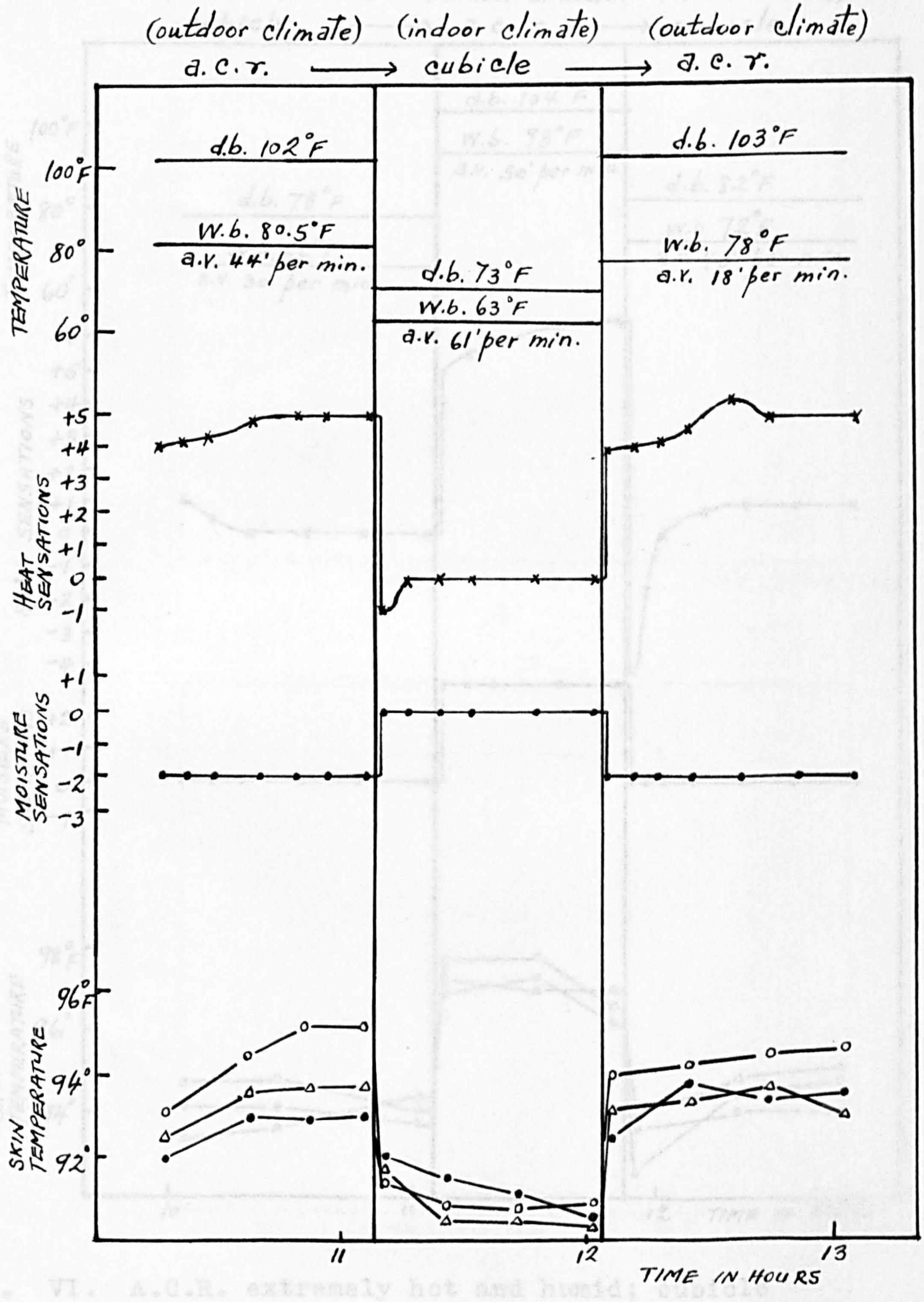


Fig. V. A.C.R. extremely hot and dry; cubicle neutral.

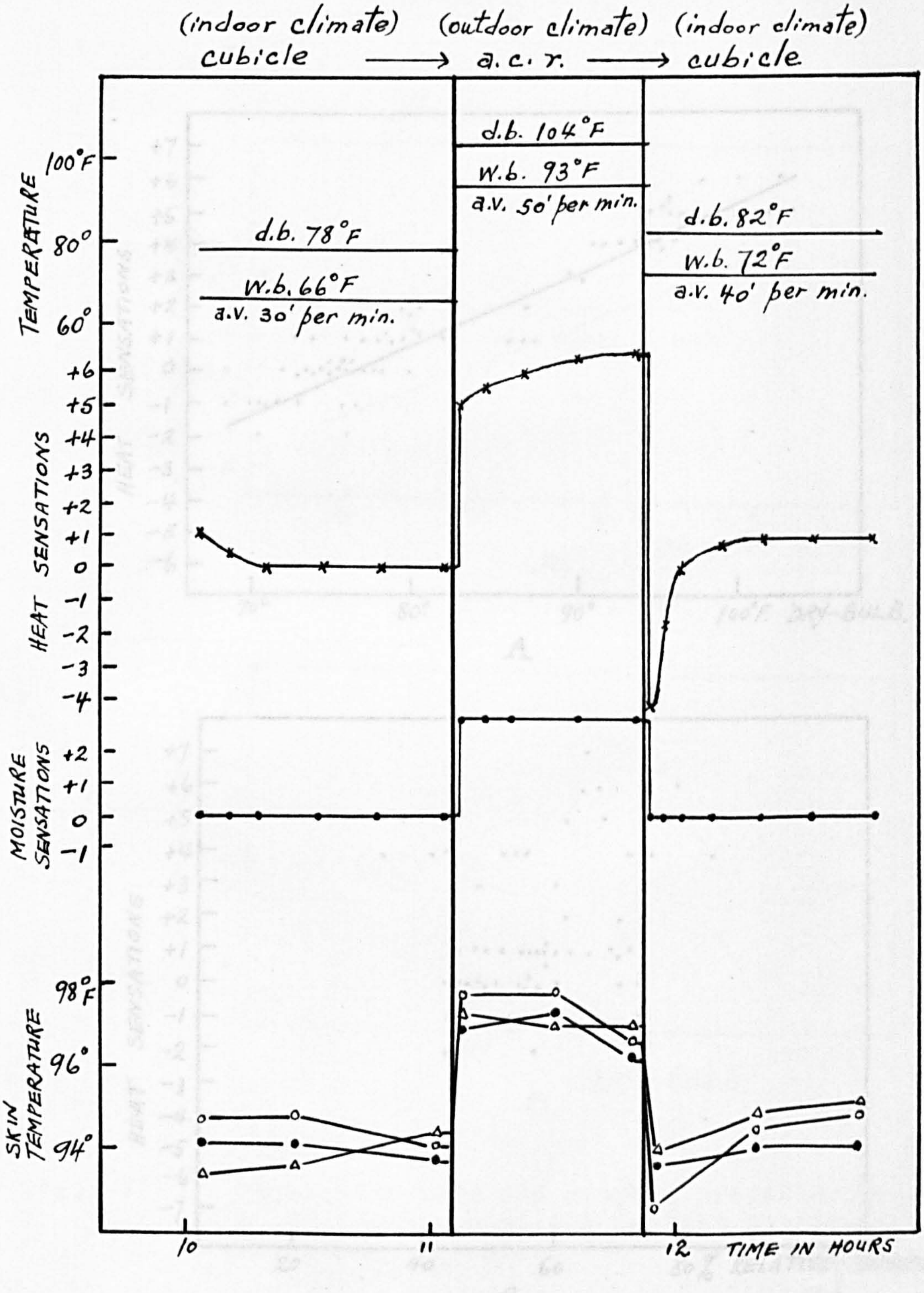
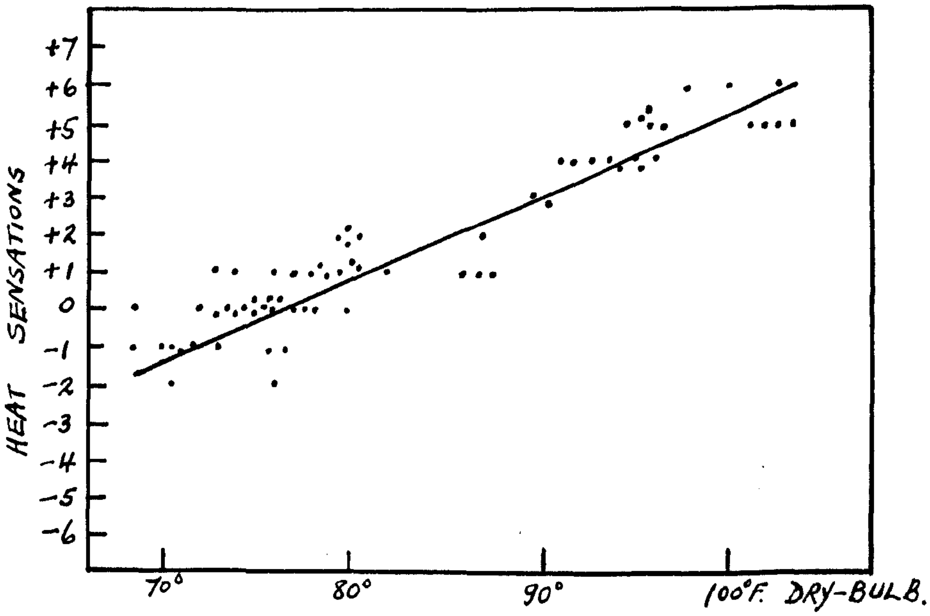
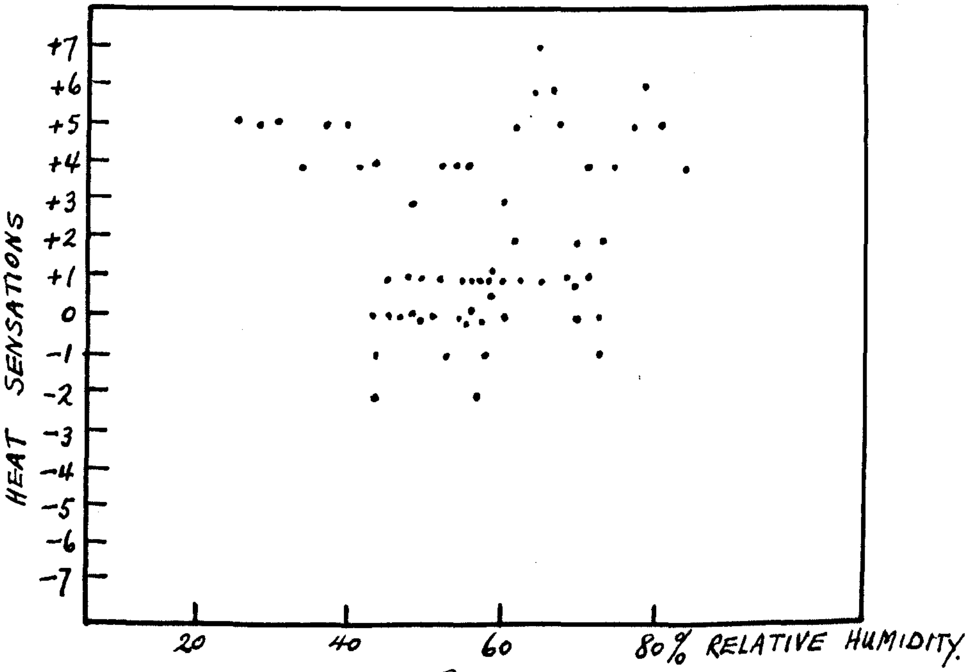


Fig. VI. A.C.R. extremely hot and humid; cubicle comfortable or comfortably warm and neutral.



A



B.

Fig. VII. Regression line and graphic presentation of heat sensations against physical factors of the air.

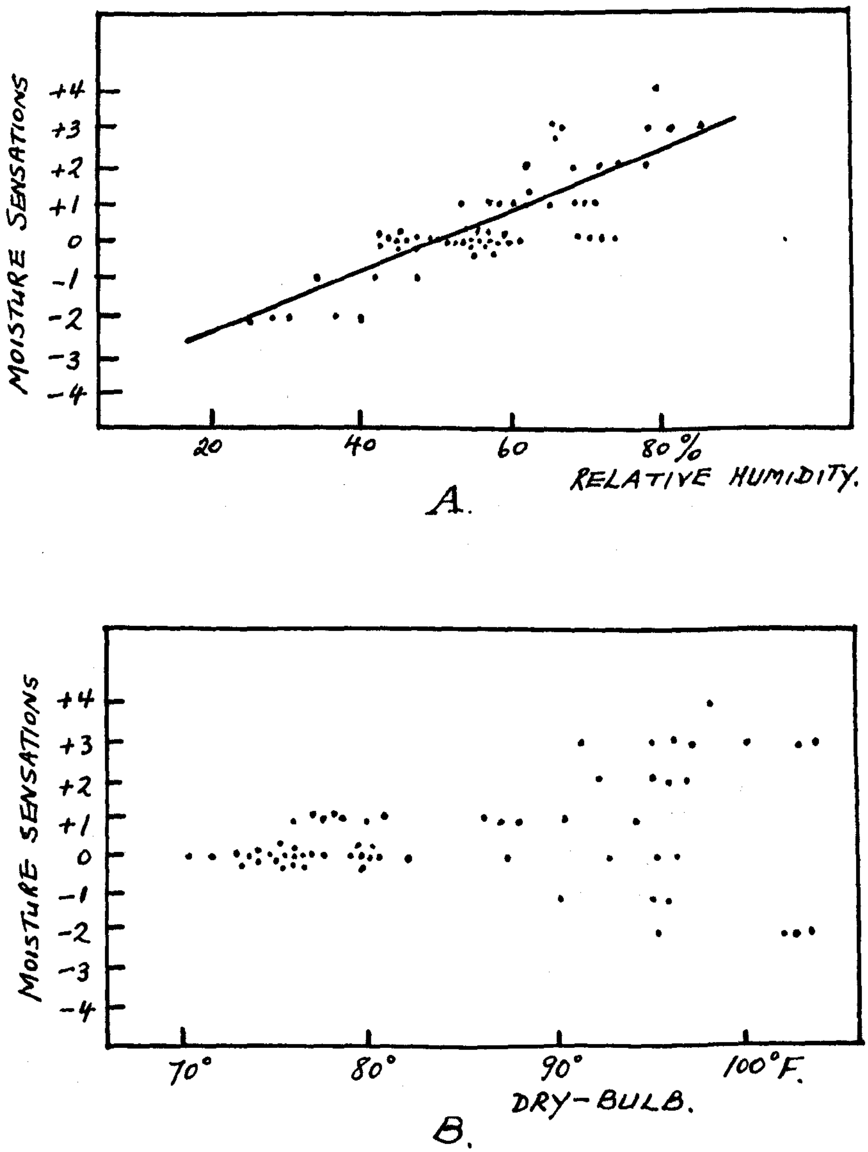
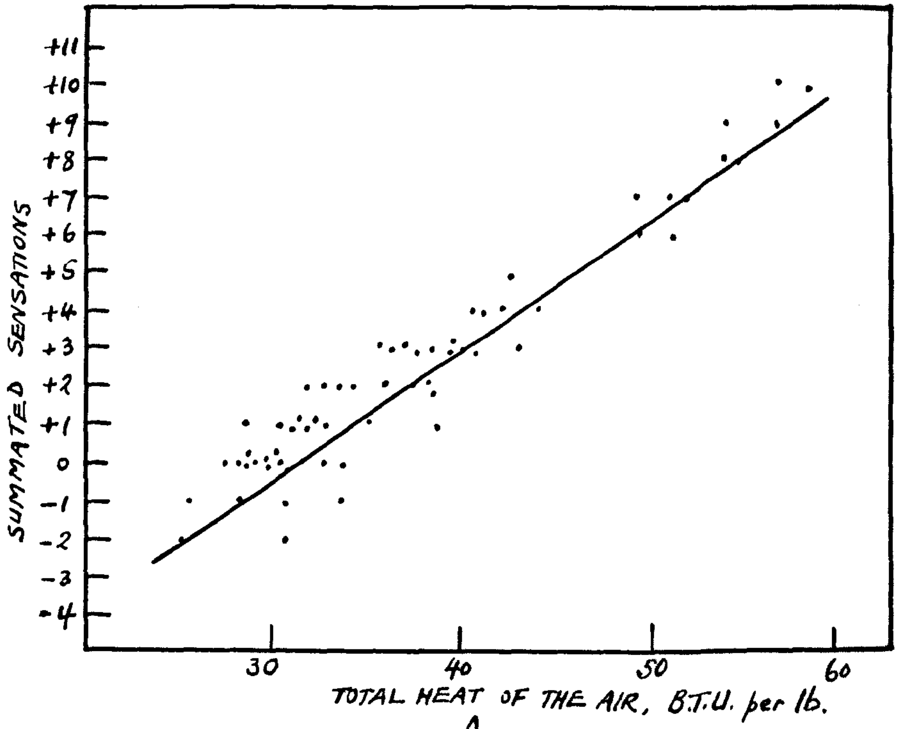
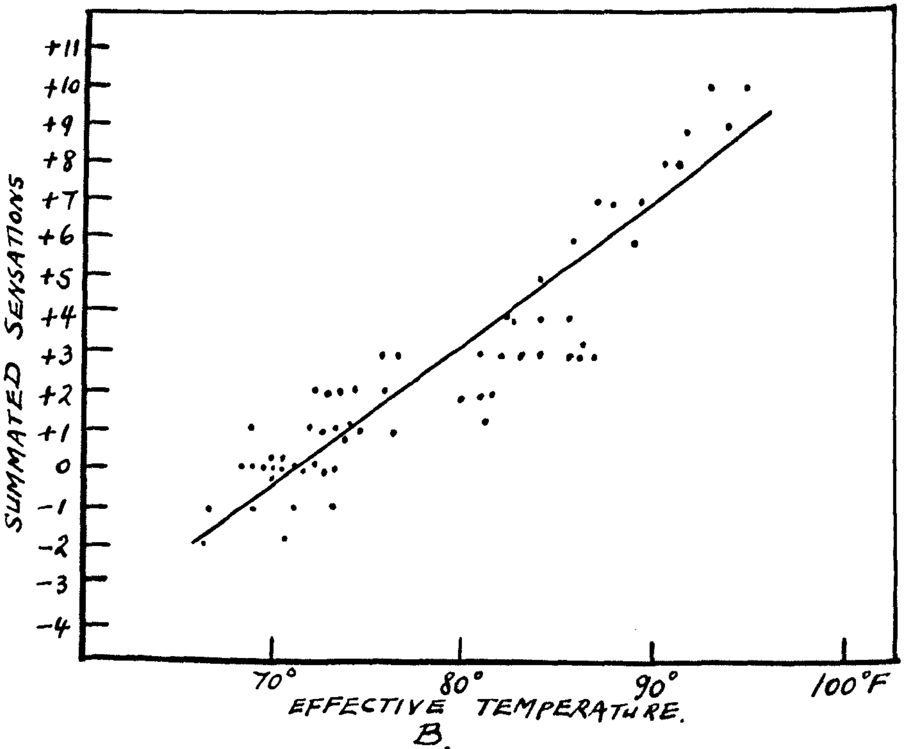


Fig. VIII. Regression line and graphic presentation of moisture sensations against physical factors of the air.



A



B.

Fig. IX. Regression line and graphic presentation of summated sensations against physical factors of the air.

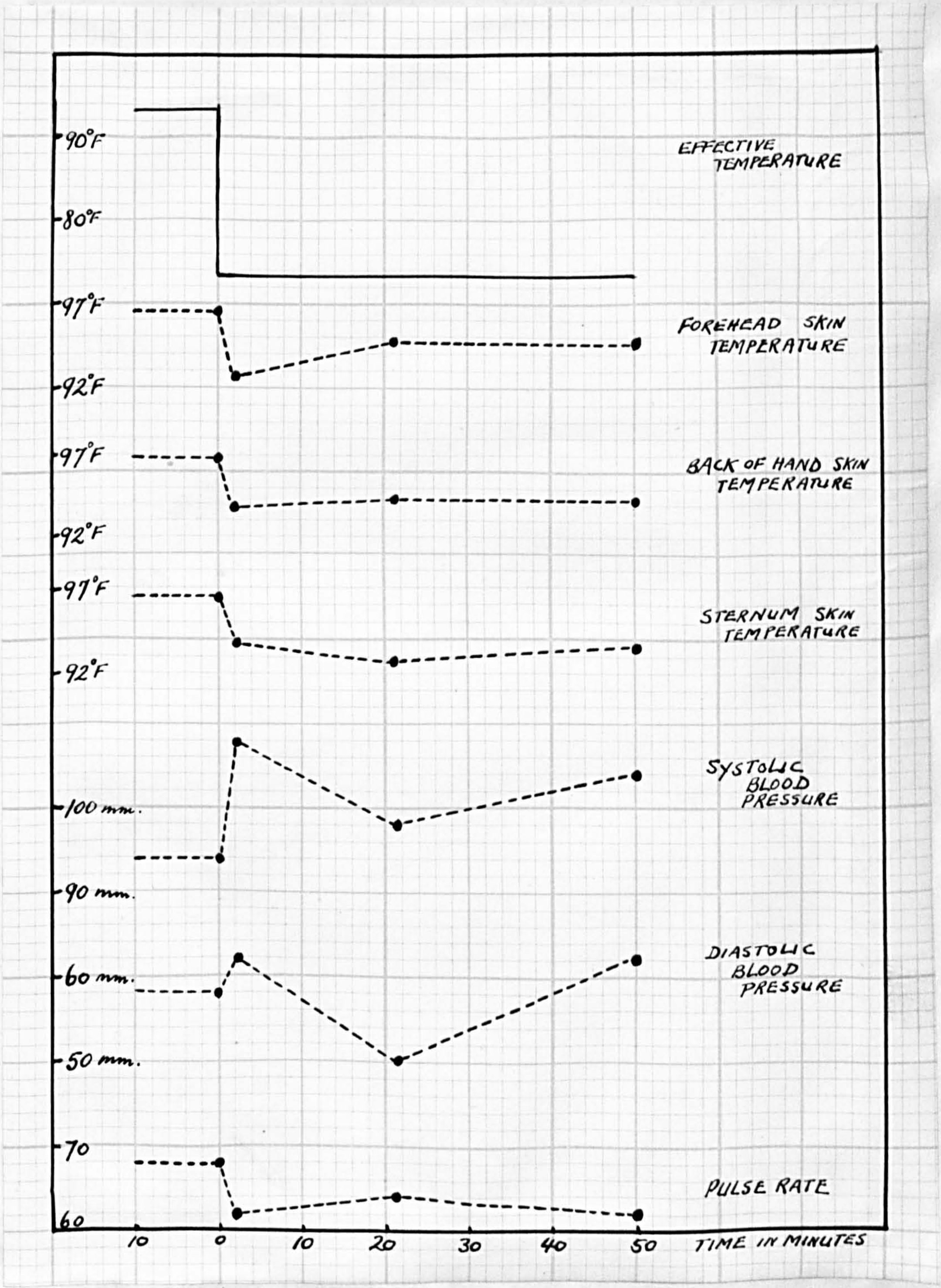


Fig. X. Changes in physiological reactions of immediate and equilibrium values in the new environment as compared with the equilibrium values in the previous environment(a change from a higher to a lower effective temperature of 20° F).

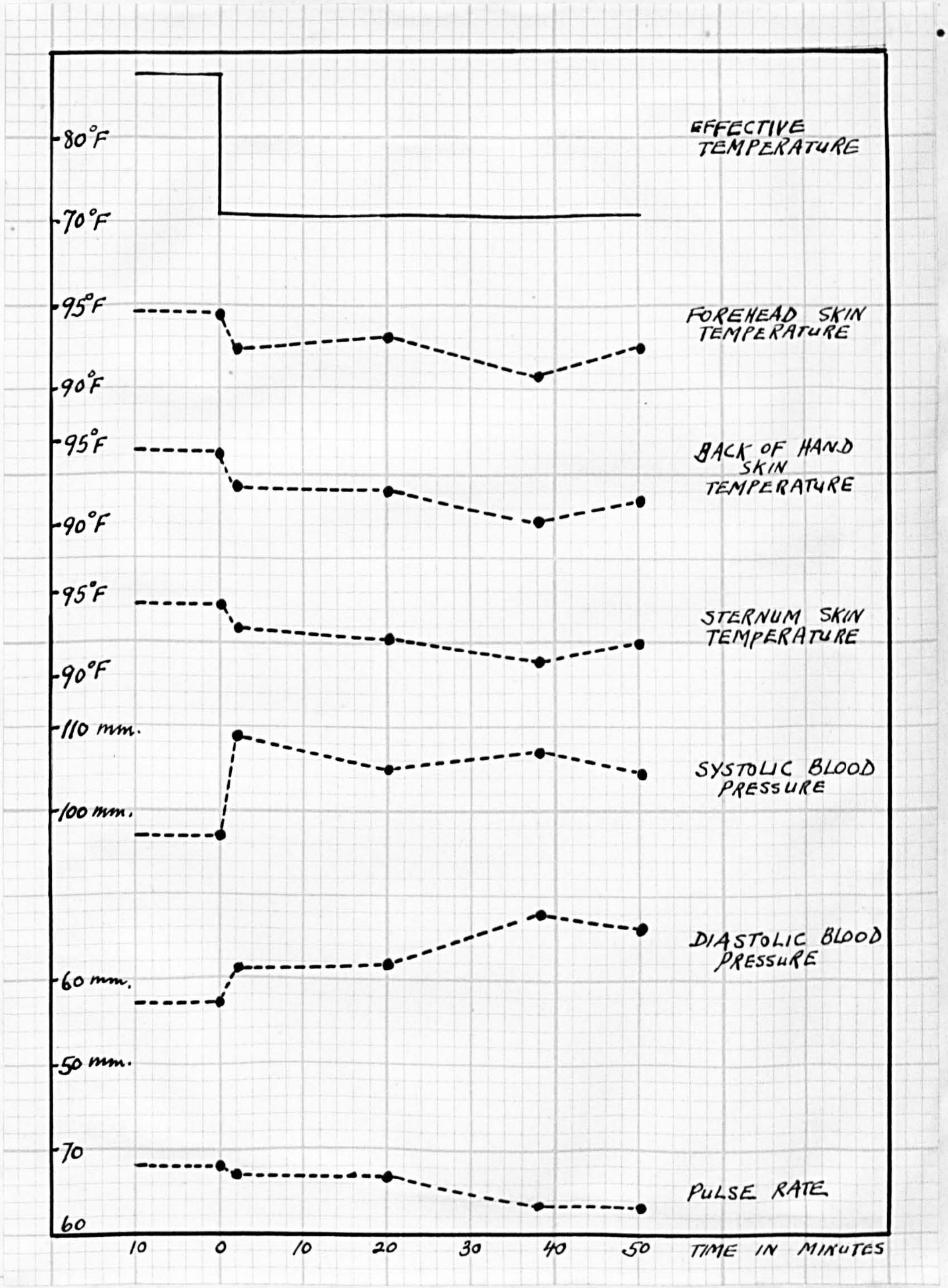


Fig. Xa. Changes in physiological reactions of immediate and equilibrium values in the new environment as compared with the equilibrium values in the previous environment(a change from a higher to a lower effective temperature of 17° F., average of eight experiments).

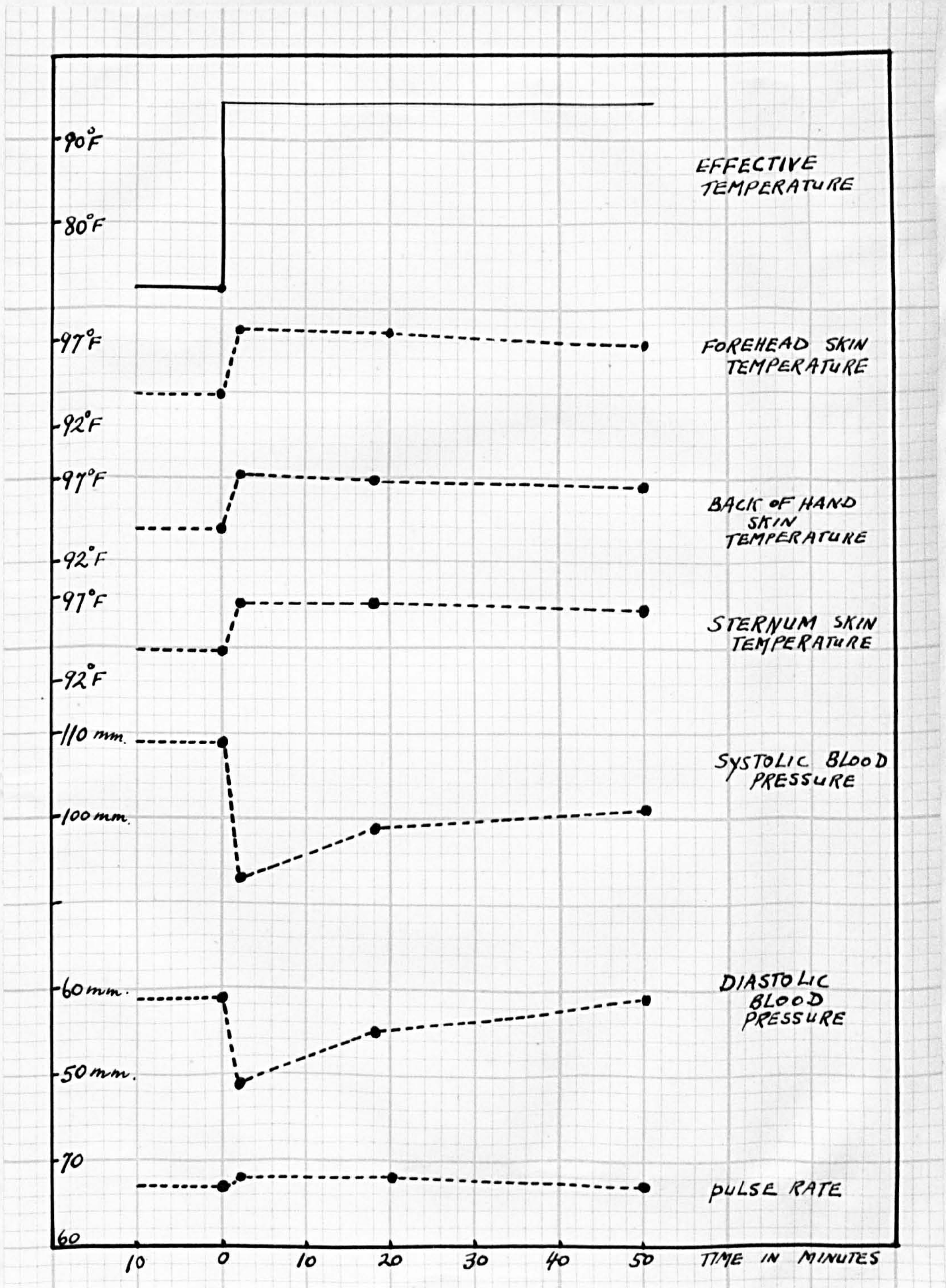


Fig. XI. Changes in physiological reactions of immediate and equilibrium values in the new environment as compared with the equilibrium values in the previous environment(a change from a lower to a higher effective temperature of 22° F).

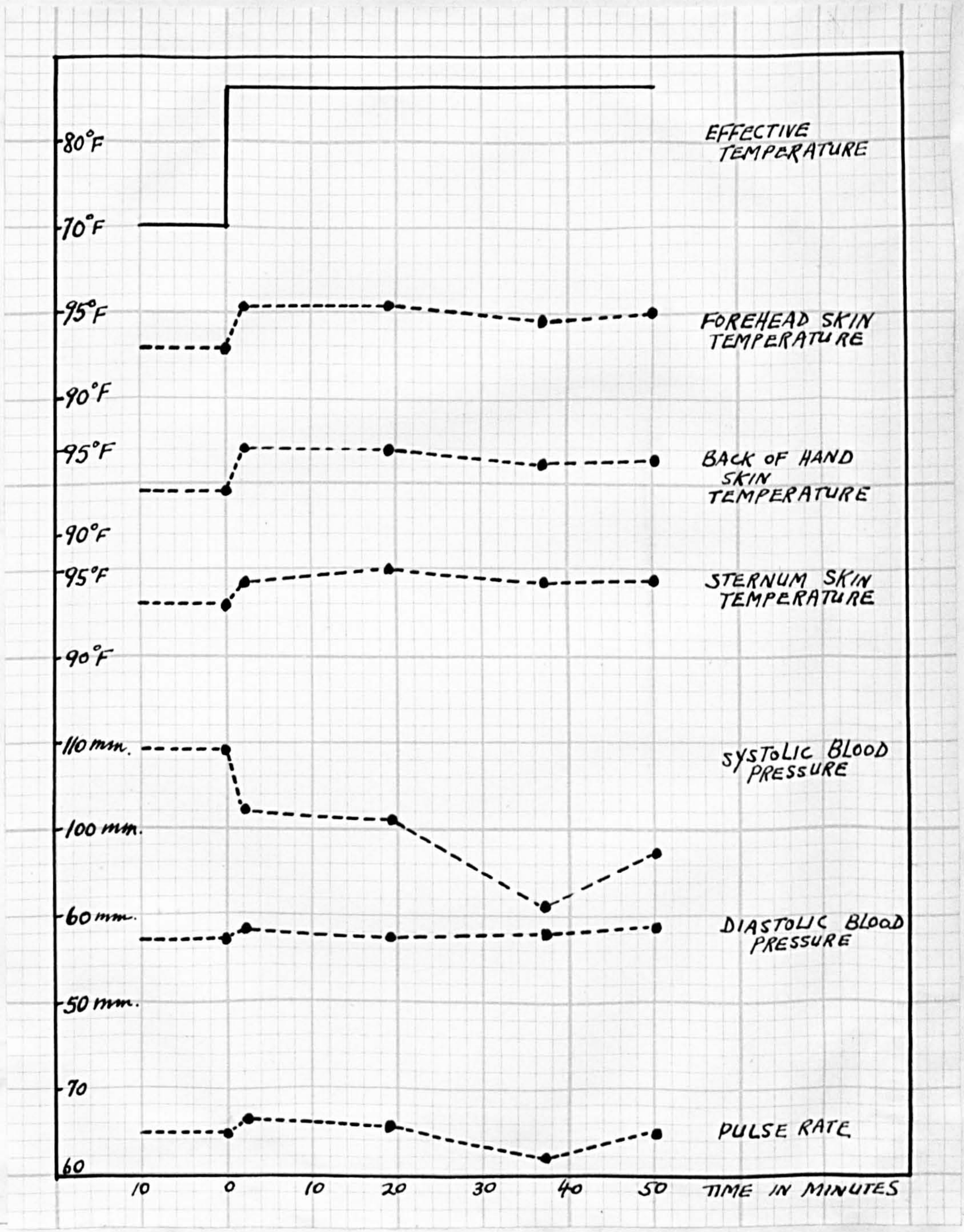


Fig. XIa. Changes in physiological reactions of immediate and equilibrium values in the new environment as compared with the equilibrium values in the previous environment(a change from a lower to a higher effective temperature of 17° F., average of six experiments).

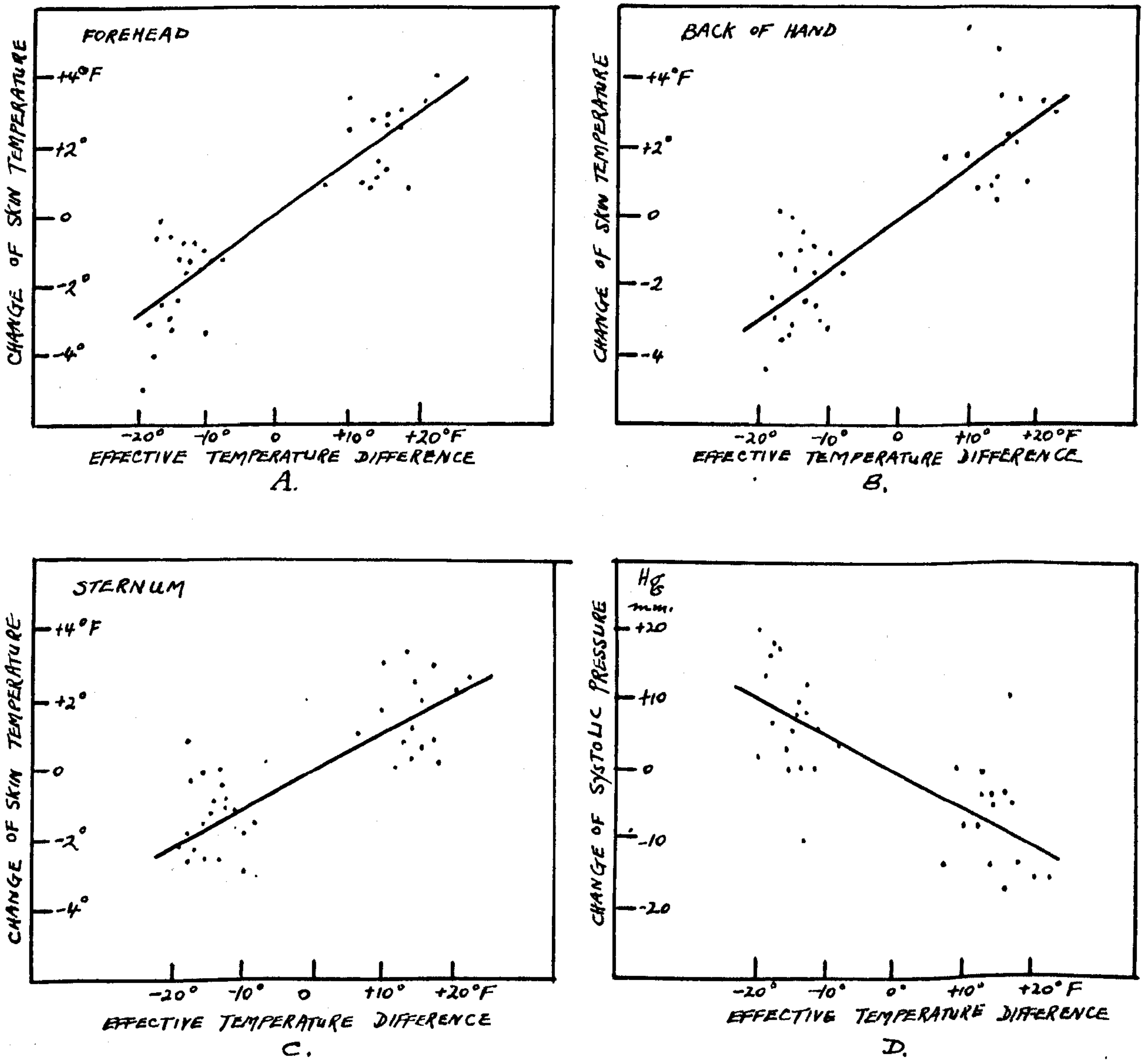


Fig. XII. Regression lines and changes in physiological reactions of the equilibrium values in the previous environment and the immediate values in the new environment in relation to effective temperature difference.

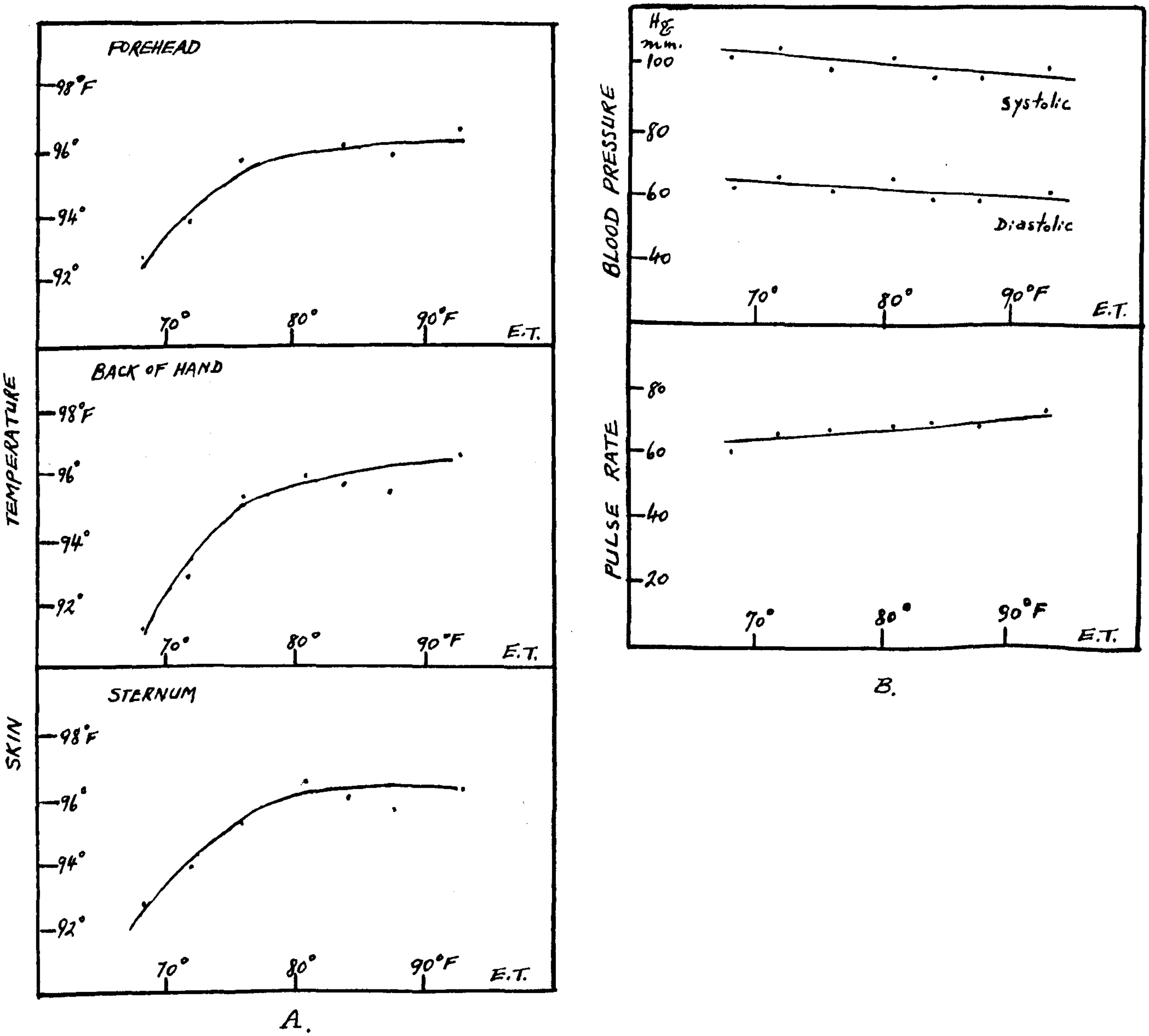


Fig. XIII. Average equilibrium values of physiological reactions in relation to effective temperature of the environment.

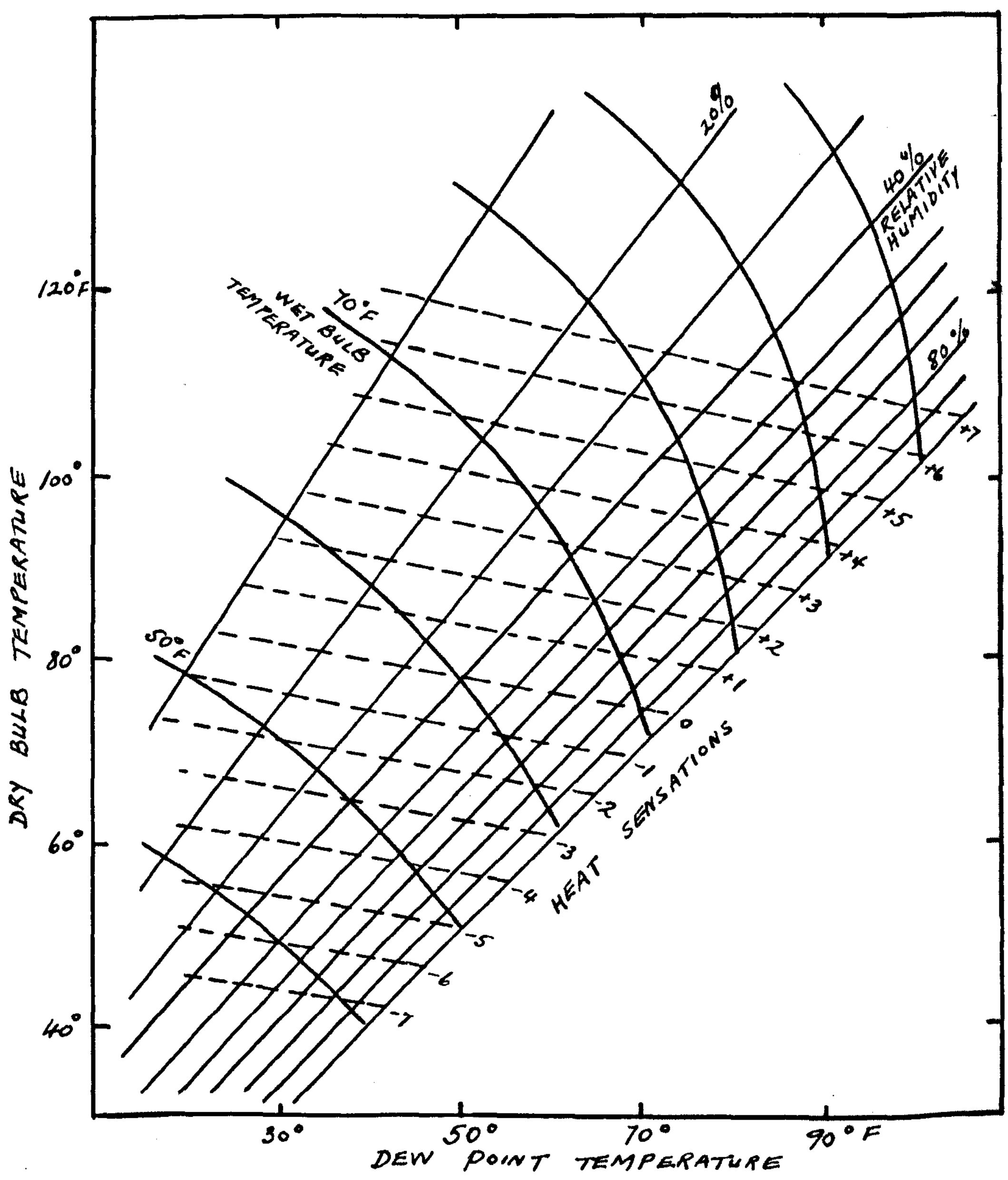


Chart I. Heat sensations in relation to dry-bulb, wet-bulb and dew point temperature, and to relative humidity.

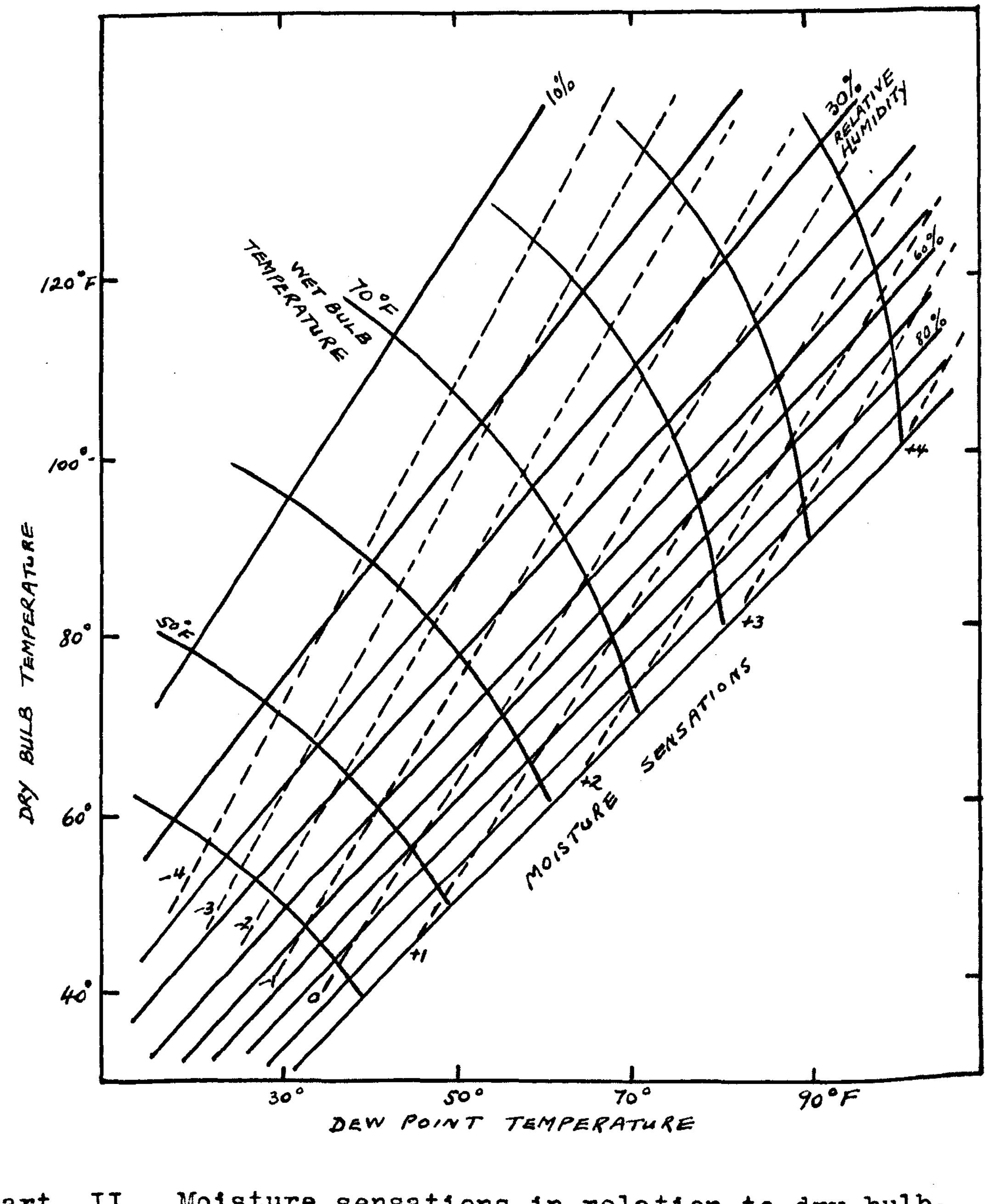


Chart II. Moisture sensations in relation to dry-bulb, wet-bulb and dew point temperature, and to relative humidity.

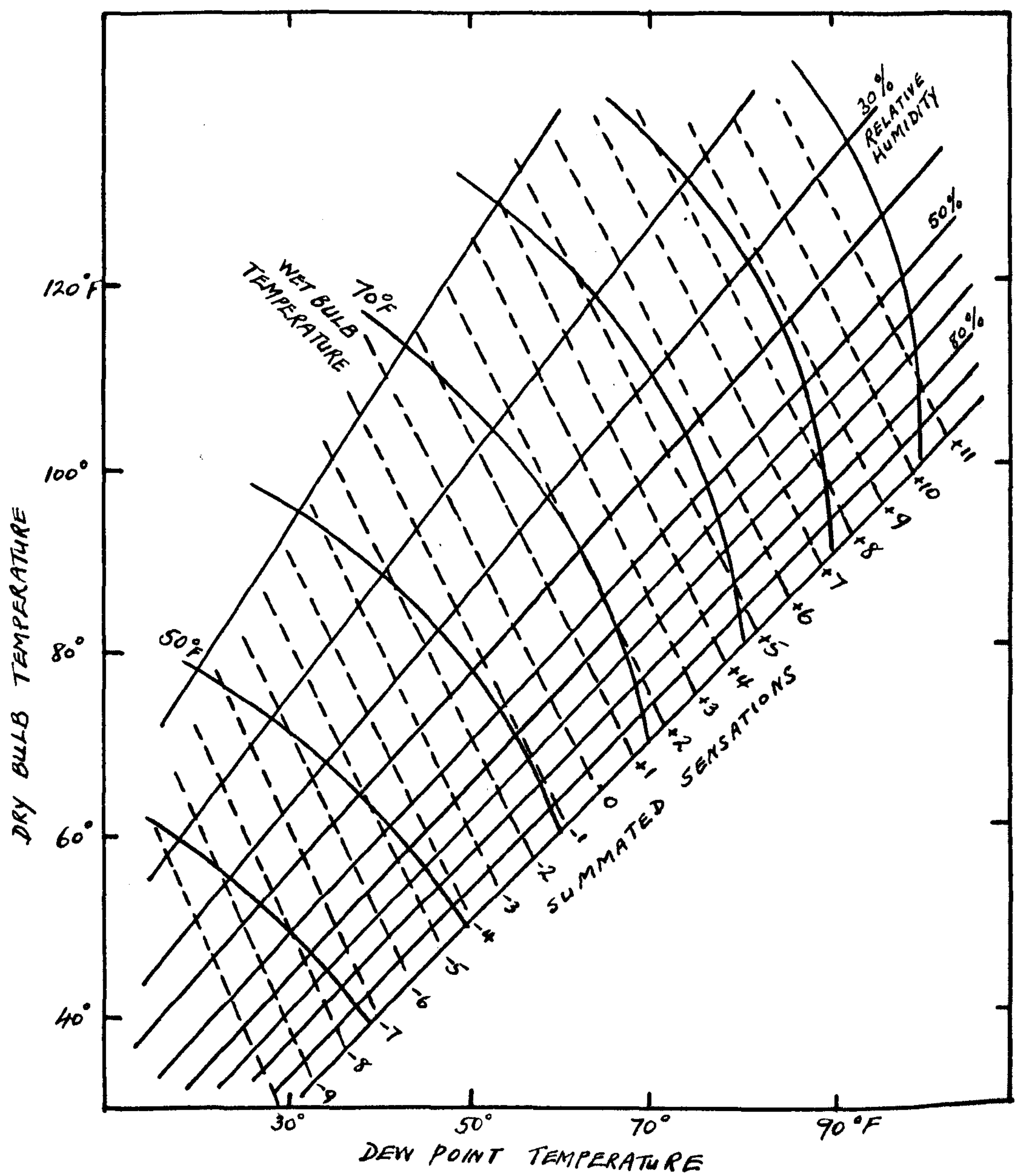


Chart III. Summated sensations of heat and moisture in relation to dry-bulb, wet-bulb and dew point temperature, and to relative humidity.

Abstract of Thesis. W.Y. Lee.

Sensations of Comfort and Physiological Reactions to Heat and Moisture on Change in Environment.

This study deals with the immediate and equilibrium reactions of the human subject to change in environment as may be experienced on entering or leaving air conditioned dwellings in the tropics.

Artificial outdoor and indoor climates were produced in air conditioned rooms and the effects of exposure to 62 different sets of conditions ranging in sensation from extremely hot and humid to comfortable were investigated. The physical characteristics of the environments varied between 71°- 104°F. dry bulb, 58°-95°F. wet bulb and 8-160 feet per minute air velocity. On each occasion determinations were made of relative and absolute humidity, dew point, vapour pressure, saturation deficiency, dry and wet kata cooling powers, evaporative cooling power, effective temperature, globe thermometer temperature, mean temperature of the surroundings and the sensible, latent and total heat of the air.

On entry and again after prolonged exposure to each environment records were made of subjective sensations of heat and moisture, skin temperature, sweating, systolic and diastolic blood pressure and pulse rate. These data

have been treated statistically and correlations between subjective sensations and many physical factors have been determined. Physiological reactions to change of environment were found to be more highly correlated with effective temperature than with dry bulb temperature. The equilibrium sensations of heat, of moisture and of the combination of both stand in highest correlation with the sensible heat, latent heat and total heat of the air respectively. The attainment of equilibrium, after changing from a lower to a higher temperature, was associated with a rise in skin temperature, an increase in pulse rate and recovery in systolic pressure.
The significance of the experimental findings is discussed from the point of view of comfort and standards of temperature and humidity for air conditioned rooms in relation to the outside climate.

LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE
(UNIVERSITY OF LONDON)
INCORPORATING THE ROSS INSTITUTE.

Telephone:
Museum 3041 (4 lines).
Telegrams:
Hygower, Westcent, London.

Keppel Street,
(Gower Street)
W.C.1.

1st June, 1938.

Dear Sir,

Owing to the present situation in China I regret that it has been impossible for me to obtain four complete sets of reprints of my previous conjoint publications, as detailed on the attached list, for submission to the University.

I have, however, one copy of each of my reprints numbered (1), (3), (4) and (5), and enclose these together with my Thesis.

Yours faithfully,

W. Y. Lee

The Academic Registrar,
University of London,
W.C.1.

CONJOINT PUBLICATIONS OF WEI YUNG LEE.

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(1) Shanghai Foods. Chinese Medical Association Special Report Series No. 8, (1937).

(2) Industrial Health in Shanghai, China. II. A Study of the Chromium Plating and Polishing Trade. Chinese Medical Association Special Report Series No. 6, (1936).

(3) Industrial Health in Shanghai, China. III. Shanghai Factory Diets Compared with those of Institutional Workers. Chinese Medical Association Special Report Series No. 7, (1936).

(4) The Effect of Light on the Production and Distribution of Ascorbic Acid in Germinated Soybeans. Journal of the Chinese Chemical Society, 4, 208, (1936).

(5) Distribution of Phosphorus in Germinating Soybeans. Chinese J. Physiology, 10, 661, (1936).

(6) Hydrolysis of Glycogen by Glycerol Extract of Muscle. J. Biol. Chem., 108, 525, (1935).

(7) Properties of Protein Films. Chinese J. Physiology, 6, 307, (1932).

(8) Biological Value of Mixed Proteins in Omnivorous and Vegetarian Diets. Chinese J. Physiology, 5, 163, (1931).

Subsidiary Paper No. 1.

Chinese Medical Association. Special Report Series No. 8

SHANGHAI FOODS

BERNARD E. READ, M.S., PH.D.
LEE WEI YUNG, M.S.
AND
CH'ENG JIH KUANG, B.S.

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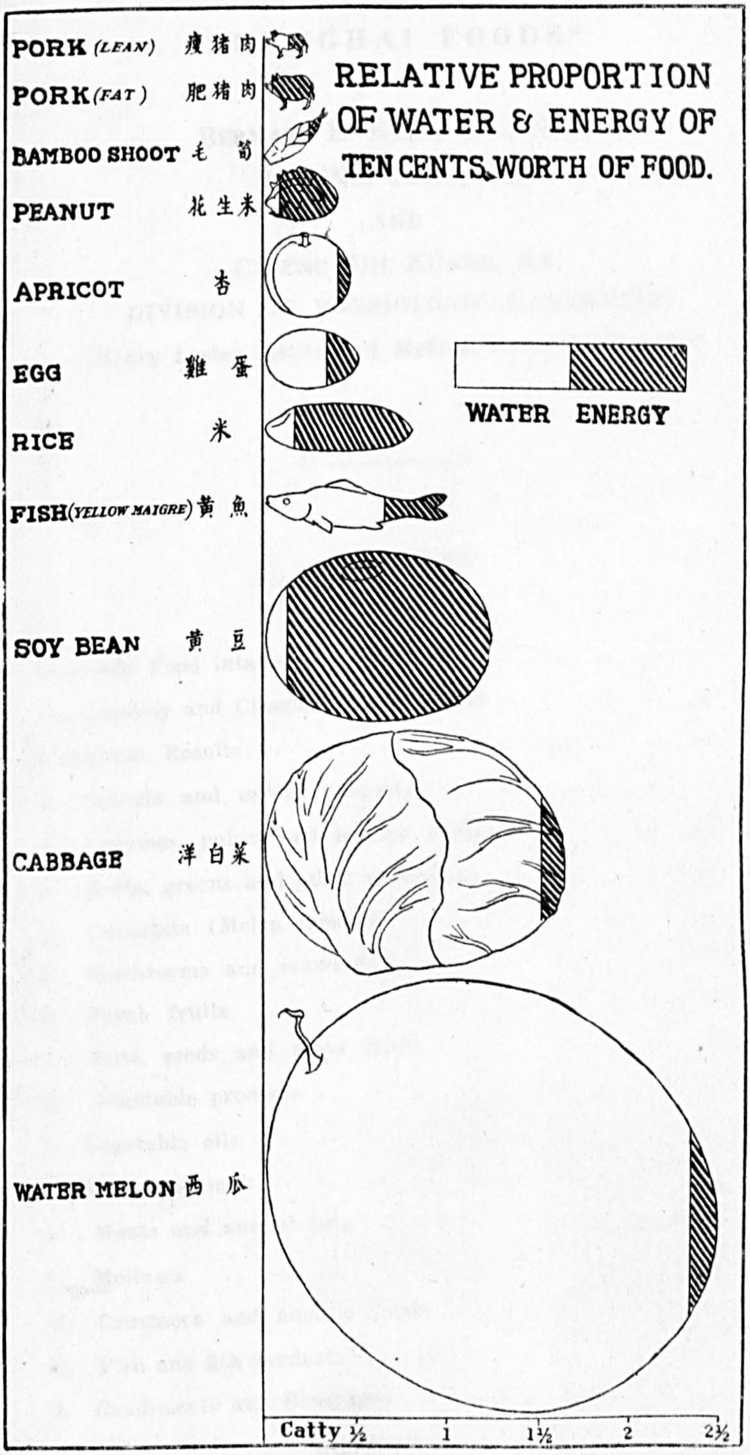

RELATIVE PROPORTION OF WATER & ENERGY OF TEN CENTS WORTH OF FOOD.
PORK (LEAN) 瘦猪肉
PORK (FAT) 肥猪肉
BAMBOO SHOOT 毛笋
PEANUT 花生米
APRICOT 杏
EGG 雞蛋
RICE 米
FISH (YELLOW MAIGRE) 黄魚
SOY BEAN 黄豆
CABBAGE 洋白菜
WATER MELON 西瓜
WATER
ENERGY
Catty ½ 1 1½ 2 2½

FIG. 1

SHANGHAI FOODS*

BERNARD E. READ, M.S., PH.D.
LEE WEI YUNG, M.S.
AND
CH'ENG JIH KUANG, B.S.
DIVISION OF PHYSIOLOGICAL SCIENCES
Henry Lester Institute of Medical Research, Shanghai

CONTENTS

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*Published February 1927.

TEN CENTS WORTH OF ENERGY.

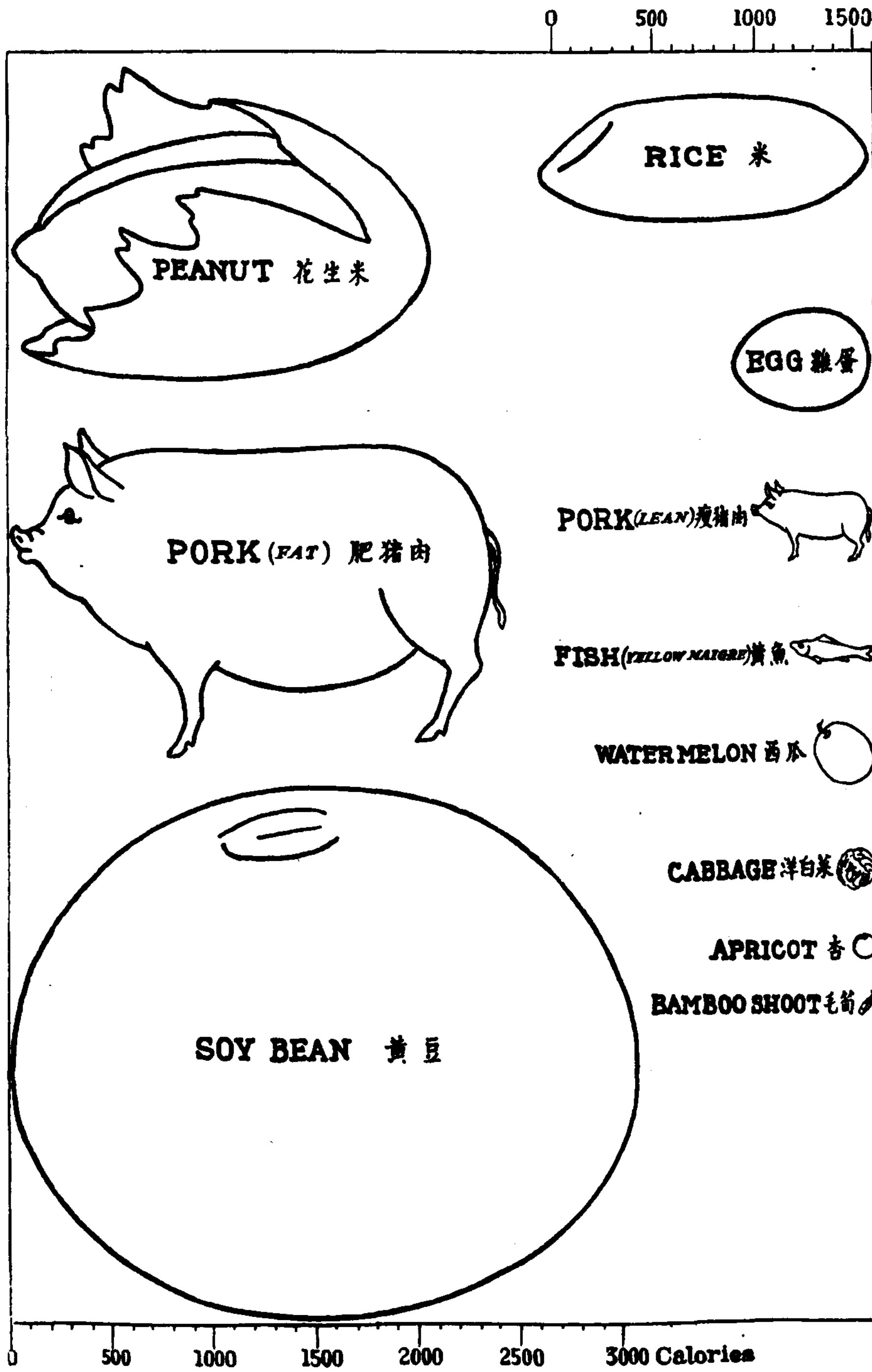

FIG. 2

SHANGHAI FOODS

Analyses of Shanghai foods have been made to ascertain their individual nutritive value and to provide the necessary data for the proper evaluation of the diets of various groups of Shanghai people, Read et al (1936), W. Y. Lee et al (1936). The incomplete or partially nutritive character of any one food is seen in the results reported, of which a satisfactory understanding can only be obtained by a study of such dietary principles as are known.

1. ADEQUATE FOOD INTAKES

The essentials of an adequate food intake can be summarized as follows:

(a) sufficient digestible material to yield the needed energy;

(b) protein adequate in quantity and quality;

(c) sufficient amounts and proportions of the inorganic salts;

(d) ample supplies of the vitamins;

(e) roughage (fibre).

a. Sufficient digestible material to yield the needed energy.

For the poorer classes information concerning the calorie value (energy) is of great importance. This is given in column 10 of our tables, and should be considered together with the figures given for the "edible portion" in column 4, and water content in column 5. Figure 1 shows the relative amount of food in catties (1 catty equals 600 grams) which can be purchased in Shanghai for ten cents, with the respective proportions of water and energy. Figure 2 shows the contrast between the energy value of some of the common foods. From these figures it is clearly seen that while the greatest amount of watermelon can be purchased for ten cents it is one of poorest providers of energy, and while peanuts by weight are far more expensive than cabbage or fish they provide greater energy for the same amount of money. The calorie values of 100 grams are calculated by multiplying the amounts of the protein and carbohydrate by 4.1, and the amount of fat by 9.3, and adding the products together. For rough practical work these factors are often taken as 4 and 9. Our analytical percentages are all based upon the edible portion, which in the case of meats is as the food is purchased, but vegetables and fruits prepared for the table show in some cases a great difference between the edible portion and the article as purchased.

The latest pronouncement regarding calorie requirement from the League of Nations (1936) is that, an adult, male or female, living an ordinary every day life in a temperate climate not engaged in manual work requires 2400 calories per day of energy available from the food actually assimilated. Light work, moderate and hard work, puberty, and nursing all require appropriate supplements to this figure.

This report deals with the nutritional values of food as analysed. The amount digested is a matter for further research. Such limited studies as have been made show that the amount ingested to provide energy may be considerably lower than the calorie value given. Wang (1936) has recently determined the coefficients of digestibility of the proximate principles of kaoliang which he found to be for protein, fat and carbohydrate 83.9, 92.3 and 99.5 respectively. Pian (1930) has shown the coefficient of digestibility of mung beans, peanuts and soy bean curd to be 86, 95 and 96 respectively.

In a mixed diet it is impossible to state without careful experimental evidence the exact degree of digestibility of any one foodstuff, because the proportions used influence the results. According to Mitchell (1924) the coefficient of digestibility of soybean protein at a level of 5 percent is 91, and at 15 percent only 84. In comparative studies upon fresh cow's milk and soybean milk Adolph and Wang (1934) found their digestibilities to be 86.6 and 84.9 respectively. McCay (1912) in studying the bulky rice diets of the Indian showed that consumption of 766 grams of rice a day lowered the coefficient of digestibility of the protein to 52 percent.

Digestibility is favorably influenced by cooking. In the absence of experimental data we are unable to state in this report anything more than is already known upon this subject. Sugimoto and his coworkers (1926) undertook a large series of experiments upon rice to show the effects of different methods of cooking, the differences were not so striking as to be of great practical value. Adolph and Tsui (1935) made a comparison of the Chinese method of steaming bread and the Occidental method of baking and obtained identical results with an apparent digestibility of 91 percent.

b. Protein adequate in quantity and quality.

It has been pointed out that in the bulky carbohydrate diets of the Chinese worker the quantity of protein is inadequate, W. Y. Lee et al (1936). The intake should not fall below 1 gram of protein per kilogram of body weight, and it should be from a variety of sources, League of Nations (1936).

A study of the various oriental food proteins as made by Suzuki, Matsuyama and Hashimoto (1926) showed that their relative nutritive value may differ considerably. Even when the coefficient of digestibility is relatively high the amount retained to promote growth and maintain the normal functions of the body may not be so good. This so called "biological value" of protein has been studied in China. Pian (1930) found mung bean, peanut and bean curd to have values of 58, 59 and 65 percent retained respectively. Li (1930) reported 77, 64, 57 and 56 for a level of ten percent intake of rice, barley, millet and kaoliang, showing that the proteins of rice and barley are superior to millet and kaoling, the latter being comparable to white flour (wheat), which according to Mitchell (1924) has a value of 52. Egg white yielded a value of 88 percent. Tso (1927) concluded from growth experiments with rats that the Chinese mung bean given as 18 per cent of the ration provided enough biologically complete protein.

Using both the chemical method of estimating the biological value and the effect upon growth in animals Adolph and Cheng (1935) found that the proteins of mixtures of five common cereals all gave evidence of supplementary relationships with higher biological values than any of the single cereals involved. The highest value was from a mixture of maize, millet and soybean.

Hence it is clear that protein requirement is something far more than a simple statement of so many grams a day.

c. Sufficient amounts and proportions of the inorganic salts.

The Technical Commission of the Health Committee of the League of Nations (1936) recognises the fact that the deficiencies of modern diets are usually in the "protective foods" (foods rich in minerals and vitamins). Our foods were all analysed for the three elements most liable to be deficient, namely calcium, phosphorus and iron, for which the League of Nations standard per day intake is 9.7, 18.9 and 0.21 milligrams per kilogram of body weight respectively. The ratio of the calcium to the phosphorus should be as given, namely 0.515, (about one to two).

Other elements in mineral metabolism may be of importance. Copper plays some part in blood formation. Adolph and Chou (1933) found the legumes and leafy vegetables relatively high in copper, also sesame seeds and aroid. Pork and pig's liver were the highest.

Iodine is a very important element in the food. Adolph and Ch'en (1930) showed that the food and water supplies in goiter areas in North China were deficient in iodine content. Later Adolph and Whang (1932) analysed the marine foods of the Shanghai-Soochow area and found them all rich in iodine. Cabbage in this area contained a considerable amount and turnips and rice showed much higher values than in the North.

Potassium, sodium, magnesium, chlorine and sulphur all need to be studied. Manganese and zinc exist in the body though little is known about their significance or the part they play in nutrition. The deleterious effect of the fluorine content of some Chinese food materials was reported on by Reid (1936).

d. Ample supplies of the vitamins.

The standard intake required for the various vitamins in international units for the European are A—4200, B1—300, C—500 to 600, D—1000 to 2000 units.

Eggs, liver and green vegetables are rich in vitamin A. Some legumes are good sources, also red peppers. This vitamin is quite low in some of the poorer diets studied, which should be improved by the addition of the richer foods. It is fat soluble, but lard is singularly lacking in this vitamin.

It is important that the diet be properly balanced in regard to vitamin B. The standard figure given is relative to the amount of protein fat and carbohydrate in the diet, which is proportional to the body weight of the individual. Unpolished rice yields an ample supply.

Vitamin C has an exact chemical entity. 500 international units equals 25 milligrams of ascorbic acid, roughly the amount contained in one orange.

The vitamin D content of many foods varies according to their activation by sunlight. Vitamin D is fat soluble. Foods low in fat are usually very poor, and lard is notably so. When the individual is confined indoors all day out of the sunlight it is vital that foods rich in this vitamin be provided.

e. Roughage.

Whilst the indigestible fibre in food is a waste product, it makes the necessary roughage for the promotion of peristalsis in the alimentary canal and should be provided for in the foods chosen as a natural means for keeping the system free from constipation. The amount required varies with the individual, modern diets tend to have too small an amount. Unmilled cereals and wheat bran are good sources. Wan (1935) has shown that wheat bran rich in protein, minerals and vitamins can be actually utilized to the extent of 15 per cent in place of the more refined cereal in an ordinary vegetarian diet.

This summary cannot be concluded without reference to the relative value of vegetarian and omniverous diets particularly as they are related to the protein contents of foods.

Wu and Wu (1928), Wu and Chen (1929), Wan and Wu (1932) &c have shown that rats born of vegetarian parents are smaller than stock rats at all ages, although they show no deficiency disease. Wan and Lee (1931) demonstrated the superiority of the mixed proteins in omniverous diets to those in a strictly vegetarian diet.

Putting aside the arguments and sentiments of a strict vegetarian, it seems most probable that the nutrition of the poorer classes would be greatly benefitted by diary products. Milk, butter, cheese and meat are sources of some of the most valuable essentials, which are only too often deficient in the diets studied. The economic aspect of this subject has been presented by Lin (1931), who states that the vegetarian nature of Chinese diets is not decided by a preference for vegetarianism *per se* but by economic considerations.

The principles discussed are more important than any absolute standards that can be laid down. In maturity simple maintainance is not as static as might appear, there are seasonal factors to be considered. Growth, reproduction, lactation, old age and conditions of disease all call for special allowances in nutrition, some of which are at present quite beyond the bounds of computation, but it is important that there be present liberal supplies of the essentials indicated.

2. THE IDENTITY AND CLASSIFICATION OF FOODS

With our present limited knowledge the exact identification and satisfactory classification of Chinese foods is not easy. The botany of the citrus fruits, the brassicas, bamboos, fungi &c is either not worked out or is appallingly confused. In such a vast country the varying colloquial names add to the confusion. In our tables on the extreme right there is given the Shanghai name with Wade's romanisation. On the left page there is the English name and the most reliable scientific description we can find, taken largely from "Chinese Medicinal Plants" by Read (1936), and the Zoological dictionary of the Commercial Press. Hsu's "Common food fishes of Shanghai" has also been used, and Watson's "Articles of Chinese commerce" is a good supplementary reference for some materials.

It is impossible to make a classification of foods according to the nutritional essentials without a great deal of unnecessary duplication. Hence adapting existing systems we have arranged our results in the following groups:—

A. Cereals and cereal products.
B. Legumes, pulses and legume products.
C. Roots, greens and other vegetables.
D. Cucurbits. (Melon family)
E. Mushrooms and seaweeds.
F. Fresh fruits.
G. Nuts, seeds and dried fruits.
H. Vegetables products.

I. Vegetable oils.
J. Eggs and milk.
K. Meats and animal fats.
L. Molluscs.
M. Crustacea and aquatic foods.
N. Fish and fish products.
O. Condiments and beverages.

Within each section the foods are arranged alphabetically according to the English name, with a number for reference purposes.

3. ANALYTICAL RESULTS

The analyses were all made upon samples of food purchased in the Shanghai markets, used by the various factories and institutions in which our dietary surveys were made. Identical procedures were adopted for the separation of the edible portion from the waste and record made of the same. The analytical figures all refer to the edible portion, from which calculation can be readily made for the composition of the crude article as purchased.

The method of sampling should be recognised as a random one, in which the variations of results cannot be seen in the one set of analytical figures given for each foodstuff, but in computing a mixed diet gross error is negligible. Rice being so important has numerous analyses presented. To make an exact nutritional study analyses of each food should continue over many years, to find the effects of varying climate, differing soils and fertilizers, methods of cultivation, harvesting, storage and any special treatment to which the food is subjected such as grading, milling, refining, salting, pickling, and so forth. Any or all of these factors may affect the water and salt content or may remove the vitamins.

All the analyses were made according to the methods of the "Association of Official Agricultural Chemists" (1930), expressed as percentages of the edible portion. The figures for carbohydrate were calculated from the difference between the total solid matter and the sum of the protein, fat, fibre and ash.

The calorie values were obtained from the sum of the percentages of protein and carbohydrate multipled by 4.1 plus the percentage of fat multiplied by 9.3, the result being large calories per 100 grams of food material. For the rapid estimation of these values in every day units Adolph and Hsu (1925) have prepared lists of Chinese foods in measures of the common rice bowl and the common Chinaware spoon. Their figures are rough approximations useful to hospitals and institutional kitchen management.

A. CEREALS AND CEREAL PRODUCTS

WHITE RICE as eaten by the majority of people consists of the husked and polished grain from *Oryza sativa*, L., of which there are countless varieties. Beside great botanical variation there are differences found in methods of local cultivation, and soil which make considerable variation in price and popular esteem, so that Chinese place names more often than not accompany the product. Usually the length of the grain is fully three times it greatest breadth. Early crops with quick maturing usually have a short grain of inferior commercial value. So called high grade or first class rice is a large white grain which has been heavily milled. A smaller sized grain is sold as second class rice, and broken grain as third class. One hundred catties of Chinese paddy (the unhulled rice as gathered called *keng* 稉) are said to yield about seventy catties of the hulled and polished article termed *mi* 米. Glutinous rice known as *no mi* 糯米 or *nien mi* 粘米 is used for making dumplings and sweetmeats, and for the preparation of rice wine. The hulls are called *k'ang* 糠; the cooked rice *fan* 飯; rice congee *chou* 粥; rice bran, the inner skin, *mi p'i tzu* 米皮子 or *hsi k'ang* 細糠.

Sheets and Semple (1931) give the following account of foreign milling processes:—

"Threshed rice is known as rough rice. The rice kernel is inclosed in a hard hull with small ridges, on the crests of which are sharp, toothlike projections. Directly beneath the hull, but separate from it and attached firmly to the starchy body of the kernel itself, is a light-brown seed coat in which seven distinct layers may be seen with a microscope. The germ, or embryo, is distinctly visible at one end of the kernel. In milling rice first the hull and then the germ and all the layers of bran are removed except a part of the last layer. There is left only the starchy part of the kernel surrounded by a part of the last seed-coat layer, which is very rich in protein. Only about 10 per cent of the protein of the rice kernel is removed by milling. However, about 85 per cent of the oil content of the kernel is removed, since most of the oil is contained in the germ and the germs go into the bran. Rice bran is a light-brown, fine, flaky material.

The rice is practically white by the time the bran is removed, although it is rather rough. Therefore, it is treated in revolving cylinders, padded with leather, which makes it smooth by removing what is known as rice polish, a fine, light-brown, flourlike material. The very small pieces of broken grains that are removed in the milling operation are called brewers' rice.

In milling a large sample of No. 1 Blue Rose rice, which is intermediate in grain size between the short grain of the Japan type and the long grain of the Fortuna variety, the percentages of first-grade rice and the various rice by-products obtained were as follows:

	Per cent
Milled (Head rice)	57
Rice hulls	19
Second head milled rice	8
Rice bran	8
Rice polish	3
Brewers' rice	2
Rice screenings	1

Dirt and shrinkage amounted to about 2 per cent. Other kinds of rice vary in milling chiefly in the quantities of head rice, brewers' rice, and screenings produced."

Percentage composition of rough rice and rice by-products.

	Moisture.	Ash	Protein	Fiber	Carbohydrate	Fat
Rough rice	9.8	5.4	7.3	8.6	66.9	2.0
Rice hulls	7.9	19.5	2.7	41.3	27.8	0.8
Rice bran	9.6	10.0	13.8	11.3	40.5	14.8
Rice polish	9.4	5.0	12.1	2.1	61.7	9.7

In Shanghai imported rice is husked and polished by large local mills and graded. The larger mills have special machines for husking, for milling or whitening by removing the cuticle, grading, polishing and facing. Local crops may be dealt with by a district mill or may be lightly milled by the individual in which case it is "undermilled." This creates great differences in the degree of polishing. As in the case of wheat the richest source of vitamin Bl is in the germ of rice, which is removed in the bran during milling. As seen from the analyses *whole* rice (hulled and unpolished) is recommended on account of its definitely superior content of vitamins, salts and protein. A study of the protein content is a scientific basis for the selection of a good grade rice. Wilson (1920) found one variety in Peking contained over ten percent. The higher protein contents of Suchow and Kiangsi rices are in their favour. There is a striking difference in the higher ash content of the two pointed grains A 13 and A 18, which look as though the ends of the grains escaped milling.

Gray (1928) in his work upon Japanese foods points out that polished rice which has not been washed retains some polishing powder yielding higher values for lime and iron than for unpolished rice. We did not wash our samples, for our analyses deal with the raw uncooked materials. Further work is needed to show losses by cooking. While steamed rice is more elegant, in Shanghai people usually boil the grain and heat to relative dryness thus retaining all the salts. Gray states that after washing polished rice in Japan contains an average of 0.004 CaO and 0.0015 Fe_2O_3 percent. These figures are about 25 percent less than for unpolished rice in Japan, in Shanghai rice is far richer in these compounds.

From our analyses and a study of other publications one concludes that Chinese rice prepared in the small country disricts is "undermilled." The mortar and pestle polishing by hand described by Shih is not likely to remove all the cuticle. The influence of various stages of milling and storage upon the vitamin Bl value of rice has been studied by Kessler (1927). Unhusked rice retains its vitamin even when three years old, but undermilled rice deteriorates after some months.

The Far Eastern Association of Tropical Medicine on various occasions have urged the governments concerned to take action to discourage the use of polished rice, legislative and educational measures were put forward by Chun and Wu in 1926. They urged the provision of undermilled rice for all public institutions and educational measures by means of extensive and persistent propaganda by the medical profession, public health authorities and the government.

MILLET even when steamed, dried and roasted has been found by Abe (1928) to have an adequate content of vitamin B_1. While the millets are not used extensively in Central China, their addition to a white rice diet has considerable advantage not only on account of the vitamin present, the proteins have been found by Kondo (1926) to be of great nutritive value, very favourable for growth.

The term millet is applied to a wide range of cereals with great botanical differences and the identity of the materials upon which work has been done is not always clear. Langworthy and Holmes studied the protein of common millet (also termed spiked millet or italian millet) *Setaria italica, B. vel. K.* and calculated a digestibility coefficient of only 35.8 percent, and for glutinous millet (also termed proso, glutinous panicled millet) *Panicum miliaceum, L. var. glutinosa* 41.2 percent. Adolph and Wang (1934) studied *hsiao mi* 小米 which is the short millet, *Seteria italica, Kth. var. germanica, Trin.* (also termed German millet or fortail) and found a digestibility of 74.4 percent compared under the same conditions with wheat showing a coefficient of 88 percent.

WHEAT bread made from white flour suffers from the same defects as polished rice. It not only loses the more valuable protein and vitamin in the germ and pericarp, the remaining 11 percent of protein does not suffice to promote growth. This can be compensated for by the addition of one third of either milk, egg or meat protein. As pointed out by Suzuki (1926), it is better to feed wheat bran to domestic animals and use the milk and meat from them for human food. Whole meal bread has been widely advocated in the West, it is a matter of discussion whether this is not overdone, too much roughage disturbs the alimentary canal.

Reference has already been made in the introduction to Adolph and Tsui's work on the digestibility of wheat bread, 91 percent, while the amount actually retained to promote growth and maintain the normal body functions is according to Mitchell only 52 percent.

MAIZE (Corn). It is well known that the protein of maize is deficient in quality, but it has been shown that a mixed diet increases in many cases the biological value of the individual proteins. Chen (1935) found that a maize diet supplemented with casein from milk greatly prolonged the average life span of rats, as compared with a simple diet of maize protein. The same was not true for soybean protein except when it was given in alternate periods, one day on soybean cake protein and two days on a maize protein diet. This supports the general recommendation that diets should be mixed and varied. The greater nutritional value of mixed diets is further shown by the work of Wang et al (1935) on green vegetables and eggs as supplements to a cereal diet.

B. LEGUMES, PULSES AND LEGUME PRODUCTS

SOYBEAN. The superior value of the soybean has been proven by numerous studies as summarized by Horvath (1929). Osborne and Mendel (1917) in their original studies concluded that its protein reacted like animal protein. There is considerable doubt as to whether it can actually replace animal protein as originally thought. Lan (1936) working with mixtures of corn, millet, wheat, wheat gluten and soybeans or soybean curd did not get as good results as when diets containing milk powder or beef were used. Wan (1932) showed that dried soybeans contain three times as much vitamin B_1. as dried milk powder, and two thirds as much B_2. Adolph and Kao (1932) found that the iron and copper contents in soybeans, bean curd and bean milk were appreciable and such as to give good hemoglobin formation and were well fortified in the anemia-preventing principle, definitely superior to cow's milk; though as an antirachitic it is inferior, Chen and Adolph (1932).

Mao tou is the fresh bean separated from the green immature pods. Much information is available regarding the nutritive value of dry soybeans and products made from them, whereas the fresh green bean has been little studied. Miller (1934) made a thorough examination with analytical results similar to ours, also vitamin assays. Compared with most green vegetables it is unusually rich in good protein, fat, calcium, iron and phosphorus, and is a very good source of vitamins A, B and G. Muramatsu (1924) found 2.6 to 4.8 percent of starch in the green bean, but there was little or none present in the ordinary dry bean. The nitrogen free extract is made up of many things, pentosans, galactans, and celluloses, not all of which are utilizable carbohydrate. Very carefully controlled experiments by Adolph and Kao (1934) indicate that about 40 per cent of soy bean carbohydrate is utilized by the animal body. On account of its low sugar content soybean flour has been recommended in diabetic diets.

There are already recognised 280 varieties of *Glycine hispida*, distinguished chiefly by the colour of the seeds; the black, white and yellow are more commonly used especially the latter as a food. The fact that the Manchurian crop alone annually exceeds four million tons gives some indication of its place as a food in the Orient. The nutritive values of the various products have been studied by Adolph and Kiang (1920). Their northern preparation of BEAN CURD with salt bittern yields a decidedly higher content of protein. We agree with their suggestion that the manufacture of bean curd and other bean products might be standardized in a manner similar to the milk and cream industry in the West. The coagulant or mixture of coagulants used be such as will add to bean curd exactly those inorganic constituents of physiological value which in the bean are deficient or not in the right proportion.

As pointed out by Adolph and Kiang (1920) the analyses of the ash of BEAN CURD are important. In the bean there is far too little calcium in proportion to the magnesium present, too little sodium relative to the large content of potassium, and too little chlorine. These ratios are all improved in soybean curd made with salt bittern lu 滷, thus adding considerably to its nutritive value. Even so Suzuki (1926) produced better growth by the addition of lime salts. There are four common methods of manufacture of bean curd, that produced by coagulation of the milk with gypsum is probably the best known producing a finer coagulum than the others. It has been studied by Adolph and Wu (1920) in Shantung where it is known as *nan tou fu* 南豆腐. Their material is fairly rich in calcium, but their phosphate is higher and the potassium is much lower than in ours.

COMPARATIVE ANALYSES OF ASH OF SOYBEAN AND CURD

Percentages of dry material

Salts	SOY BEAN Osborne & Mendel	SOY BEAN Our results Shanghai	BEAN CURD Adolph & Kiang	BEAN CURD Adolph and Wu	BEAN CURD Shanghai
CaO	0.25	0.29	0.57	1.90	3.01
MgO	0.50	—	0.60	0.62	—
K_2O	2.48	2.26	0.71	0.30	1.75
Na_2O	0.19	—	0.33	0.03	—
P_2O_5	1.88	1.58	0.70	2.28	1.78
Cl	0.005	—	0.38	0.01	—
Fe	—	0.011	0.01	0.01	0.017

SOYBEAN MILK is prepared simply by grinding up soybeans with water and straining the product. It has the same appearance as cow's milk. Tso (1928) (1929) (1931) has worked extensively upon this product as a vegetable substitute for cow's milk in the feeding of infants. Chang and Tso (1931) prepared for the first time a soluble soybean milk powder with properties similar to cow's milk powder. Made up in water with the addition of lime and salt supplemented with cod liver oil and cabbage water to provide vitamins D and C, a test feed on one infant for a period of 84 days they reported as completely successful. Reid (1934) (1935) has prepared a milk powder from soybean and egg yolk of high nutritive value practically free from any beany smell or taste. Miller (1936) has worked extensively with this preparation in human nutrition.

SOYBEAN SPROUTS have been found by Lee (1936) to contain a good amount of vitamin C, which has also been demonstrated for other germinated legumes such as the pea, Lee (1926), and mung bean, Millar and Hair (1928,) the dry beans being a poor source of this vitamin.

Chen, (1930) has studied the properties of the FLAT BEAN and found that even when fed at a level of 55 to 60 percent of the diet it does not promote normal growth. Compared with a well balanced diet the quality of the protein is low, it is deficient in minerals, and low in vitamin A and vitamin B complex.

Tso (1927) studied the MUNG BEAN, and while he found the proteins biologically complete, stated that it was deficient in lime and sodium chloride, it was rich in vitamin B and had a moderate amount of vitamin A. Heller (1927) found the protein superior to that of many members of the bean family though it was deficient in cystine. Its vitamin A content was more adequate than in most cereals. Ordinary light cooking improved the utilization of the protein. Sherman (1929) found that while mung beans gave normal growth to white mice, fertility and survival of the offspring was poor, this was best supplemented by small amounts of peanut, gelatin or casein. Kim (1928) has shown that by germination, the sprouted mung bean develops a high content of vitamins B and C. This confirms the general finding of Fürst (1912) and Chick and Delf (1919) that whereas dry cereals, and pulses do not prevent scurvy, they acquire anti-scorbutic properties when allowed to germinate.

Mottled gram 黑小豆, a variety of MUNG BEAN has been studied by Lo (1934). Its protein is not biologically complete. When used as the sole source of protein food it is incapable of supporting normal growth, but it is decidedly rich in vitamin A, it is a good source of the vitamin B complex, has a moderate amount of vitamin D, and no significant amount of vitamin C. It resembles other legumes in being deficient in sodium and chlorine, and its utilizable phosphorus is low. Whilst its protein is incomplete Lo (1935) has shown that it has a remarkable supplementary relation to the protein of panicled millet (黄米) both glutinous and non-glutinous, there is also a small supplementary value to yellow corn, but it fails to supplement oats or red kaoliang.

The COWPEA, *Vigna sinensis*, has been studied by Adolph and Chiang (1935). They isolated five proteins, of which glutelin has a high content of cystine, and the albumin and two globulins are high in lysine. The Indian workers Niyogi, Narayana and Desai (1931) have isolated and analysed the total protein for which they record a biological value of 72, fed at a ten percent intake level, a value which ranks it rather high among legume proteins. Other studies in China upon the nutritive value of legume proteins in mixed diets have been referred to in the introduction.

C. ROOTS, GREENS AND OTHER VEGETABLES

This class might be divided into roots and leafy vegetables. The roots and tubers as natural reservoirs of food for the plant show much higher energy values though only about one quarter that of cereals or seeds. However vegetables are considered as a whole on account of their being rich sources of mineral salts and vitamins, and their comparative value should be judged largely from that standpoint. Green and red AMARANTH, BEET TOPS, and SHEPHERD'S PURSE are particularly recommended for their high ash and good calcium and iron values. Red amaranth is richer than spinach in lime and iron, and the green species not only excels in lime, it is unusually rich in vitamin C and probably vitamin A. It is unfortunate that the market season for this vegetable is short, it is worthy of wider cultivation, and possibly salting down with rice bran.

Young ALFALFA, known in Britain as lucerne, is used for human food when the first tender leaves appear. The full grown tall plant has been used in China as a horse food since the days of Chang Ch'ien (B.C. 96) when it was brought with the Arabian horses to old Peking from the West. It has a high content of vegetable protein and its salts and vitamin content rate it as an unusually high class vegetable.

The BRASSICAS, cabbages, colza, cauliflower, kohlrabi, mustard and turnip, have each their particular value. Owing to the excellent botanical work of Bailey the identity of this group has been greatly clarified. It is unfortunate that colloquial names vary so much that there is still much confusion in proper identification.

Wu and Wu (1928) in their growth experiments with vegetarian diets concluded that the superior dietary quality of SMALL CABBAGE, COLZA, KOHLRABI and KAI T'SAI, suggests their utilization in human nutrition.

SMALL CABBAGE has a good content of lime, and according to various reports from foreign sources *Brassica chinensis* contains all the known vitamins. It is probable that these reports in some cases refer to *Ta pai ts'ai* C21, which is correctly termed *B. pekinensis*, Rupr. often called Chinese, Peking or Shantung cabbage. COLZA is often erroneously called rape, which is nonexistant in China, its salts and vitamins are good. MUSTARD leaves are also rich in vitamins. The FLAT

CABBAGE is a good source of lime, though Chen (1936) by feeding experiments finds that it has only about one fifth as much vitamin C as Peking cabbage.

Analyses of the mineral salt content of leafy vegetables by Hsu and Adolph (1935) and by Wang (1936) show that the lamina of the outer leaf is far richer in lime and iron than the leaf stalk or heart leaves, while phosphorus is most abundant in the inner leaves. Generally speaking the vegetables are richer in the inorganic elements in spring than in autumn.

For sources of vitamin A one usually turns to the more highly coloured vegetables such as RED PEPPERS, CARROTS and SPINACH. Even when dried, peppers retain their vitamin A potency though the vitamin C is very greatly reduced, Hou (1935).

SALTED or pickled VEGETABLES are part of the daily dietary of northern people in China. Certain facts associated with the method of salting have an important bearing on their nutritional value. Miller and Abel (1933) have shown that salting Chinese cabbage with and without rice bran profoundly affects the vitamin B_1 content of the product. Chen (1936) tested TURNIP, MUSTARD LEAVES and PEKING CABBAGE after salting in strong brine and after salting in a rice-bran and salt paste. The vitamin B_1 in all three was destroyed by salting in brine for 3 days. When treated with rice bran and salt paste the turnip and cabbage were found to be about 50 percent more potent than the fresh vegetable with reference to their vitamin B_1 content, and mustard was found to have retained all of the potency of the fresh leaf.

Our knowledge of the vitamin C content of Chinese vegetables is more extensive than that of any other of the vitamins. The rapid chemical mehod of assay has enabled workers in different parts of the country to examine their local foodstuffs. Their results are at least a qualitative index of the presence of this vitamin. From a biological standpoint there are several things to be considered. The vitamin may be shown chemically to be present yet for some reason not be very active biologically. Hou (1936 a) has shown that AMARANTH one of the richest sources of vitamin C is not utilized fully by the organism. Again the vitamin often occurs in reduced form and is not detected by direct chemical titration. Prolonged boiling destroys this vitamin but light cooking, as usually undertaken in the Chinese kitchen, in some cases is known to liberate vitamin many times greater in amount than is found free in the raw vegetable. Hence an exact estimation of the vitamin activity is best made by biological assay upon the cooked material. Very little work has been done with the cooked material Hou (1936 c), but exact biological assays with raw foods have been undertaken by Chen (1936), Hou, Embrey, Tso and others cited in the literature upon vitamins. Hou (1936 b) has studied the market and seasonal variations of this vitamin in AMARANTH, ALFALFA, and CHILLIES.

Comparisons have often been made between the ordinary WHITE POTATO and the SWEET POTATO. Though of remotely different botanical origins they have much in common with regard to food value, somewhat in favour of the latter, although the white potato is richer in protein. The sweet potato is lower in salts but its vitamin content is decidedly superior. There are a number of different sweet potatoes and yams in China. Peck (1924) tested the Shanghai variety and found it moderately rich in vitamin C even after baking in the ordinary way. Storage of sweet potatoes over a period of 2 months was found to increase considerably the vitamin A content. Prolonged storage rapidly caused deterioration.

D. THE CUCURBITS (MELON FAMILY)

The melon family is classed separately for various reasons. Some are regarded as vegetables *t'sai kua* 菜瓜 and other as fruits *kuo kua* 果瓜. They all have a very high water content with small energy value, low salt content but of considerable value as sources of vitamins. From the figures given for the percentage of edible portion it is seen that CUCUMBERS are the only ones eaten with the skin on. It is cut up and cooked in the meat dishes.

The CALABASH is the pear shaped or double bellied bottle shaped gourd to which numerous colloquial names apply. It is probaby grown more for it service as a water ladle than for its value as a food. Its various Chinese names often apply to the pumpkin.

The T'IEN KUA shows great variety in size, shape, colour and texture. The skin varies from bright yellow to dark green, sometimes striped in green and yellow. Some are mealy like an overripe melon and others firm like a cucumber. All have more or less an aromatic flavour and fragrance, hence are often called 香瓜 *hsiang kua,* though this name also applies to musk-melon.

The BITTER GOURD when ripe has a yellow skin under which is a bright red sweet pulp full of seeds. The dried fruit is an article of commerce. The *Tung kua* is the large WHITE GOURD of India widely cultivated in China. On account of its waxy skin it is often referred to as the wax or tallow gourd. The LOOFAH is over one inch in diameter, from one to four feet long, deep green in colour and mottled, and as a fresh vegetable is stewed or baked. Its fibrous structure makes it when old useful as a vegetable sponge.

The SQUASH when cooked is compared by the Chinese with the sweet potato. It is especially esteemed when cooked with pork but it is considered to be deleterious prepared with mutton. The latter idea may be due to the supposed value of the squash in benefitting fertility in women, while mutton is said to have male aphrodisiac properties. Baking does not lessen its vitamin A activity to any extent.

The WATERMELON is most extensively grown in China, and being very juicy is eaten as a cooling fruit in summer. Several varieties are known; some having red pulp, some yellow, some white. The seeds are of varying colours; black, red, brown and white. The black seeded red pulp variety is usually the finest flavoured. The seeds *kua tzu* are eaten extensively after salting and drying.

The watermelon is low in salts and energy value. Work by Munsell (1930) shows it to be a fair source of vitamin A, a poor source of vitamins B and G, and a fair to good source of vitamin C. The cucurbits in Western countries have in some cases been found to be good sources of vitamin G. Lo (1935) reports CUCUMBER as a good source of this vitamin and the *wo kua* PUMPKIN as moderately so, but MUSKMELON *hsiang kua* is quite low or totally deficient.

E. MUSHROOMS AND SEAWEEDS

The percentage composition of this whole group of foodstuffs does not give a true indication of their nutritive value, inasmuch as the material reported as carbohydrate is not starch nor any of the common sugars in food, nor are the figures given for protein anything more than the nitrogen analyses multiplied by 6.25, and should not be regarded as having high nutritive value.

This particularly applies to AGAR which consists mainly of the hemicellulose "gelose" which gelatinizes with water to make jelly-like food. The bulk of it is undigested, it imbibes water and acts as a mild colloid laxative, only 8 to 27 percent is utilized in man.

Fa ts'ai E10 as the Chinese name implies occurs in dark tangled masses resembling horsehair. Treated with boiling water it forms a gelatinous mass used as a thickening medium in various culinary preparations, such as are made with shrimps. The protein value is good but it contains no sugar or starch. The same applies to the other seaweeds.

CHINESE SEAWEEDS were found by Read and How (1927) to be rich sources of calcium, iron and iodine. A more intensive study of the iodine contents has been undertaken by Tang and Whang (1935) showing that "Hai tsao", the SARGASSUMS are rich in this element.

Shimoda (1926) studied the vitamin content of LAVER E8 and found it very rich in vitamin A and moderately so in vitamin B. This agrees with the general finding for green algae. Seaweeds have no demonstrable quantity of vitamin C, Collado (1926). The Japanese exported material is described by Miller (1933) with practical information regarding the nutritive value and common cooking recipes.

It has often been questioned whether MUSHROOMS have any nutritive value. Chen (1936) has estimated the vitamin contents of *Mo ku, Mu erh* and *Hsiang ku* and found them all deficient in vitamins A and C, *Mo ku* is rich in vitamin D and is a relatively good source of vitamin B. The common mushroom in the West has been studied and found rich in vitamin B and lacking in C and D. The ash content of the mushrooms is high with good values for lime and iron, particularly in the common *mo ku* and *ke hsien mi*. Most of them are rich in nitrogenous matter (reckoned as protein).

F. FRESH FRUITS

Fruits are like vegetables in being important sources of the vitamins and salts. Vegetables on the whole contribute more of the three essential minerals, calcium, phosphorus and iron. Fruits though low in protein and fat contain in many cases sufficient sugar to make than of considerable importance as sources of energy. Their organic acids and volatile constituents add greatly to their flavour. It should be clearly understood that most fruit acids are well oxidised in the body and their salts increase the alkalinity of the urine. The cereals high in phosphorus yield in the body an acid ash which should be balanced with plenty of vegetables and fruits yielding an alkaline reaction. Moreover as sources of adequate supplies of vitamins and salts we recommend more of them in regular Chinese diets. Fruit is so often regarded as an after thought, a titbit between meals, a thirst quencher on a walk, or full of fresh vitamins sweet loot from a garden. It would be wiser to provide it as a regular item at the end of a meal when the appetite may need a little encouragement.

A plentiful supply of BANANAS imported from Canton and Amoy is now found upon the Shanghai market. They are picked when fully grown but still green and are stored for a considerable time to ripen and develop the flavour. Refrigeration prevents proper ripening, hence after local purchasing they should not be put in the refrigerator till fully ripened. When ripe and ready for use the skin is flecked with brown spots or may be almost entirely brown, but it should be free from bruises. In the green stage one half to one third of the total carbohydrate may be in the form of starch, but when fully ripe almost no starch remains and practically all of the carbohydrate is in the form of readily digested sugars. They have been used successfully with milk in infant feeding, Johnston (1927). When fully ripe their vitamin content is good, and like most fruits and vegetables yield an alkaline ash in the body. There is an enormous number of varieties, some with a higher iron content than that here analysed. Unripe bananas eaten raw may cause digestive disturbances, but when cooked they may be served as a starchy vegetable taking the place of potatoes. Some people advise milk and bananas on account of their bulk as a good slimming diet, the reverse might be true if there were no control of appetite.

FIGS are native to China. Old literature makes a clear distinction between the small inferior fruit grown on irregular shrubs in the Yangtse valley and the Persian fig introduced through Turkistan. The two products we analysed F7 and F8 are probably both Turkish figs, home grown and imported respectively. It is a good food with a low acid value and high digestible sugar content. It is a fair source of lime and some of the vitamins, as studied by Miller (1936).

LITCHIS or lichees refer to the fresh oval fruit imported from Amoy. The edible portion is the white flesh separated from the brickred outer shell and the single brown seed inside. The canned fresh fruit and the dried fruit are both marketed. The dried product known as "lichi nuts" bear the same relation to the fresh fruit as raisins do to fresh grapes. The analysis and nutritive value of the dried fruit was reported upon by Read (1918), who found the carbohydrates to be a mixture of simple easily digested sugars. Smith and Sah (19297) found vitamins A and B both lacking in the dried fruit. There are a number of varieties of litchi showing considerable difference in the size of the inner seed, even seedless fruit have been grown. The Canton fruits are described in a special bulletin published by Groff of the Lingnan University (1921). The sugar content of the different species may vary nearly 100 percent, Miller (1936).

MANGOES have been cultivated to such an extent that there exist today over 500 types, Watt (1891). In India, which is the original habitat, there are three distinct strains commonly known as Bombays, Lungrahs and Maldas. The mango is cultivated in South China but our Shanghai market is supplied chiefly with the large juicy yellow fruit from Manila. They have a high sugar content, and poor salt value. They are rich in vitamins. Guha and Chakravorty (1933) found them a fair source of vitamin B and a good source of vitamin G. The amounts of vitamins A and C apparently vary a great deal in the different strains. The deep yellow colour of the flesh of the imported Manila fruit suggests a rich A content, more than the conservative amount given in our table. We are dependent on foreign assays for no work in China has as yet been done on its vitamin A content. Crawford and Perry (1933) found one variety as high as good butter, other varieties showed about half this value. They examined the vitamin C potency and found values in different species varying from nothing up to twice the content of lemons. Titrated in our own laboratories the Manila mango was found to be rich.

ORANGES being native to China it is not surprising to find many varieties cultivated. Hou (1936) has examined a large number and finds the tight skin Canton orange superior to the Sunkist in its content of vitamin C. The Siam orange F16 is a little more than half as good, but the Wenchow tangerine F19 is distinctly inferior. The Swatow loose skin variety F18 is very good in its vitamin content, and has plenty of good flavoured juice. We did not analyse the Canton *Hsin hui* orange so common in Shanghai, for which Hou reports a high vitamin content.

PERSIMMONS in Shanghai are somewhat smaller and more globular than the flat variety seen in Peiping, where more than 100 million are produced annually. However the analysis does not show much difference. It has far more carbohydrate than the Japanese fruit which contains many seeds. When green and unripe, persimmons are very astringent due to the tannins present, which upon ripening to a golden yellow resolve into sugars, see the work of Komatsu and Ueda (1922-4). There are other species of persimmons in China. The dateplum (Diospyros lotus, L.) 黑棗 *hei tsao* is a small dark fruit of excellent flavour about the size of a chestnut. A large green type yields a resinous juice used for varnishing umbrellas and fans.

THE PUMELO is one of our best sources of vitamin C. The Kwang-hsi *Sha t'ien* 沙田 type is the richest fruit we have examined, its values run double the best oranges, though the Amoy varieties both red and white are about the same as the Swatow orange.

RED FRUIT F27 on account of size and texture is apt to be over-looked. Its acid and pecten form a good basis for making excellent red fruit jelly. The dried article is cheap and is used in some hospitals for making syrup.

The nutritive value of GRAPES is similar to other fruits in their having a very palatable source of sugar and salts that give an alkaline urine. The acids of the purple Concord grape have been shown to consist of about 60 percent of readily oxidised malic acid and 40 percent of tartaric acid in the form of alkali salts. The latter exercises a very mild laxative action. As far as is known the grape cannot be regarded as a good source of any of the vitamins, Daniel and Munsell (1932).

CANARIUM is the so-called Chinese olive. From the analysis of the fat and other constituents it is seen that this has nothing but a most superficial resemblance to the olive. It grows on a small shrub in the south-eastern provinces. There are two varieties, green and black, oblong pointed fruit 1¼ to 1½ inches long.

G. NUTS, SEEDS AND DRIED FRUITS

The proteins of nuts and seeds are usually rich in the essential amino-acids, and quantitatively they show high values. They have been found relatively rich in copper and iodine, but their contents of vitamins A, C and D are usually insignificant. With the exception of the chestnut, they contain high percentages of oil giving exceedingly high energy values. The chemical character of certain things like the water calthrop G28 is similar to the watery fruits in which a high water content is associated with low fat and protein values. The hard shell of the dried material gives it the popular status of a nut.

Dried fruits such as raisins and persimmons still hold a good deal of water in their tissues. A number of this group of foodstuffs are exported to Chinese colonies in America, and the Strait Settlements. Blasdale (1899) analysed several of them on the American market.

APRICOT KERNELS, both sweet and bitter, are used in China for making a very tasty gruel and compound almond flour. The dried sweet kernels are eaten like watermelon seeds or salted pumpkin seeds. The very poisonous character of the bitter apricot kernel is due to the generation of prussic acid. Read and Feng (1927) reported on the characters of these two varieties. The bitter toxic kind is smaller, thirty weigh about 10 grams, the larger sweet kind weigh more than half as much again. They resemble in most respects the sweet and bitter almonds used in Western countries. The very large amount of oil present makes a fine emulsion when the kernels are rubbed up with water.

FOXNUTS closely resemble lotus seeds in their habits of growth as a water plant. They are smaller and more farinaceous. Our analysis is similar to that done by Blasdale (1899) on material in America, ours has less fat. The carbohydrate consists almost entirely of fine starch granules. Ch'en (1936) examined them for vitamin C and found it absent.

GINKGO is the Japanese rendering of the Chinese name meaning "silver apricot." It is the seed from the famous Maiden-hair Tree Fern. As the common name implies the nut is white, uncooked it has a bitter disagreeable taste and odour. As analysed by Blasdale (1899) the most important constituent is chiefly starch. This is somewhat remarkable, as it is the only instance recorded in which starch has been observed in any considerable quantity in the seed of a coniferous plant. The characteristic flavour is due to the presence of the series of fatty acids from formic to caprylic acid. We have found no record of its vitamin content, we do not think it is likely to be a good source.

JUJUBES are the dried fruits of *Zigyphus vulgaris*, which furnish the important constituent of the jujube paste of Western confectioners. Though often referred to in China as a date, this spiny rhamnaceous shrub is in no way related to the date or date palm. Its carbohydrate consists chiefly of easily digested sugars. The fruit preserved in honey has an excellent flavour.

The KOLANUT grows on a large leaf ornamental tree resembling the wood oil tree. The seeds are borne on the leafy margins of the follicular carpels. The seeds enter into the composition of the moon cakes eaten at the autumn festival. Further work is needed regarding the quality of its protein and the character of the fat and carbohydrate before a true estimate of its nutritive value can be stated.

LOCUST SEEDS are from the common pagoda tree, not the *Robinia pseudoacacia* indicated in Embrey's list (1921). Whilst the nutritive value appears high we have no exact knowledge of the character of the carbohydrate and protein with regard to digestibility and utilization. The carbohydrate includes rhamnose and rhamninose. The very high ash suggests a good source of calcium and iron.

LOTUS SEEDS are eaten either raw, boiled or roasted, and in some ways resemble the chestnut, highly palatable so that it is said, "the more you eat, the more you want of them." The dark green germ is decidedly bitter and must be removed before cooking. The analysis shows them to contain a high percentage of nutrients. The protein is considerably above that of the common cereals, though not so great as in the leguminous seeds such as the peanut. Nearly all of it is of an albuminoid nature. Most of the carbohydrate consists of starch, though small amounts of the sugars are present. Nothing is known concerning their vitamin content, except the fact that the fresh seed is rich in vitamin C, Chen (1936). The dried article is not likely to be so.

LUNGNGANS are closely related to lichee, and have similar nutritive properties, but they are smaller in size. The aril forms nearly half of the seed, hence the smallness of the edible portion. The name comes from the Chinese word meaning, "Dragon's eyes." They appear similar in composition to dried lichee. They contain no starch, the carbohydrate is about half cane sugar and the remainder easily digested reducing sugars.

PEANUTS are of two kinds, a small nut in a rough pod of good flavour, and a larger variety sometimes called the foreign peanut. Both are of foreign origin, the latter being of later introduction. Large quantities are roasted and eaten in China by all classes. After shelling the fried or salted article is prepared for sale. The very highly nutritive character of this nut and its cheapness places it next to the soybean in importance. Wallis (1918) recommended one part of peanut flour to four parts of wheat flour as providing all the protein needed for normal growth. Johns and Finks in proportions of one to three found there was sufficient protein and vitamins provided to give normal growth. The protein was utilized almost twice as well as in ordinary wheat bread.

THE WATER CALTHROP is a curiously shaped seed, aptly compared with the head and horns of a cow. The taste and consistency resemble the chestnut, hence it is often spoken of as the horned chestnut, or the water chestnut. The latter name more correctly refers to the *Pichi, Scirpus tuberosus.* It grows plentifully in the ponds and rivers, a number of varieties being known. The commonest is the large two horned fruit, there are also three and four horned kinds, and some are coloured red. There are so many intermediate forms that botanists are inclined to regard them all as varieties of one species. The larger type has decidedly more carbohydrate which is known to be chiefly starch. Chen (1936) has found them moderately rich in vitamin C. They are eaten boiled.

H. VEGETABLE PRODUCTS

H 1. BEAN PASTE according to Shih may be made from any kind of beans, but is largely made from the soybean. After soaking, washing and boiling in water, the beans are taken out and dipped in wheat flour so that it thoroughly covers them. They are then spread out on mats to mold, after about one week they are placed in the sunshine for two days. Ten catties of the moulded beans are added to eight catties of salt and forty catties of water and constitute *chiang pan* 醬板. Further maturing, grinding and sunning of the product constitutes *tou chiang* 豆醬 or bean paste. The Japanese preparations of *natto* and *miso* represent more highly standardised products. The composition of *miso*, soybean paste, has been studied by Takahashi (1908). It is made from beans and fermented rice with *Aspergillus oryzae*, containing the enzymes which convert the starch and protein of the soybean into soluble proteoses and maltose. The very high ash is chiefly salt added in preparation. Saiki reports that *miso* contains no appreciable amount of the vitamins. These Japanese foods used in Hawaii are reported upon by Miller, q.v.

H 2. SWEET FLOUR PASTE is made by the fermentation of wheat flour on the same principle as the above, with the subsequent addition of a small amount of sugar.

H 3. CURRY POWDER is a mixture of powdered curry leaves and yellow turmeric root with numerous condiments stimulating appetite and gastric secretion, such as pepper, chillies, cloves, ginger, cinnamon and cardamon seeds. Our analysis points to a high content of the first three, which make it a hot curry. Rosedale (1935) gives the individual analyses of 15 currystuffs used in Malay curries.

H 4. The starches of the LOTUS and WATER CALTHROP were studied by Blasdale q.v., who gives drawings of the characteristic granules, which are distinct in morphological charater from the common starches of rice and potato.

Capsicum?

H 5. PEPPER PASTE has a high ash which consists chiefly of salt added to fresh red peppers (chillies) which are ground to a fine paste.

H 6. SESAME PASTE consists simply of the crushed seed with none of the oil removed. It is comparable to peanut butter.

I. VEGETABLE OILS

It is well known that fats and oils are often carriers of vitamins A and D. Lo (1935) tested the oils of linseed, mustard and hemp used as the principle source of fat by the people of Suiyuan, for the presence of these vitamins and found none or only a trace, the results were very poor with the larger intakes of hempseed oil. Judged from the effects upon growth and the life span of rats he arranged common oils in the following decreasing order of nutritional efficiency; (1) soybean, (2) peanut, (3) linseed, (4) sesame, (5) mustard seed, (6) hempseed.

Burr and his co-workers have brought forward evidence to show that a small amount of particular fatty acids (linolic and linolenic acids) must be present in the food if normal nutrition is to be maintained. Lo's tests are some measure of the presence of these essential fatty acids. None of the oils mentioned showed signs of such deficiency.

Suzuki (1934) from his experiments on fertility concludes that soybean oil contains vitamin E.

J. EGGS AND MILK

Whilst there is a vast export trade in EGGS, the home consumption in China is not relatively large. Their highly nutritive character is seen in the values for protein, fat, calcium, iron and the various vitamins except vitamin C. There are two kinds on the Shanghai market. The common Chinese egg is less than four fifths the weight of a foreign egg. The smaller type weighs 35 to 45 grams; the larger kind termed *Yu chi tan* weighs 50 to 55 grams. They are preserved by keeping them in strong brine one or two months. The egg is made up of about 10 percent of shell and membrane, 34 percent of yolk and 56 of egg white. The desiccated material is manufactured by heating at 140° F in shallow pans, the Spray process or by the Krayseska method. The yolk contains about

30 per cent of egg oil termed 卵油 *luan yu.* A product on the market known as "melange" is a liquid mixture of the albumen and the yolk. The liquid yolk with added preservative is also marketed. They cannot be considered as good as the fresh article.

DUCK'S EGGS preserved in lime (J9) have been analysed in America by Blunt and Wang (1918). They give the following description of their preparation. "To an infusion of 1 1/3 pounds of strong black tea are stirred in successively 9 pounds of lime, 4½ pounds of common salt, and about 1 bushel of freshly burned wood ashes. This pasty mixture is put away to cool over night. Next day 1000 duck's eggs of the best quality are cleaned and one by one carefully and evenly covered with the mixture, and stored away for 5 months. Then they are covered further with rice hulls, and so, with a coating fully ¼ inch thick, are ready for the market. They improve on further keeping, however, for at first they have a strong taste of lime which gradually disappears. Eggs preserved in lime water and salt are also said to have a limelike taste. The eggs are eaten without cooking."

Their average weight of egg was 60.15 grams, edible portion 85.1 percent, white 26.85, yolk 58.25, and ash 3.68 percent. They observed decomposition of the phospholipoids and the generation of some ammonia. Our results show some increase in the lime but more striking is the large increase in potash from the wood ashes; there is some loss of phosphorus and iron. Blunt and Wang compared their results with those from fresh duck's eggs in America. Our results compared with local duck's eggs, which are apparently about ten percent smaller than the American egg, show no loss of water, the fats and phosphorus are similarly decreased, but from the ash figure we conclude that our limed eggs were not so aged. Gibbs (1912) describes the methods used in the Philippines also their analysis. Svoboda (1902) gives the Oriental methods of preservation in woodashes. Hanzawa (1913) describes a number of Chinese methods and the results of bacteriological study. Tso (1926) has shown that by preservation the originally rich vitamin B content of duck's eggs is almost completely destroyed, but the potency of vitamins A and D is little or not at all affected.

It is possible to get high grade COW'S MILK in Shanghai. Our recent surveys showed that a good deal of B grade milk is used. Our analysis was made upon a B grade sample, it compares quite favourably with that given for whole milk by Sherman. The use of buffalo milk has been advocated by Levine and Cadbury (1918) as a wholesome and palatable substitute for cow's milk. Average analysis showed a very high content of fat, 12.6 percent. It contains the following percentages, 6.04 of protein, 3.7 sugar, 0.86 ash. For infant feeding they recommend 10 ozs buffalo milk, 1¾ ozs sugar and enough water to make 30 ozs. Butter and cream from buffalo milk is sold in Shanghai.

K. MEATS AND ANIMAL FATS

There is so much discussion in standard works upon meats there is little need for notes upon the subject except to point out the predominance of pork and pig products in China, resulting in the widespread use of lard as a cooking oil. Its deficiency in vitamins makes it inferior to some of the good vegetable oils or other animal fats. The liver, kidney and heart are highly nutritive, and pig's stomach is reputed for its value in blood formation, not for its iron content, rather it has a strong antianemic factor.

The ducks and fowls contain much less fat than those on the northern markets. The mutton and pork are fatter than western meats.

The pickling of the various meats adds to their salts, particularly the calcium and potassium, and chloride of sodium. Pig and duck bloods are sources of iron.

To avoid diseased meat people are strongly recommended to insist on only getting abattoir killed animals, which have been properly inspected.

L. MOLLUSCS

Shell fish in general with the exception of the dried products, such as the scallop and mussel, do not have high energy value. They are exceedingly good sources of lime and iron, and have some vitamin value. Suzuki (1926) q.v. considers that fish protein is equivalent to animal protein and fish contain many valuable extractives indispensable in nutrition. The carbohydrate is good digestible material, when fresh in the form of glycogen.

The ligament of the SCALLOP L10, Suzuki reports, is especially rich in the essential amino-acid lysine, though it is a relatively poor source of the important salts of lime and iron. He found that drying did not lessen its nutritive value.

Saiki (1926) found a considerable amount of vitamin A in OYSTERS, also vitamin C. They also contain glycogen.

The MUSSEL is of widespread interest all over the world as an article of food. Its values have been set forth by Field (1911) It is rich in lime and iron, high in good protein and digestible carbohydrate. Singh (1936) analysed the anterior retractor muscle of the *Mytilus* and found about 0.37 percent of sodium and 0.145 percent of potassium in fresh tissue containing an average of 78 percent of water. We report a similar result for potassium in our dried material. A satisfactory balance between these two elements in the diet is essential. Their specific requirements are not known, but excessive potassium disturbs the water balance and the normal functioning of the body.

B. CRUSTACEA, ETC.

Fresh shell fish are an expensive source of energy because the edible portion is usually so small and the shells are a total waste. However the first class character of their proteins and other constituents render them a valuable addition to the diet.

We have included in this group other foods which do not logically fall into any other class. There are not enough things like frogs and turtles to make a separate grouping. Such delicacies of diet are dealt with in detail by Kinoshita (1925).

M 1. BIRD'S NEST protein is inadequate in character, belonging to the mucin-like substances the glycoproteins. Wang (1921) isolated hexosamine. The mucin-like character of bird's nest confirms the idea that it is formed by the salivary secretion of the swift. It is digested more slowly than boiled eggs. Wang's analyses of material on the Chicago market gave water 11.6 percent, nitrogen 8.8, ash 2.51, phosphorus 0.035. Allowing for the greater dryness of her samples, there was no significant difference in our results. The carbohydrate is combined with the protein, so our figures correspond with Wu's (1928) who reported protein 85.6, carbohydrate 0, which is a truer expression of its actual content but not of its available nitrogen.

Heiduschka and Graefe (1933) have published further analyses of birds nest showing that about one quarter of the ash consists of sodium chloride. There is no iodine present. They found present tyrosin 5.6, trytophan 1.4, cystine 2.4, histidine 2.7, and arginine 2.7 percent. Hydrolysis of the mucin substance yielded 18 percent of a product similar to chitosamine. It was not digested to any extent either by pepsin or trypsin.

M 6. FISH MAWS are made from the gelatinous membranes of the swimming bladders of many species of fish, particularly the sturgeons. In cold water they soften, swell up and become opalescent. Boiling water almost entirely dissolves them. The insoluble impurities of the better grades amount to less than 2 percent. The common name is isinglass. It is composed of collagen which on boiling hydrolizes to gelatin. Ordinary gelatin is sometimes used as an adulterant and produces a much higher percentage of ash. The very high percentage of protein in isinglass yields chiefly glycine. Like ordinary gelatin, isinglass protein is deficient in some of the important constituents of first class protein. It is dealt with in detail in standard drug books such as the U.S. Dispensatory, or B. P. Codex.

A careful protein analysis of the SEA SLUG M11 (or sea cucumber) by Lin and Chen (1927) showed that the moisture free material contains 0.97 percent cystine, 5.74 arginine, 1.57 histidine, 3.89 lysine, 0.9 tryptophane, and 4.36 percent of tyrosine, and may be regarded as protein of fair quality.

N. FISHES AND OTHER MARINE PRODUCTS

The Shanghai Fish Market has published in Chinese a very useful bulletin describing eighty six common food fishes on the local market, Hsu (1935). It is illustrated and gives the scientific names. Our identifications are based largely upon this bulletin.

In China fish are a potentical source of food not yet fully developed. Improved communications are likely to expand trade in salted products, and to provide wider markets in general for the fisherman.

Fish are a valuable article of food containing good protein, glycogen, inorganic salts, extractives and in some cases an appreciable amount of fat with its associated vitamins. Suzuki

(1926) q.v. has made interesting comparisons of fish proteins with beef, rice and legume protein. The herring, salmon, scallop and crab gave nearly the same results as beef, while tunny, mackerel, and globe-fish were not as good. Higher levels of legume protein gave equally good results, but rice protein was inferior to fish protein.

In studying the effect of high protein diets on the growth of animals Chen (1936) used a level of 65 percent of fish protein, he did not indicate the source. Although there appeared to be adequate provision of all other dietary essentials his animals failed to grow and finally died, unless the diet was supplemented with 8 percent dried whole yeast. Supplements of egg white, spinach and onions made no improvement. This does not suggest lack of quality in fish protein, rather there was a deficiency of other essentials in his diet.

There is an entire lack of specific information concerning the vitamins in Chinese fish. The fish oils so far studied come almost entirely from fish livers. Except in the case of tiny sardine like fish, the market article is gutted and we are dealing with the muscle tissue. The entire body of the HERRING and sardine are about as potent as the liver of the cod, so there is reason to suppose that some of the fish listed may be good sources of vitamin D. Our MACKEREL (N24 and N25) may be compared with Boston mackerel, the liver of which is 7½ times more potent than that of the cod (Bills 1935). Pacific dogfish (N14) are known to contain vitamin D. Wang and Kan (1936) have found the liver of the STING RAY (N37) twice as potent as cod liver oil.

The body oils as well as the liver oils of some fish are quite rich in vitamin A. The fact of the matter is Chinese diets lack good fat and unfortunately the commonest local fish is a river species (N26) containing little or no vitamin bearing fat. Fatty sea fish are recommended as being more likely to carry the fat soluble vitamins. The *Le* fish in our list locally termed a herring is different from the Western one which is a *Clupea.*

O. CONDIMENTS AND BEVERAGES

The first four items are all forms of glutamic acid condiments, the chemistry of which is dealt with by Wei and King (1935). An initial material such as wheat gluten is hydrolysed and the product neutralized with soda. The condiment occurs in the form of a white powder with a strong meat like flavour. It is put into soups or sprinkled over starchy foods to add to the taste, it also increase their nutritional value. Cheng and Adolph (1935) have made a comparison of the yield of glutamates from various sources other than wheat gluten. Their results suggest the ecomical use of various cheap sources in the making of condiments. It is claimed that sodium glutamate used as a condiment under the name of *Wei ching* 味精 aids digestion. The experiments of Hsu and Adolph (1936) show that it has no appreciable influence on the digestion and absorption of the carbohydrate of rice.

O 5. CHINESE PEPPER, also known as 'fagara', comes from more than one species of *Xanthoxylum* which bear on spiny shrubs in the axils of the twigs and leaves tiny fruits smaller than a peppercorn. They have an aromatic odour and a characteristic pungent taste due to the presence of a volatile oil containing cuminal, phellandren &c. which have a carminative effect. Fried food is dipped into the powdered condiment, which adds a spicy flavour.

O 7. COMMON SALT shows the presence of much impurity, which varies with the source. The Szechuan salt wells produce about 3 million catties annually of salt rich in potash. Along the seacoast of Kiangsu north of the Yangtse, salt is prepared by lixiviation of salt earth with water or brine, the strong salt solution formed being concentrated till crystals separate out. It is a clean looking product but not considered as fine as that made in Ningpo or Chekiang generally. Clean samples of crude salt contain up to 90 percent sodium chloride and about 3 percent soluble magnesium and calcium salts. The impurities make it inconveniently deliquescent, but they add to its saline taste. The refined article is dry and free from silt and organic impurities, Read and Pak (1936).

The iodine in SALT is of great nutritional importanee. Wang and Cheng (1935) made a comprehensive survey of the iodine content of Chinese common salt in the various provinces. Kiangsu Huai-pei salt contained 56 parts per million. REFINED SALT showed 11 to 45 parts. The highest contents found were in samples from Szechuan, a Nan-lang sample was found to contain 5100 parts of iodine per million parts of salt. Common salt from Kiangsu analysed by Wang (1936) shows the presence of the following percentages, of calcium 0.274, magnesium

1.062, phosphorus 0.046, and iron 0.06. The refined article from Kiangsu had calcium 0.254, magnesium 0.325, phosphorus 0.015, and iron 0.002. These figures should be taken into account when the mineral intake in the diet is being considered.

O 9. VINEGAR in China is made from rice, wheat, sorghum, and numerous vegetables sources. Our Shanghai sample was probably made from rice. It had a titratable acidity of 3.3 percent, but distillation showed somewhat less than 2 percent of acetic acid present. Good malt vinegar should contain not less than 4 percent. Vinegar often contains small amounts of organic acids other than acetic acid, together with dextrin, sugar, pigments and a notable amount of phosphates. The very small amount of ethers and aldehydes present add greatly to its appetising effect.

O 10. Inukai (1934) has studied RICE WINE and its press cake and finds a moderate amount of vitamin G present.

A. CEREALS AND

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm.	Ash	Ca
A 1	Corn from the cob. (Maize)	Zea Mays L. (White)	100	54.64	3.60	2.19	37.52	1.05	189	1.00	0.001
A 2	Millet, short.	Setaria italica, (Kth.) Var germanica, Trin.	100	10.02	9.27	3.15	75.71	0.61	377	1.24	0.014
A 3	Rice, polished 1st grade.	Oryza Sativa, L.	100	12.25	7.29	0.46	79.16	0.18	358	0.66	0.052
A 4	Rice, 2nd grade.	,, ,,	100	14.89	6.48	0.47	77.53	0.22	348	0.41	0.048
A 5	Rice, 2nd grade.	,, ,,	100	14.21	5.95	0.82	78.24	0.25	353	0.53	0.034
A 6	Rice, 3rd grade.	,, ,,	100	10.65	9.55	0.90	77.22	0.52	366	1.16	0.041
A 7	Rice, polished An chen.	,, ,,	100	15.49	6.21	0.47	77.19	0.19	346	0.45	0.070
A 8	Rice, polished Ch'ang shu.	,, ,,	100	15.16	6.47	0.99	76.53	0.29	349	0.56	0.071
A 9	Rice, polished Ch'ing P'u.	,, ,,	100	15.45	6.52	0.28	77.10	0.26	347	0.39	0.010
A 10	Rice, polished Kiangsi.	,, ,,	100	14.89	7.61	1.18	75.34	0.40	351	0.58	0.007
A 11	Rice, polished Kiangyin.	,, ,,	100	15.12	5.70	0.44	78.13	0.29	348	0.32	0.031
A 12	Rice, polished K'un shan.	,, ,,	100	14.14	6.61	0.94	77.27	0.28	353	0.76	0.179
A 13	Rice, polished K'un shan Yang chien.	,, ,,	100	13.67	6.15	0.90	78.13	0.20	353	0.95	0.290
A 14	Rice, polished Suchou high grade.	,, ,,	100	14.97	7.47	0.86	75.81	0.28	349	0.61	0.115
A 15	Rice, polished Suchou winter.	,, ,,	100	13.82	6.67	0.54	78.08	0.32	352	0.57	0.102
A 16	Rice, polished T'sao ch'iao.	,, ,,	100	14.86	6.39	0.33	77.72	0.21	348	0.49	0.037
A 17	Rice, polished Wusi.	,, ,,	100	14.39	5.47	0.88	78.56	0.25	352	0.45	0.035
A 18	Rice, polished Wusi pointed.	,, ,,	100	13.97	6.00	1.38	76.99	0.33	353	1.33	0.432
A 19	Rice, polished Yi Hsing.	,, ,,	100	14.82	6.07	0.79	77.29	0.27	349	0.76	0.039
A 20	Rice, glutinous Li Yang.	O. glutinosa, Lour.	100	14.20	5.88	1.41	77.18	0.20	353	1.13	0.315
A 21	Rice, 1st grade upland,	Oryza montana, L.	100	13.78	7.12	0.26	77.40	0.68	349	0.76	0.059
A 22	Rice, Whole.	Oryza Sativa, L.	100	16.95	6.68	0.35	74.98	0.30	338	0.78	0.056
A 23	Rice, Whole. Wusi.	,, ,,	100	15.28	7.33	0.74	75.24	0.52	345	0.89	0.066
A 24	Rice, Whole Ch'ang shu.	,, ,,	100	13.95	7.30	2.76	74.81	0.08	362	1.11	0.013
A 25	Rice, Whole Suchou.	,, ,,	100	15.40	7.52	0.93	74.82	0.49	346	0.84	0.018
A 26	Rice, for congee.	Average Sample	100	13.21	6.59	0.32	79.01	0.24	353	0.63	0.094
A 27	Rice, red, polished.	O. praecox, Lour.	100	15.78	7.53	2.92	71.73	0.80	352	1.24	0.025
A 28	Rice, fermented.	O. Sativa, L.	100	11.80	13.88	9.32	58.46	5.45	383	1.09	0.091

CEREAL PRODUCTS.

P	Fe	K	VITAMINS A	B	C	D	E	G	Romanized Name	Chinese Name	No.
0.187	0.0015	0.257	1.2 O	1.2 +	1.2 O	1.2 ±	1.2 ++	1.2 ±	Hsien Lao Yu Mi	鮮老玉米	A 1
0.235	0.0068	0.303	33.2 +	1.2 ++	1.2 O			1.2 +	Hsiao Mi	小米	A 2
0.099	0.0021	0.144	2.1 O	2.1 O	2.1 O		1.2 Oto+	1.2 O	T'ou Hao Pai Mi	頭號白米	A 3
0.114	0.0010	0.127							Erh Hao Pai Mi	二號白米	A 4
0.078	0.0012	0.127							Erh Hao Pai Mi	二號白米	A 5
0.202	0.0031	0.520							San Hao Pai Mi	三號白米	A 6
0.083	0.0027	0.136							An Chen Pai Keng	安鎮白粳	A 7
0.083	0.0028	0.180							Ch'ang Shu Pai Keng	常熟白粳	A 8
0.064	0.0037	0.391							Ch'ing P'u Po Tao	清浦薄稻	A 9
0.119	0.0021	0.136							Kiangsi Chien Mi	江西尖米	A 10
0.079	0.0026	0.139							Kiang Yin Pai Keng	江陰白粳	A 11
0.117	0.0035	0.585							K'un Shan Pai Keng	崑山白粳	A 12
0.134	0.0041	0.507							K'un Shan Yang Chien Mi	崑山洋尖米	A 13
0.115	0.0056	0.440							Suchow Hsiang Keng	蘇州香粳	A 14
0.110	0.0025	0.141							Suchow Tung Shuang Mi	蘇州冬霜米	A 15
0.090	0.0034	0.767							Ts'ao Ch'iao Pai Keng	漕橋白粳	A 16
0.078	0.0029	0.202							Wusi Pai Keng	無錫白粳	A 17
0.149	0.0024	0.536							Wusi Fu Chien Mi	無錫埠尖米	A 18
0.105	0.0076	0.122							Yi Hsing Pai Keng	宜興白粳	A 19
0.086	0.0047	0.331							Li Yang No Mi	溧陽糯米	A 20
0.161	0.0012	0.098	1.2 O		2.1 O		1.2 Oto+	1.2 O	T'ou Hao Hsien Mi	頭號秈米	A 21
0.158	0.0046	0.226	1.2 +	2 ++		1.2 O		1.2 +	T'sao Mi	糙米	A 22
0.192	0.0030	0.276							Wusi Ts'ao Mi	無錫糙米	A 23
0.259	0.0058	0.253							Ch'ang Shu Wei Sheng Mi	常熟衛生米	A 24
0.165	0.0040	0.178							Suchow Wei Sheng Mi	蘇州衛生米	A 25
0.091	0.0024	0.135							Chou Mi	粥米	A 26
0.250	0.0028	0.284							Sung Mi	紅米	A 27
0.155	0.0085	0.197							Hung Ch'ü Mi	紅麴米	A 28

A. CEREALS AND

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories 100 gm	Ash	Ca
A 29	Rice, polishings.	O. Sativa, L.	100	10.35	13.82	17.93	41.37	6.58	393	9.95	0.934
A 30	Rice, polishings.	,, ,,	100	10.46	13.04	12.68	37.61	11.18	326	15.03	0.703
A 31	Rice, Cooked.	Average sample.	100	59.39	3.38	0.45	36.42	0.19	167	0.17	0.008
A 32	Rice, Congee.	,, ,,	100	90.62	0.81	0.01	8.44	0.04	39	0.06	0.003
A 33	Wheat Bread.	Triticum vulgare, Vill.	100	32.79	10.80	1.18	53.64	0.26	275	1.33	0.035
A 34	Wheat gluten.	,, ,,	100	69.80	20.29	0.29	9.30	0.07	124	0.25	0.027
A 35	Wheat gluten, fried.	,, ,,	100	1.92	24.93	68.54	3.68	0.30	754	0.63	0.033
A 36	Wheat gluten and flour, fried.	,, ,,	100	1.73	25.11	32.44	39.62	0.16	567	0.94	0.161
A 37	Spaghetti.	,, ,,	100	29.55	8.16	0.56	60.74	0.34	288	0.64	0.033
A 38	Vermicelli, wrapped.	,, ,,	100	14.85	10.20	0.25	73.88	0.19	347	0.63	0.021
A 39	Wheat fritters, twisted and fried.	,, ,,	100	31.95	5.92	12.52	45.47	0.16	327	3.98	0.026

B. LEGUMES, PULSES AND

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories 100 gm	Ash	Ca
B 1	Cowpea pods, white fresh.	Vigna Sinensis *Hassk*	100	90.15	2.64	0.46	4.87	1.40	35	0.48	0.046
B 2	Cowpea pods, green and narrow.	,, ,,	98	91.19	2.76	0.48	4.13	0.84	33	0.60	0.051
B 3	Flat bean, fresh pods.	Dolichos Lablab, L.	100	88.30	3.16	0.27	5.36	2.10	38	0.81	0.081
B 4	Flat bean, runners.	,, ,,	92	90.07	2.54	0.17	5.13	1.46	33	0.63	0.110
B 5	Flat bean, green fresh pods.	,, ,,	92	89.23	2.99	0.22	5.47	1.43	37	0.66	0.123
B 6	Horse bean, fresh from pod.	Vicia Faba, L.	25	71.79	8.76	0.46	13.78	3.98	97	1.23	0.031
B 7	Horse bean, fresh, peeled.	,, ,,	59	79.44	8.23	0.61	10.32	0.31	82	1.09	0.015
B 8	Horse bean, dried peeled.	,, ,,	100	15.97	29.44	1.81	47.55	2.07	333	3.16	0.093
B 9	Horse bean, salted & fried.	,, ,,	100	11.12	28.17	8.91	47.14	1.30	391	3.36	0.055
B 10	Horse bean, soaked. sprouted. Peeled.	,, ,,	100	60.15	13.55	0.77	23.40	0.67	159	1.46	0.054
B 11	Horse bean, sprouted. Peeled.	,, ,,	80	63.78	13.00	0.81	19.59	0.63	141	2.19	0.109
B 12	Mung bean.	Phaseolus mungo, L. var. radiatus (Bak)	100	9.88	22.97	1.50	57.78	4.04	345	3.83	0.034
B 13	Mung bean, sprouted.	,, ,,	100	93.22	2.50	0.15	3.18	0.63	25	0.32	0.019

CE EAL PRODUCTS.—*(Continued)*

P	Fe	K	VITAMINS A	VITAMINS B	VITAMINS C	VITAMINS D	VITAMINS E	VITAMINS G	Romanized Name	Chinese Name	No.
1.751	0.0399	1.851	33.1.2 +	2 +++				1.2 +	Hsi K'ang	細糠	A 29
1.835	0.0712	1.964	1.2 +	2 +++				1.2 +	Hsi K'ang	細糠	A 30
0.044	0.0011	0.056	1.2 O	1.2 O	1.2 O		1.2 O to+	1.2 O	Mi Fan	米飯	A 31
0.010	0.0002	0.011							Pai Mi Chou	白米粥	A 32
0.081	0.0010	0.091	33.2 O	1 +	1.2 O				Mien Pao	麵包	A 33
0.054	0.0062	0.038							Mien Chin	麵筋	A 34
0.099	0.0112	0.051							Yu Cha Mien Chin	油炸麵筋	A 35
0.078	0.0064	0.120							Yu Cha Fen Mien Chin	油炸粉麵筋	A 36
0.091	0.0076	0.154							Mien T'iao	麵條	A 37
0.105	0.0015	0.193							Wei Sheng Kua Mien	衛生掛麵	A 38
0.093	0.0051	0.390							Yu T'iao	油條	A 39

LEGUME PRODUCTS

P	Fe	K	VITAMINS A	VITAMINS B	VITAMINS C	VITAMINS D	VITAMINS E	VITAMINS G	Romanized Name	Chinese Name	No.
0.048	0.0026	0.154	1.2 ++	1.2 ++	30 +++			2 +	Pai Chiang Tou Chia (Hsien)	白豇豆莢(鮮)	B 1
0.060	0.0011	0.200		40 ++					Ch'ing Hsi Chiang Tou Chia	青細豇豆莢	B 2
0.068	0.0034	0.273	8 +	40 +++	30 +				Pai Pien Tou Chia (Hsien)	白扁豆莢(鮮)	B 3
0.049	0.0021	0.225							Pai Chia Pien Tou Chia (Hsien)	白架扁豆莢(鮮)	B 4
0.077	0.0009	0.310							Ch'ing Chia Pien Tou Chia (Hsien)	青架扁豆莢(鮮)	B 5
0.123	0.0016	0.412	4 +	4 +	7 +				Hsien Ts'an Tou	鮮蠶豆	B 6
0.217	0.0017	0.383	4 +	4 +	7 +				Hsien Ts'an Tou, Ch'ü Nei P'i	鮮蠶豆,去內皮	B 7
0.225	0.0062	1.123							Kan Ts'an Tou, Ch'ü P'i	乾蠶豆,去皮	B 8
0.222	0.0067	0.994							Cha Hsien Ts'an Tou Pan	炸鹹蠶豆瓣	B 9
0.239	0.0059	0.539							Ts'an Tou Pan	蠶豆瓣	B 10
0.382	0.0082	0.775							Ts'an Tou Ya	蠶豆芽	B 11
0.222	0.0097	1.114	10 +	1.2 ++	1.2 low				Lü Tou	綠豆	B 12
0.310	0.0030	0.089	28 +	40.34 ++	28 ++				Lü Tou Ya	綠豆芽	B 13

B. LEGUMES, PULSES AND

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
B 14	Mung bean, starch jelly.	Phaseolus mungo, L. var. radiatus (Bak)	100	95.32	0.02	0.01	4.56	nil	19	0.09	0.002
B 15	Mung bean starch, sheet.	,, ,,	100	80.06	0.02	0.02	19.74	0.01	81	0.15	0.002
B 16	Mung bean starch, strip.	,, ,,	100	14.73	0.34	nil	84.62	nil	348	0.31	0.027
B 17	Peas, green. Fresh, from pod.	Pisum sativum, L.	38	75.79	6.36	0.57	13.21	3.15	86	0.92	0.038
B 18	Pea sprouts.	,, ,,	100	89.18	4.46	0.74	2.97	1.30	37	1.35	0.156
B 19	Red gram bean.	Phaseolus mungo, L. var. subtrilobata, (Fr. et Sav.)	100	14.91	19.06	0.76	57.40	4.44	321	3.43	0.067
B 20	Soybean.	Glycine soja, yellow (S. et Z.)	100	8.70	40.50	20.20	21.00	4.60	440	5.00	0.190
B 21	Soybean in pod, fresh beans.	,, ,,	80	64.14	15.20	7.10	9.74	2.00	168	1.82	0.100
B 22	Soybean, fried.	,, ,,	100	3.38	32.70	30.52	23.05	5.56	512	4.79	0.230
B 23	Soybean, curd.	,, ,,	100	87.29	6.90	3.30	1.33	0.07	65	1.11	0.273
B 24	Soybean, green, salted.	,, green variety.	100	18.29	34.30	16.70	19.26	3.88	375	7.57	0.197
B 25	Soybean curd cake.	,,yellow variety.	100	68.33	18.50	9.00	2.80	0.17	171	1.20	0.098
B 26	Soybean curd cake, with mushroom.	,, ,,	100	59.48	24.40	9.17	2.72	0.20	196	4.03	0.097
B 27	Soybean curd cake, spiced.	,, ,,	100	59.39	20.93	6.41	8.97	0.19	182	4.11	0.080
B 28	Soybean curd, fermented.	,, ,,	100	79.05	11.40	6.21	1.80	0.10	112	1.44	0.072
B 29	Soybean curd, fried, large.	,, ,,	100	50.66	23.60	19.20	1.57	nil	284	4.97	0.384
B 30	Soybean curd, fried, small.	,, ,,	100	8.01	39.60	37.72	11.72	0.05	561	2.90	0.191
B 31	Soybean curd, pickled.	,, ,,	100	65.86	10.65	6.01	7.00	0.26	128	10.22	0.157
B 32	Soybean curd, sheet.	,, ,,	100	41.07	32.90	18.80	4.39	0.10	325	2.74	0.733
B 33	Soybean milk clot.	,, ,,	100	7.68	47.68	28.85	13.48	0.16	519	2.15	0.319
B 34	Soybean pickled.	,, ,,	100	25.95	24.20	11.59	27.89	6.03	322	4.34	0.059
B 35	Soybean sauce.	,, ,,	100	72.37	5.92	1.15	5.15	nil	56	15.41	0.059
B 36	Soybean, sprouted.	,, ,,	100	83.02	6.80	2.40	6.24	0.65	76	0.89	0.068
B 37	String bean, fresh in pod.	Phaseolus vulgaris, L.	100	93.01	1.70	0.74	3.13	0.78	27	0.64	0.066

LEGUME PRODUCTS—*(Continued)*

P	Fe	K	VITAMINS A	VITAMINS B	VITAMINS C	VITAMINS D	VITAMINS E	VITAMINS G	Romanized Name	Chinese Name	No.
0.001	0.0009	0.011							Lü Tou Liang Fen	綠豆涼粉	B 14
0.008	0.0006	0.039							Fen P'i	粉皮	B 15
0.024	0.0008	0.139			1.2 ++				Hsien Fen	綫粉	B 16
0.079	0.0001	0.431	1.2 ++	1.2.40 ++	1.2.6 +++			2 +	Hsien Wan Tou	鮮豌豆	B 17
0.082	0.0075	0.439			21 ++		1.2 +++		Wan Tou Miao	豌豆苗	B 18
0.305	0.0052	1.171					2 +		Ch'ih Hsiao Tou	赤小豆	B 19
0.631	0.0102	1.715	33.31 +	39.34 ++	O			1.2.39 +	Huang Tou	黄豆	B 20
0.219	0.0064	0.734	31 +	33.33 ++	+			1.2 +	Mao Tou	毛豆	B 21
0.565	0.0102	1.791							Yu Huang Tou	油黄豆	B 22
0.096	0.0022	0.185	33.1 +	1 ++					Tou Fu	豆腐	B 23
0.456	0.0073	1.751							Yen Ch'ing Tou	鹽青豆	B 24
0.175	0.0058	0.154							Tou Fu Kan	豆腐乾	B 25
0.315	0.0055	0.238							Mo Ku Tou Fu Kan	蘑菇豆腐乾	B 26
0.351	0.0079	0.180							Hsiang Kan	香乾	B 27
0.153	0.0042	0.122							Ch'ou Tou Fu	臭豆腐	B 28
1.057	0.0174	0.594							Ta K'uai Yu Tou Fu	大塊油豆腐	B 29
0.574	0.0094	0.300							Hsiao K'uai Yu Tou Fu	小塊油豆腐	B 30
0.205	0.0123	0.269							Chiang Tou Fu	醬豆腐	B 31
0.459	0.0069	0.169							Ch'ien Chang, Pai Yeh	千張百頁	B 32
0.436	0.0096	0.446							Yu P'i	油皮	B 33
0.222	0.0041	0.739							Chiang Yu Huang Tou	醬油黄豆	B 34
0.100	0.0049	0.390							Chiang Yu	醬油	B 35
0.102	0.0064	0.302		34 ++	22 ++				Huang Tou Ya	黄豆芽	B 36
0.049	0.0016	0.224	4.2 ++	1.2 ++	1.2.30 +				Yün Pien Tou Chia (Hsien)	芸扁豆莢(鮮)	B 37

C. ROOTS, GREENS AND

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
C 1	Alfalfa (young leaves).	Medicago denticulata, Willd.	100	82.88	5.95	0.14	9.51	0.13	65	1.39	0.168
C 2	Amaranth, green.	Amaranthus mangostanus, L.	100	81.16	3.88	1.07	9.38	1.28	64	3.23	0.320
C 3	Amaranth, red.	Amaranthus blitum, L.	100	85.02	3.50	0.24	6.56	1.59	43	3.09	0.464
C 4	Aroid; Taro.	Colcasia antiquorom, Schott.	90	83.81	0.99	0.40	13.36	0.65	63	0.79	0.039
C 5	Aroid, large Cantonese.	——	70	77.27	2.17	0.80	17.32	1.47	87	0.97	0.033
C 6	Asparagus.	Asparagus officinalis, L.	63	94.30	0.71	0.31	3.41	0.68	20	0.59	0.016
C 7	Asparagus, salted dried.	,, ,,	100	35.40	4.22	0.39	27.62	9.10	134	23.27	0.780
C 8	Aster shoots.	Aster trinervius, Roxb.	100	86.37	3.90	0.91	5.92	1.09	49	1.81	0.145
C 9	Bamboo shoots spring variety.	Bambusa, sp.	48	92.66	2.10	0.33	3.19	0.79	25	0.93	0.009
C 10	Bamboo shoots, hairy large.	,, ,,	43	91.23	2.76	0.39	3.42	0.85	29	1.35	0.009
C 11	Bamboo shoots, soaked and dried.	,, ,,	100	93.71	1.16	0.19	3.05	1.79	19	0.10	0.007
C 12	Bamboo shoots, young.	,, ,,	70	89.88	1.80	nil	5.61	1.82	30	0.89	0.014
C 13	Bamboo shoots, young, salted.	,, ,,	100	57.12	4.67	1.19	6.75	2.75	59	27.52	0.121
C 14	Bamboo shoots, young dried.	,, ,,	100	27.67	16.54	2.42	29.35	6.34	211	17.68	0.121
C 15	Bamboo shoots, winter variety.	,, ,,	33	89.13	4.01	0.40	3.88	0.79	36	1.79	0.061
C 16	Bamboo shoots, steeped in hot oil.	,, ,,	100	86.94	2.48	2.04	3.77	0.54	45	4.23	0.020
C 17	Bamboo shoots, pickled.	,, ,,	100	86.67	2.20	2.08	3.53	1.23	43	4.29	0.021
C 18	Beet root.	Beta vulgaris, L.	100	85.31	1.46	0.23	11.05	0.74	54	1.21	0.032
C 19	Beet tops.	,, ,,	100	85.37	3.04	0.95	5.37	1.61	43	3.66	0.160
C 20	Beet, Sugar, tops.	Beta vulgaris, L. var. rapa.	100	93.91	1.66	0.32	2.06	0.58	18	1.47	0.031
C 21	Cabbage, Chinese	Brassica pekinensis, Rupr.	97	95.93	0.94	0.12	1.67	0.61	12	0.73	0.045
C 22	Cabbage, salted.	,, ,,	100	67.20	4.82	3.77	8.90	2.28	91	13.03	0.168
C 23	Cabbage, flat.	Brassica narinosa, Bailey.	100	90.86	2.95	0.35	3.05	1.01	28	1.78	0.241
C 24	Cabbage, foreign.	Brassica oleracea, L.	100	94.53	1.40	0.15	2.32	0.95	17	0.65	0.062
C 25	Cabbage, salted, Haining.	Brassica sp.	100	78.85	3.56	1.22	8.64	1.48	61	6.26	0.159
C 26	Cabbage, small.	Brassica chinensis, L.	100	94.34	1.60	0.19	1.94	0.75	16	1.18	0.141
C 27	Cabbage, small, sprouts.	,, ,,	100	93.31	1.96	0.37	2.09	0.62	20	1.65	0.075
C 28	Carrot, red.	Daucus carota L.	75	94.47	0.99	0.22	2.74	0.87	17	0.71	[illegible]

OTHER VEGETABLES.

P	Fe	K	Vitamins A	Vitamins B	Vitamins C	Vitamins D	Vitamins E	Vitamins G	Romanized Name	Chinese Name	No.
0.064	0.0076	0.314	4 +++	4 ++	14.9.17 +++		1.2 +++		Ts'ao T'ou, Mu Hsü	草頭, 苜蓿	C 1
0.087	0.0083	0.337	33 ++++	40. +++	9.14.17 ++++				Ch'ing Hsien Ts'ai	青莧菜	C 2
0.074	0.0235	0.546	33 +++		9.14 ++				Hung Hsien Ts'ai	紅莧菜	C 3
0.049	0.0039	0.395	1.2 ±	1.2 +	27 +				Yü T'ou	芋頭	C 4
0.061	0.0014	0.396							Kwangtung Ta Yü T'ou	廣東大芋頭	C 5
0.047	0.0019	0.202	1. ++	1. ++					Lung Hsü Ts'ai, Lu Sun	龍鬚菜, 蘆筍	C 6
0.073	0.0068	1.773							Lung Hsü Ts'ai (Kan)	龍鬚菜(乾)	C 7
0.069	0.0062	0.533							Ma Lan T'ou	馬蘭頭	C 8
0.024	0.0009	0.398		2 +	6.30 +			2 O	Ch'un Chu Sun	春竹筍	C 9
0.039	0.0007	0.486		2 O	30.9 +			2 O	Mao Sun	毛筍	C 10
0.010	0.0016	0.005							Shui Ch'in Kan Mao Sun	水浸乾毛筍	C 11
0.044	0.0020	0.475		40 ++	9 O				Pien Sun	鞭筍	C 12
0.061	0.0072	0.678							Yen Pien Sun	鹽鞭筍	C 13
0.444	0.0105	2.595							Pien Sun Kan	鞭筍乾	C 14
0.129	0.0052	0.694							Tung Sun	冬筍	C 15
0.069	0.0012	0.475							Yu Men Sun	油燜筍	C 16
0.041	0.0011	0.835							Kuan T'ou Chu Sun	罐頭竹筍	C 17
0.042	0.0022	0.370	2. +	1 ++	14.1.2 +			2 ++	T'ien Ts'ai Ken	菾菜根	C 18
0.040	0.0200	0.698	1.2.4 ++	1.2 ++	14 ++			2 +++	T'ien Ts'ai Yeh Ching	菾菜葉莖	C 19
0.036	0.0009	0.177	1. +	1.33 ++	1 +				T'ien Ts'ai, Ken Tao Ts'ai	菾菜, 根刀菜	C 20
0.029	0.0006	0.287	1.41. Oto +	40. ++	23.38 ++			29 low	Pai Ts'ai	白菜(大)	C 21
0.197	0.0377	1.392			1.2.24 O				Chin Tung Ts'ai	金冬菜	C 22
0.066	0.0033	0.599			+				T'ai Ku Ts'ai	太古菜	C 23
0.028	0.0007	0.253	1.2 ++	1.2 ++	1.2.24 +++	1 +	1 +	1.2 ++	Chüan Hsin Ts'ai	捲心菜	C 24
0.078	0.0070	0.051							Shih Hsien Ts'ai (Haining)	濕鹹菜(海寧)	C 25
0.029	0.0039	0.357	2 ++	1.2 ++	1.2.42 +++	1.2 +	1.2 +	1.2 +	Hsiao Pai Ts'ai	小白菜	C 26
0.055	0.0050	0.380	2 Oto +	1.2 ++	9 +++			1.2 +	Chi Mao Ts'ai	雞毛菜	C 27
0.023	0.0019	0.126	2 +++	2 ++	1.2 ++	1.2 ±		1.2 ++	Hung Hu Lo Fu	紅胡蘿蔔	C 28

C. ROOTS, GREENS AND

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
C 29	Carrot, yellow.	Daucus Carota, L.	98	90.10	0.30	0.21	7.85	0.85	35	0.69	0.032
C 30	Cauliflower	Brassica oleracea, var. botrytis, L.	46	90.54	3.31	0.28	3.53	1.07	31	1.27	0.015
C 31	Cedar shoots.	Cedrela sinensis, Juss.	100	83.65	5.97	1.02	6.57	1.31	61	1.48	0.030
C 32	Cedar, salted.	,, ,,	99	82.66	4.52	0.56	4.81	1.51	43	5.94	0.175
C 33	Cedar, salted, dried	,, ,,	100	53.72	6.61	0.93	7.91	2.16	68	28.67	0.158
C 34	Celery, Chinese.	Apium graveolens, L.	80	93.64	0.52	0.40	3.30	1.18	17	1.22	0.110
C 35	Celery, Foreign.	,, ,,	86	92.93	0.88	0.02	3.64	1.17	19	1.36	0.059
C 36	Celery, Water.	Oenanthe stolonifera, D.C.	86	93.30	1.51	0.28	2.47	1.04	19	1.40	0.062
C 37	Chrysanthemum.	Chrysanthemum coronarium, L.	88	93.57	1.85	0.43	2.57	0.60	22	0.98	0.065
C 38	Colza, small.	Brassica campestris, L. var. oleifera.	100	95.20	1.20	0.19	1.58	0.53	13	1.30	0.181
C 39	Colza, large.	Brassica juncea, H.F. var. oleifera.	100	95.25	1.11	0.33	1.92	0.46	15	0.93	0.108
C 40	Colza, salted.	,, ,,	100	91.54	1.68	0.29	2.32	0.83	19	3.34	0.069
C 41	Colza shoots.	Brassica juncea, H.F. var. oleifera.	100	93.51	1.85	0.49	2.59	0.75	23	0.81	0.071
C 42	Colza, dried flowering top.	,, ,,	100	16.57	27.60	3.78	28.90	15.70	267	7.45	0.614
C 43	Coriander.	Coriandrum sativum, L.	80	86.99	2.36	0.71	6.62	1.37	43	1.95	0.171
C 44	Egg plant.	Solanum Melongena. L.	97	92.82	1.00	0.31	4.38	0.91	25	0.58	0.017
C 45	Fennel.	Foeniculum vulgare, L.	53	86.66	3.80	0.59	6.43	0.63	47	1.89	0.092
C 46	Fennel, young.	,, ,,	81	87.88	3.64	0.71	6.63	0.13	49	1.97	0.114
C 47	Garlic.	Allium sativum, L.	97	62.52	5.45	0.24	29.20	0.91	144	1.68	0.010
C 48	Garlic, green.	,, ,,	50	90.21	3.46	0.84	3.36	1.10	36	1.03	0.074
C 49	Ginger.	Zingiber officinale, Rosc.	100	89.14	1.26	0.57	6.87	0.90	39	1.26	0.020
C 50	Ginger, pickled.	,, ,,	100	75.86	2.18	0.70	7.46	0.92	46	12.88	0.088
C 51	Ginger shoots.	,, ,,	97	93.04	0.85	0.55	3.01	1.18	21	1.37	0.042
C 52	Kohl-rabi.	Brassica caulorapa, Pasq.	96	89.76	1.65	0.11	6.55	0.94	35	0.99	0.034
C 53	Leeks.	Allium odorum, L.	100	91.79	3.10	0.61	2.72	0.73	30	1.05	0.084
C 54	Leek shoots.	,, ,,	100	95.25	1.72	0.22	1.97	0.57	17	0.27	0.010
C 55	Lettuce.	Lactuca sativa, L.	98	94.00	1.37	0.26	3.22	0.52	21	0.63	0.035
C 56	Lettuce stems, Chinese,	Lactuca Scariola, L. var.	55	95.75	1.08	0.25	2.08	0.28	15	0.56	0.016

OTHER VEGETABLES.—*(Continued)*

P	Fe	K	VITAMINS A	B	C	D	E	G	Romanized Name	Chinese Name	No.
0.032	0.0006	0.212	2 +++	2.40 ++	1.2.33 ++	1.2 ±		1.2. ++	Hu Lo Fu	胡蘿蔔	C 29
0.082	0.0012	0.402	4. +	1.2 +	23.6 +++			2 ++	Ts'ai Hua	菜花	C 30
0.102	0.0032	0.576		34 O	7 low +				Hsien Hsiang Ch'un T'ou	鮮香椿頭	C 31
0.096	0.0046	0.499		34 O					Yen Hsien Hsiang Ch'un T'ou	鹽鮮香椿頭	C 32
0.108	0.0220	0.722		34 O					Yen Hsiang Ch'un T'ou (Kan)	鹽香椿頭(乾)	C 33
0.039	0.0031	0.218	1.4 +	1.40 ++	6 ±	6 ±			Ch'in Ts'ai	芹菜	C 34
0.015	0.0027	0.146	4.1.2. +	1.2 ++	6 ±	6 ±			Yang Ch'in Ts'ai	洋芹菜	C 35
0.053	0.0052	0.547							Shui Ch'in Ts'ai	水芹菜	C 36
0.024	0.0021	0.125		40 +++	9 ++				T'ung Hao Ts'ai	筒蒿菜	C 37
0.040	0.0070	0.329		1.2 +	9 ++			1.2 ++	Hsiao Ch'ing Ts'ai	小青菜	C 38
0.030	0.0010	0.185		1.2 +	9 +++			1.2 ++	Ch'ing Ts'ai	青菜	C 39
0.052	0.0023	0.205							Hsien Ch'ing Ts'ai	鹹青菜	C 40
0.018	0.0022	0.222							Yu Ts'ai Chieh	油菜節	C 41
0.598	0.0146	1.773							Kan Yu Ts'ai T'ai	乾油菜薹	C 42
0.080	0.0063	0.665			6.7.34. ++				Yüan Sui, Hsiang Ts'ai	蒝荽，香菜	C 43
0.030	0.0014	0.253	1.2.4 +	1.4.41 +	30.1 +				Ch'ieh Tzu	茄子	C 44
0.079	0.0043	0.395							Hui Hsiang Ts'ai (Lao)	茴香菜(老)	C 45
0.054	0.0208	0.282							Hui Hsiang Ts'ai (Nen)	茴香菜(嫩)	C 46
0.227	0.0023	0.602		40 +	6.7.9. ++				Ta Suan	大蒜	C 47
0.049	0.0030	0.368							Ch'ing Suan	青蒜	C 48
0.045	0.0070	0.387	33 +		7. 9 + low				Chiang	薑	C 49
0.026	0.0033	0.379							Chiang Lao Chiang	醬老薑	C 50
0.055	0.0049	0.475			7. +				Chiang Ya	薑芽	C 51
0.047	0.0016	0.328			6.9.34 ++++				P'ieh Lan (P'ieh La)	苤藍(撇拉)	C 52
0.043	0.0089	0.326		33 +	6.7.9 +				Chiu Ts'ai	韭菜	C 53
0.009	0.0005	0.062			7 +				Huang Chiu Ya	黃韭芽	C 54
0.041	0.0012	0.202	2.1 ++	1. ++	1.42 ++	1.2 O	1.2 +++	1.2 ++	Sheng Ts'ai	生菜	C 55
0.141	0.0010	0.231		34 O	6.9.34. O				Wo Sun	萵筍	C 56

C. ROOTS, GREENS AND

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
C 57	Lettuce leaf, Chinese.	Lactuca Scariola, L. var. sativa.	27	92.91	2.28	0.63	2.59	0.68	26	0.91	0.071
C 58	Lily flowers, dried.	Hemerocallis fulva, L.	100	18.13	9.33	2.45	60.49	4.76	309	4.84	0.298
C 59	Lotus root.	Nelumbium nucifera, Gaerth.	94	95.70	0.40	0.02	2.63	0.13	13	1.12	0.035
C 60	Mustard leaves.	Brassica juncea, Thoms.	94	93.46	1.80	0.26	2.86	0.73	22	0.89	0.056
C 61	Mustard leaves, dried.	,, ,,	100	14.54	18.16	2.26	40.09	12.78	260	12.17	1.163
C 62	Mustard leaves, Shaoshing.	,, ,,	100	48.07	8.99	1.87	15.10	5.72	116	20.25	0.354
C 63	Mustard leaves, salted.	,, ,,	100	83.08	1.50	0.40	4.07	1.65	27	9.30	0.214
C 64	Mustard root.	,, ,,	100	88.02	1.49	0.14	7.11	2.07	37	1.17	0.039
C 65	Mustard root, spiced.	,, ,,	100	67.26	4.40	1.20	5.68	3.08	52	18.38	0.224
C 66	Mustard root, pickled.	,, ,,	100	50.38	3.69	0.66	19.54	2.92	102	22.81	0.214
C 67	Onion, Chinese.	Allium fistulosum, L.	90	90.62	1.21	0.34	6.91	0.63	37	0.29	0.018
C 68	Onion, Foreign.	Allium Cepa, L.	95	90.37	1.40	0.04	6.78	0.86	34	0.55	0.040
C 69	Onion, Small.	Allium fistulosum, L.	90	91.09	1.74	0.53	5.23	0.77	34	0.64	0.119
C 70	Peppers, green. Chillies.	Capsicum annuum, L. var.	98	92.97	1.40	0.15	3.05	1.93	20	0.50	0.017
C 71	Peppers, Red.	,, ,,	90	87.08	1.71	0.54	7.16	2.62	41	0.89	0.012
C 72	Potato.	Solanum tuberosum, L.	96	81.23	1.80	0.02	15.83	0.37	73	0.75	0.013
C 73	Potato, Sweet.	Ipomaea Batatas, Lam.	100	75.25	1.08	0.19	21.49	1.37	94	0.62	nil
C 74	Potato, Sweet, Canton.	——	97	77.19	0.61	0.54	20.83	0.20	93	0.63	0.038
C 75	Parsnip.	Peucedanum sativum, L.	95	66.74	2.46	1.50	25.99	2.00	131	1.31	0.054
C 76	Radish,	Raphanus sativus, L.	100	91.89	0.63	0.08	5.18	1.40	24	0.82	0.017
C 77	Shepherds purse.	Capsella bursapastoris, Moench.	100	87.83	3.30	0.58	5.01	1.02	39	2.26	0.356
C 78	Shepherds purse.	,, ,,	100	91.42	2.91	0.34	3.25	0.63	28	1.45	0.061
C 79	Spinach.	Spinacea oleracea, Mill.	100	91.46	2.40	0.30	3.20	0.88	26	1.76	0.103
C 80	Tomato.	Lycopersicum esculentum, Mill.	99	95.00	1.15	0.30	2.56	0.56	18	0.43	0.008
C 81	Turnip, white.	Brassica Rapa, L. var.	100	95.51	0.70	0.24	1.76	0.86	12	0.93	0.038
C 82	Turnip, salted,	,, ,,	100	51.43	2.84	0.69	21.77	2.42	107	20.85	0.249
C 83	Turnip, pickled.	,, ,,	100	74.15	2.48	0.29	12.61	1.15	65	9.32	0.074
C 84	Turnip, green, salted.	,, ,,	100	61.65	1.80	0.31	11.74	1.22	59	23.28	0.083

OTHER VEGETABLES.—*(Continued)*

P	Fe	K	VITAMANS A	B	C	D	E	G	Romanized Name	Chinese Name	No.
0.035	0.0027	0.203		40 +++					Wo Sun Yeh	萵 筍 葉	C 57
0.261	0.0243	1.658	34 ++	34 +					Chin Chen Ts'ai	金 針 菜 (黃 花 菜)	C 58
0.124	0.0014	0.403			6.7.34 ++				Ou	藕	C 59
0.021	0.0019	0.099	5.41. ++	5.41 ++	9. ++++	5 ++			Chieh Ts'ai Yeh (Hsien)	芥菜葉(鮮)	C 60
0.314	0.0262	2.031							Kan Chieh Ts'ai Yeh	乾芥菜葉	C 61
0.021	0.0167	0.199							Shao Hsing Kan Ts'ai	紹興乾菜	C 62
0.033	0.0166	0.223		24 O					Hsien Ts'ai, Hsüeh Li Hung	鹹菜，雪裏紅	C 63
0.037	0.0010	0.447				6 O			Ta T'ou Ts'ai Ken (Hsien)	大頭菜根(鮮)	C 64
0.125	0.0081	1.328							Cha Ts'ai	榨 菜	C 65
0.049	0.0082	0.981							Ta T'ou Ts'ai	大 頭 菜	C 66
0.018	0.0006	0.114		33 +	9.24 ++				Ta Ts'ung	大 葱	C 67
0.050	0.0018	0.212	4.2 O to +	1.2.40 +	1.2 ++			2 +	Yang Ts'ung T'ou	洋 葱 頭	C 68
0.032	0.0014	0.175			7 + low				Hsiao Ts'ung	小 葱	C 69
0.037	0.0021	0.254	1.2.15 ++	1.2.40 ++	17.6 +				Ch'ing La Chiao	青 辣 椒	C 70
0.071	0.0010	0.374	15 ++		14.15 ++++				Hung Shih Hsing La Chiao	紅柿形辣椒	C 71
0.057	0.0013	0.290	1. O to ±	1.2 +	1.6. ++			2 ++	Fan Shu	番 薯	C 72
0.060	0.0006	0.194	4 ++	1.2.41 ++	1.2.33 ++				Pai Shu, Shan Yü	白薯，山芋	C 73
0.028	0.0017	0.168	1.2	40 +					Pai Shu (Kwangtung)	白薯，(廣東)	C 74
0.117	0.0050	0.451	1.2 O to +	2.4 ++					Chin Ts'ai Lo Fu (YangFangFeng)	金菜蘿蔔 (洋 防 風)	C 75
0.044	0.0004	0.267	1.2 O	1.2.40 ++	35 ++				Pien Lo Fu, La Hung	扁蘿蔔，辣紅	C 76
0.068	0.0242	0.486	++	++	6.9 ++++				Ch'i Ts'ai	薺 菜	C 77
0.129	0.0087	0.301							Yeh Ts'ai	野 菜	C 78
0.038	0.0195	0.400	1.2.4 +++	1.2.40 ++	4.33 +++	1.2 ±		1.2 ++	Po Ts'ai	菠 菜	C 79
0.011	0.0008	0.239	1.2 ++	1.2.40 ++	1.2 +++			2 +	Fan Ch'ieh	番 茄	C 80
0.025	0.0018	0.326	4 O to +	2 +	9.38 ++			1 O to +	Pai Lo Fu	白 蘿 蔔	C 81
0.134	0.0140	1.388		24 O					Yen Pai Lo Fu Kan	鹽白蘿蔔乾	C 82
0.067	0.0032	0.307							Chiang Pai Lo Fu	醬白蘿蔔	C 83
0.059	0.0079	0.420							Ch'ing Lo Fu Kan	青蘿蔔乾	C 84

C. ROOTS, GREENS AND

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm.	Ash	Ca
C 85	Vegetables, pickled.	Brassica Rapa, L. var.	100	60.12	4.69	1.03	16.67	2.87	97	14.62	0.057
C 86	Water Bamboo.	Zizania aquatica, L.	84	92.37	0.95	0.26	4.65	1.10	25	0.67	0.011
C 87	Water Chestnut.	Scirpus tuberosus, Roxb.	74	84.94	0.77	0.30	12.68	0.51	58	0.80	0.004
C 88	Yam.	Dioscorea Batatas, Dcne.	90	76.76	1.87	0.06	19.86	0.45	90	1.00	0.044

D. CUCURBITS,

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm.	Ash	Ca
D 1	Calabash.	Lagenaria vulgaris, Ser. var. clavata.	85	94.50	0.64	0.09	3.33	1.06	17	0.38	0.012
D 2	Cantaloupe.	Cucumis melo, L,	83	96.12	0.14	0.13	2.82	0.39	13	0.39	0.008
D 3	Cucumber.	Cucumis sativus, L.	100	95.23	1.05	0.13	2.31	0.74	15	0.54	0.031
D 4	Cucumber, pickled.	,, ,,	100	66.65	6.63	0.95	12.01	3.19	85	10.57	0.079
D 5	Gourd, bitter.	Momordica charantia, L.	81	93.91	0.91	0.23	3.29	1.10	19	0.56	0.021
D 6	Gourd, white.	Benincasa cerifera, Savi.	78	96.91	0.40	0.05	1.77	0.59	9	0.28	0.019
D 7	Loofah.	Cuffa cylindrica, Roem.	90	93.42	1.40	0.10	4.28	0.32	24	0.48	0.018
D 8	Musk melon.	Cucumis conomon, Mak.	80	92.42	0.38	0.45	5.64	0.41	29	0.70	0.019
D 9	Pumpkin.	Cucurbita pepo , L.	76	96.55	0.55	0.17	1.90	0.46	12	0.37	0.017
D 10	Squash.	Cucurbita maxima, L.	82	86.51	1.70	nil	10.18	0.56	49	1.05	0.031
D 11	Squash, old.	,, ,,	76	92.13	0.49	0.35	6.01	0.49	30	0.53	0.020
D 12	Water melon.	Citrullus vulgaris, L.	50	12.30	0.58	0.43	6.33	0.10	33	0.26	0.006
D 13	Water melon, small.	,, ,, var.	62	96.58	0.21	0.25	2.63	0.06	14	0.27	0.008

E. MUSHROOMS AND

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm.	Ash	Ca
E 1	Agar-agar.	Gelidium corneum, Laner.	100	22.41	0.97	nil	73.39	nil	305	3.23	0.474
E 2	Fungus.	——	100	14.86	14.63	0.23	51.16	3.94	272	15.18	0.406

OTHER VEGETABLES.—*(Continued)*

P	Fe	K	VITAMINS						Romanized Name	Chinese Name	No.
			A	B	C	D	E	G			
0.096	0.0141	0.249							Chiang Hsiao Ts'ai	醬 小 菜	C 85
0.052	0.0012	0.293			9 O				Chiao Pai	茭 白	C 86
0.045	0.0008	0.436		34 O	7.34 ++				Pi Ch'i	荸 薺	C 87
0.050	0.0011	0.076			7 low +				Shan Yao	山 藥	C 88

(MELON FAMILY)

0.017	0.0003	0.165		34 ++					Yeh K'ai Hua, Hu Tzu	夜開花，瓠子	D 1
0.008	0.0004	0.030	2 ++	40 +++	2 ++				Ch'ing P'i T'ien Kua	青 皮 甜 瓜	D 2
0.031	0.0010	0.225	2 ±	2 +	2 ++				Huang Kua	黃 瓜	D 3
0.165	0.0084	0.408							Chiang Huang Kua	醬 黃 瓜	D 4
C.032	0.0066	0.208		40 +++					K'u Kua	苦 瓜	D 5
0.006	0.0004	0.124		34 +					Tung Kua	冬 瓜	D 6
0.039	0.0009	0.186		34 ++					Szu Kua	絲 瓜	D 7
0.022	0.0003	0.348							Huang Chin Kua	黃 金 瓜	D 8
0.047	0.0005	0.017	2 ++	2.34 +	2 +				Hsi Hu Lu (Lao)	西葫蘆(老)	D 9
0.040	0.0011	0.479	2 ++	40 ++					Nan Kua	南 瓜	D 10
0.029	0.0005	0.124							Nan Kua (Lao)	南 瓜 (老)	D 11
0.010	0.0002	0.113							Hsi Kua	西 瓜	D 12
0.007	0.0003	0.126							Pang Kua	浜 瓜	D 13

SEAWEEDS.

nil	0.0077	0.295							Yang Fen, Hai Ts'ai	洋 粉，海 菜	E 1
0.157	0.2900	0.181							Ke Hsien Mi	葛 仙 米	E 2

E. MUSHROOMS AND

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
E 3	Fungus.	——	100	15.77	6.60	3.12	68.01	0.99	335	5.51	0.643
E 4	Mushrooms.	Russula, sp.	100	11.98	13.98	1.67	62.11	6.34	328	3.92	0.061
E 5	Mushrooms.	Agaricus Bretschneideri K. & T.	100	10.45	14.38	1.99	59.19	8.55	321	5.44	0.124
E 6	Mushrooms.	Agaricus campestris, L.	100	9.08	36.09	3.54	31.02	6.00	308	14.27	0.131
E 7	Mushrooms, Jew's ear.	Auricularia auricula-Judae, Schröt.	100	14.36	9.42	1.18	65.37	4.24	317	5.43	0.210
E 8	Seaweed, Laver.	Porphyra laciniata, Ag.	100	9.20	24.74	0.90	31.14	3.47	237	30.55	0.912
E 9	Seaweed, Seagirdle	Laminaria religiosa, Miyabe.	100	56.24	5.79	0.44	22.35	5.29	119	9.89	0.100
E 10	Seaweed, Seahair	Nostoc commune, Vauch.	100	13.11	20.00	0.33	56.53	2.03	317	8.00	0.767
E 11	Seaweed, Gulfweed.	Sargassum siliquastrum, Ag.	100	17.48	20.92	3.72	28.95	0.20	239	28.73	0.329

F. FRESH

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
F 1	Apple, Chinese	Pirus malus, L.	75	86.92	0.27	0.24	11.38	0.95	50	0.24	0.022
F 2	Apricot (Tsingtao)	Prunus armeniaca, L.	91	89.37	0.88	0.51	4.80	2.13	28	2.31	0.062
F 3	Apricot (Hangchow)	,, ,,	91	91.14	0.62	0.67	4.77	1.48	28	1.32	0.021
F 4	Banana (Canton).	Musa sapientum, L.	50	81.53	1.26	0.85	14.73	0.66	74	0.97	0.010
F 5	Canarium.	Canarium album, Raeusch.	80	79.90	1.15	0.97	12.03	4.12	63	1.63	0.204
F 6	Cherry.	Prunus pseudocerasus, Lindl.	42	90.52	1.09	0.23	6.99	0.66	35	0.51	0.006
F 7	Fig, Chinese.	Ficus carica, L.	74	83.62	0.99	0.44	12.58	1.92	60	0.45	0.049
F 8	Fig, foreign.	,, ,,	80	82.05	0.98	0.81	14.85	0.76	73	0.53	0.051
F 9	Grape, long, white.	Vitis vinifera, L. var.	75	88.56	0.38	0.53	9.17	1.07	44	0.29	0.009
F 10	Grape, purple	,, ,,	87	87.88	0.36	0.64	8.20	2.63	41	0.27	0.010
F 11	Lemon.	Citrus Medica L. var. Limonum, Hoak.	65	89.37	0.82	0.89	7.84	0.65	44	0.43	0.033
F 12	Litchi (Fukien).	Litchi chinensis, Sonn.	63	84.83	0.68	0.58	13.31	0.23	63	0.37	0.006
F 13	Loquat, red.	Eriobotrya japonica, Lindl.	56	89.58	0.50	0.68	8.07	0.81	41	0.36	0.015
F 14	Loquat, white.	,, ,,	61	83.32	0.53	0.22	14.65	0.41	64	0.87	0.030
F 15	Mango.	Mangifera indica, L.	78	82.45	0.56	0.86	15.22	0.46	73	0.45	0.007

SEAWEEDS.—*(Continued)*

P	Fe	K	VITAMINS A	B	C	D	E	G	Romanised Name	Chinese Name	No.
0.250	0.0304	0.987							Yin Erh, Pai Mu Erh	銀耳，白木耳	E 3
0.343	0.0089	1.606							Tung Ku	冬　菇	E 4
0.415	0.0253	1.960	1. 2. 24 very low	24 O	1.24 O	1.2.24 O			Hsiang Chün	香　菌	E 5
0.718	0.1885	3.169	1. 2. 24 very low	1.2.24 ++	1.24 O	24 ++			Mo Ku Chün	蘑　菰　菌	E 6
0.210	0.1013	0.773	24 O	24 O	24 O	24 O			Mu Erh	木　耳	E 7
0.721	0.1832	5.493	+++	++					Tzu Ts'ai	紫　菜	E 8
0.115	0.0060	1.503							Hai Tai	海　帶	E 9
0.045	0.1206	0.213							Fa Ts'ai	髮　菜	E 10
0.203	0.0994	0.488							Hai Tsao	海　藻	E 11

FRUITS.

P	Fe	K	A	B	C	D	E	G	Romanised Name	Chinese Name	No.
0.007	0.0010	0.083	1.2.4 +	1.2.4 +	1.2.9 ++			2 +	P'ing Kuo	蘋　果	F 1
0.085	0.0033	1.271	1 ++		2.9 O				Hsing, (T'singtao)	杏（青　島）	F 2
0.056	0.0016	0.699	1 ++		2.3 O to +				Hsing, (Hangchow)	杏（杭　州）	F 3
0.035	0.0008	0.474	1.2.41 ++	1.2.41 +	1.2.33 +++	1. ±	1.2 ++	1. ++	Hsiang Chiao (Canton)	香蕉（廣東）	F 4
0.060	0.0014	0.493							Kan Lan, Ch'ing Kuo	橄欖，青果	F 5
0.031	0.0059	0.112	1.2 ++	1.2 ++	9 +				Ying T'ao	櫻　桃	F 6
0.023	0.0004	0.180							Chung Kuo Wu Hua Kuo	中國無花果	F 7
0.029	0.0013	0.172	2 +	+	O			+	Wai Yang Wu Hua Kuo	外洋無花果	F 8
0.014	0.0014	0.119	1.2 +	1.2. +	1.2 ++			O	Ch'ang Pai P'u T'ao	長白葡萄	F 9
0.008	0.0030	0.095	1 +	1 +				O	Tzu P'u T'ao	紫　葡　萄	F 10
0.024	0.0006	0.193	1 ±	1 ++	1.16 +++				Ning Meng	檸　檬	F 11
0.034	0.0005	0.205	2 O	2 O	9.30 ++				Li Chih (Fuchien)	荔枝（福建）	F 12
0.016	0.0003	0.203			9 O				P'i Pa, Hung	枇　杷，紅	F 13
0.055	0.0004	0.493							Pai P'i Pa, (Tung-t'ing)	白枇杷(洞庭)	F 14
0.022	0.0003	0.304	19.1.41 +	40 +++	9.42 +++			+++	Mang Kuo	杧　果	F 15

F. FRESH

No	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories 100 gm	Ash	Ca
F 16	Orange (Siam).	Citrus Tankan, Hoyada.	64	89.39	0.41	0.58	8.38	0.71	41	0.53	0.030
F 17	Orange (Fukien).	Citrus nobilis, Lour. var.	80	86.76	0.58	0.35	11.55	0.40	53	0.36	0.020
F 18	Orange (Swatow).	Citrus poonensis, Hort. ex Tankan.	78	89.18	0.64	0.16	9.23	0.34	42	0.45	0.034
F 19	Orange (Wenchow).	Citrus nobilis, Lour. var.	80	88.33	0.75	0.14	9.86	0.37	45	0.55	0.041
F 20	Peach (Ningpo).	Prunus persica, S. et Z. var. vulgaris Maxim.	74	82.38	0.79	0.60	14.84	0.66	70	0.73	0.007
F 21	Pear, Chinese.	Pirus sinensis, Lindl.	80	88.13	0.18	0.23	10.61	0.45	46	0.40	0.010
F 22	Pear.	Pirus sp.	74	95.35	0.29	0.14	4.01	0.78	19	0.43	0.010
F 23	Persimmon.	Diospyros kaki, L.	80	82.21	0.35	0.20	16.30	0.57	70	0.37	0.010
F 24	Plum (Hangchow).	Prunus mume, S. et Z. var.	93	91.13	0.93	0.94	5.07	1.07	33	0.86	0.011
F 25	Pomegrante.	Punica granatum, L.	15	78.73	0.64	0.55	16.79	2.46	77	0.83	0.013
F 26	Pumelo.	Citrus decumana, L.	61	84.82	0.74	0.56	12.20	0.82	58	0.86	0.041
F 27	"Red fruits", (Haws).	Crataegus pinnatifida, Bge.	90	73.86	0.44	1.03	22.10	1.78	102	0.79	0.085
F 28	Strawberry.	Fragaria, sp.	100	91.52	1.00	0.52	4.37	2.07	27	0.52	0.032
F 29	Sugar cane.	Saccharum officinarum, L.	82	84.25	0.22	0.50	12.32	2.30	56	0.41	0.008

G. NUTS, SEEDS AND

No	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories 100 gm	Ash	Ca
G 1	Apricot kernels. (sweet).	Prunus armeniaca, L.	100	6.39	25.40	47.30	15.04	2.97	606	2.90	0.139
G 2	Canarium, salted. (Chinese olive).	Canarium album, Raeusch.	68	46.54	1.85	3.62	20.99	6.50	127	20.50	0.160
G 3	Chestnut.	Castanea vulgaris, Lam.	80	50.53	4.45	1.38	41.47	1.19	201	0.98	0.015
G 4	Chestnut, Baked,	,, ,,	80	38.04	4.65	2.10	52.31	1.43	254	1.47	0.037
G 5	Foxnut, dried.	Euryale ferox, Salish.	100	13.55	9.80	0.26	75.67	0.16	352	0.56	0.039
G 6	Ginkgo seeds, dried.	Ginkgo biloba, L.	73	53.68	6.48	2.46	35.75	0.30	196	1.32	0.010
G 7	Hazel nut.	Corylus heterophylla, Fisch.	16	10.23	21.00	49.70	12.17	2.79	598	4.11	0.816
G 8	Jujube, dried. (Chinese date).	Zizyphus vulgaris, Lam.	90	27.85	2.90	2.32	62.94	2.72	292	1.27	0.063
G 9	Jujube preserved, (Honey dates).	,, ,,	90	17.17	1.11	1.49	77.91	1.57	338	0.75	0.026

FRUITS.—*(Continued)*

P	Fe	K	VITAMINS A	VITAMINS B	VITAMINS C	VITAMINS D	VITAMINS E	VITAMINS G	Romanized Name	Chinese Name	No.
0.026	0.0004	0.323	1.2 +	1.40 ++	17 ++	1. almost O	1.2 +	++	Chü (Hsien Lo)	橘(桔)(暹羅)	F 16
0.008	0.0020	0.142	1.2 +	1. ++	16 ++	1. almost O	1.2 +		Fuchien Hsiao Hung Chü	福建小紅桔	F 17
0.020	0.0005	0.167	1.2 +	1. ++	14 +++	1. almost O	1.2 +		Shan T'ou Mi Chü	汕頭蜜桔	F 18
0.014	0.0008	0.217	1.2 +	1. ++	17 +	1. almost O	1.2 +		Huang Yen Chü	黃巖桔	F 19
0.032	0.0008	0.445	1. ++	1.4 +	1.2 ++				T'ao (Ningp'o)	桃(寧波)	F 20
0.007	0.0007	0.135		1. ++					Ya Li (Tientsin)	鴨梨(天津)	F 21
0.017	0.0006	0.178							Sheng Li Kua	生梨瓜	F 22
0.025	0.0004	0.138	33.34 ++	34.2 O	30.11 +				Shih	柿	F 23
0.036	0.0018	0.424		1. +	9 O				Ch'ing Mei (Hangchow)	青梅(杭州)	F 24
0.016	0.0016	0.220			1.34 ++				Shih Liu	石榴	F 25
0.043	0.0009	0.332	33 +		9.17 ++++				Yu	柚	F 26
0.025	0.0021	0.327			13.1.34. ++				Shan Li Hung, Hung Kuo	山裏紅, 紅果	F 27
0.041	0.0011	0.242	1.2 ±	1.2 +	1.23 +++				Hsi Yang Yang Mei	西洋楊梅	F 28
0.004	0.0013	0.089	2 O	2 O	2.9 O				Kan Che (Canton)	甘蔗(廣東)	F 29

DRIED FRUITS.

P	Fe	K	A	B	C	D	E	G	Romanized Name	Chinese Name	No.
0.349	0.0050	0.716	4 +	4 ++					Hsing Jen (T'ien)	杏仁(甜)	G 1
0.016	0.0063	0.616							Yen Kan Lan	鹽橄欖	G 2
0.091	0.0017	0.549		1.33 +				2 +	Li Tzu	栗子	G 3
0.150	0.0019	0.504							Ch'ao Shu Li Tzu	炒熟栗子	G 4
0.086	0.0012	0.057			24 O				Chi T'ou Mi, Ch'ien	雞頭米, 芡	G 5
0.218	0.0015	0.529							Pai Kuo, Yin Hsing	白果, 銀杏	G 6
0.556	0.0083	0.967		1.2 ++					Chen Tzu	榛子	G 7
0.061	0.0031	0.632							Hung Tsao	紅棗	G 8
0.043	0.0027	0.273			63 low				Chin Szu Mi Tsao	金絲蜜棗	G 9

G. NUTS SEEDS AND

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
G 10	Jujube, Smoked.	Zizyphus vulgaris, Lam.	90	22.78	3.11	3.46	62.08	6.62	299	1.95	0.053
G 11	Kolanut (Dryandra)	Sterculia platanifolia, L.F.	70	2.48	23.60	38.80	28.42	2.16	574	4.54	0.027
G 12	Locust seeds.	Sophora japonica, L.	100	4.54	19.32	11.60	51.41	9.46	398	3.67	0.253
G 13	Lotus seeds, dried.	Nelumbium nucifera, Gaertn.	98	13.47	16.62	1.97	61.87	2.17	340	3.90	0.089
G 14	Lotus seeds, preserved.	,, ,,	100	23.08	5.63	0.83	68.77	0.76	314	0.93	0.056
G 15	Lungngans, dried.	Nephelium longana, Camb.	35	25.63	3.95	0.03	64.34	2.16	280	3.89	0.041
G 16	Peanut.	Arachis hypogoea, L.	63	7.27	24.68	48.77	15.12	2.10	616	2.06	0.036
G 17	Peanut, small	,, ,,	62	7.02	28.00	48.60	11.53	2.32	614	2.53	0.070
G 18	Peanut, fried.	,, ,,	100	6.39	20.70	48.40	19.81	2.50	616	2.20	0.395
G 19	Peanut, salted.	,, ,,	98	2.19	26.70	45.20	19.95	2.82	611	3.14	0.124
G 20	Persimmon, dried.	Diospyros Kaki, L.	97	34.76	1.90	0.47	59.70	1.58	256	1.59	0.038
G 21	Pine seed.	Pinus tubulaeformis, Carr.	30	3.59	15.33	63.25	12.37	2.82	702	2.64	0.077
G 22	Pumpkin seed, salted.	Cucurbita pepo, L.	64	3.05	26.53	51.60	10.56	1.18	632	7.08	0.056
G 23	Yew seeds.	Torreya nucifera, S. et Z.	60	6.43	10.01	44.12	29.61	6.86	573	2.97	0.071
G 24	Raisin.	Vitis vinifera, L.	100	25.31	3.11	0.48	68.54	0.18	299	2.38	0·057
G 25	Sunflower seed.	Helianthus annuus, L.	50	5.56	30.36	44.67	12.61	2.66	592	4.14	0.044
C 26	Walnut.	Juglans regia, Lour.	41	3.23	15.78	66.85	10.81	1.51	730	1.82	0.119
G 27	Water calthrop, large.	Trapa natans, L.	43	45.46	4.97	0.67	46.63	0.88	218	1.39	0.036
G 28	Water calthrop, red.	,, ,,	45	81.23	2.56	0.31	14.37	0.45	72	1.08	0.022
G 29	Watermelon seed, dried.	Citrullus vulgaris, Schrad.	36	2.81	21.25	43.06	26.50	1.69	597	4.69	0.238
G 30	Watermelon seed, pickled.	,, ,,	35	4.44	30.81	35.34	23.32	1.95	551	4.14	0.044
G 31	Watermelon seed, salted.	,, ,,	35	2.61	32.28	39.66	19.04	1.81	579	4.60	0.237
G 32	Watermelon seed, sugared.	,, ,,	36	2.48	27.70	53.40	11.17	1.71	655	3.54	0.069

DRIED FRUITS.—*(Continued)*

P	Fe	K	VITAMINS A	B	C	D	E	G	Romanized Name	Chinese Name	No.
0.123	0.0043	0.562							Hei Tsao	黑棗	G 10
0.212	0.0048	1.206							Wu T'ung Tzu	梧桐子	G 11
0.260	0.0241	1.018		34 O					Huai Tzu	槐子	G 12
0.285	0.0064	2.057							Kan Lien Tzu	乾蓮子	G 13
0.132	0.0022	0.138							Mi Chien Lien Tzu	蜜餞蓮子	G 14
0.177	0.0049	1.549							Kuei Yüan, Lung Yen.	桂圓，龍眼	G 15
0.383	0.0020	1.004	1.2 + low.	31 ++			1.2 +		Lo Hua Sheng	落花生	G 16
0.408	0.0029	1.212	2 +	1.4 ++			2 +		Chung Kuo Hsiao Hua Sheng	中國小花生	G 17
0.107	0.0020	0.557							Yu Cha Hua Sheng Jen	油炸花生仁	G 18
0.180	0.0016	0.738							Wu Hsiang Hua Sheng Jen	五香花生仁	G 19
0.078	0.0048	0.445							Shih Ping (Shantung)	柿餅(山東)	G 20
0.234	0.0066	0.620	1.4 +	1.4 +					Sung Jen	松仁	G 21
0.305	0.0105	0.830							Yen Pai Kua Tzu	鹹白瓜子	G 22
0.275	0.0036	0.850							Fei Tzu	榧子	G 23
0.140	0.0038	0.619	1 O	2 +	1 O				P'u T'ao Kan (Boy P'ai)	葡萄乾 (Boy 牌)	G 24
0.344	0.0042	0.815	2 O	4 +	1 O				Hsiang Jih K'uei Tzu	向日葵子	G 25
0.362	0.0035	0.536	1.2 +	1.2 ++			2 +		Ho T'ao	核桃	G 26
0.165	0.0016	0.574			24 +				Ling Chüeh Mi	菱角米	G 27
0.121	0.0011	0.403							Hung Shui Ling	紅水菱	G 28
1.139	0.0087	0.834							Hsi Kua Tzu	西瓜子	G 29
0.684	0.0079	0.813							Chiang Yu Hsi Kua Tzu	醬油西瓜子	G 30
0.751	0.0083	0.757							Yen Hsi Kua Tzu	鹹西瓜子	G 31
0.810	0.0119	1.359							T'ien Hsi Kua Tzu	甜西瓜子	G 32

H. MISCELLANEOUS

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Ca bohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
H 1	Bean paste.		100	49.08	13.13	6.94	8.98	2.23	155	0.13	0.009
H 2	Cane sugar.		100	2.65	0.61	nil	96.61	nil	399	7.86	0.316
H 3	Curry powder.		100	19.45	8.70	7.25	47.84	8.90	299	19.64	0.081
H 4	Lotus root starch.	"Chinese ARROWROOT."	100	11.94	0.16	0.06	87.29	nil	359	0.55	0.075
H 5	Pepper paste.		100	83.78	0.45	0.45	7.96	0.89	39	6.47	0.036
H 6	Sesame paste.		100	0.37	20.30	54.00	17.97	2.94	659	4.42	1.050
H 7	Sweet flour paste.		100	46.96	5.90	1.19	36.91	2.70	187	6.34	0.032
H 8	Water calthrop starch.		100	18.54	0.24	0.24	80.77	nil	334	0.21	0.026

I. VEGETABLE

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Ca bohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
I 1	Peanut oil.	Arachis hypogaea, L.	100	0	0	100	0	0	930		
I 2	Seasame oil.	Sesamum indicum, L.	100	0	0	100	0	0	930		
I 3	Soybean oil.	Glycine Soja, S. et Z.	100	0	0	100	0	0	930		

J. EGGS AND

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Ca bohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
J 1	Egg, Small whole.	Gallus domesticus, Briss.	90	70.76	11.78	15.06	1.32		194	1.08	0.058
J 2	Egg, Small, white.	,, ,,	100	88.02	10.00	0.12	1.22		47	0.64	0.019
J 3	Egg, Small, yolk.	,, ,,	100	53.51	13.57	30.00	1.32		340	1.60	0.134
J 4	Egg, Large whole.	,, ,,	91	70.32	12.33	15.41	0.81		197	1.13	0.066
J 5	Egg, Large, white.	,, ,,	100	87.51	10.50	0.10	1.32		49	0.57	0.006
J 6	Egg, Large, yolk.	,, ,,	100	53.13	14.15	30.72	0.32		345	1.68	0.127
J 7	Egg, duck's, whole.	Anas domesticus, L.	86	67.27	14.24	16.00	0.50		210	1.99	0.073
J 8	Egg, Duck's, salted.	,, ,,	90	57.73	14.02	16.60	4.12		229	7.53	0.102
J 9	Egg, duck's, limed.	,, ,,	90	67.05	13.55	12.40	4.02		187	2.98	0.082
J 10	Milk, Cow's.	Bos taurus, L.	100	86.65	3.31	4.18	5.13		73	0.73	0.122

VEGETABLE PRODUCTS.

P	Fe	K	VITAMINS A	B	C	D	E	G	Romanized Name	Chinese Name	No.
0.007	0.0011	0.027	2 O	2 O	2 O			2 O	Pai T'ang	白糖	H 1
0.401	0.0721	2.199							Chia Li Fen	咖喱粉	H 2
0.159	0.0123	0.619							Tou Pan Chiang	豆瓣醬	H 3
0.021	0.0047	0.061							Ou Fen	藕粉	H 4
0.024	0.0081	0.260	15 ++						La Chiang	辣醬	H 5
0.492	0.0192	0.582							Chih Ma Chiang	芝麻醬	H 6
0.104	0.0057	0.183							T'ien Mien Chiang	甜麵醬	H 7
0.045	0.0022	0.022							Ling Fen	菱粉	H 8

OILS.

P	Fe	K	A	B	C	D	E	G	Romanized Name	Chinese Name	No.
			1.2 ±	1.4 O	4 O	2 O	1.2 +		Hua Sheng Yu	花生油	I 1
			1.2 O			1.2 ±	2 O		Ma Yu	麻油	I 2
			1.2 ±				1.2 +		Tou Yu	豆油	I 3

MILK.

P	Fe	K	A	B	C	D	E	G	Romanized Name	Chinese Name	No.
0.248	0.0043	0.218	1.4.37 ++	1.2 ++	1.4 O	1. ++			Chi Tan	鷄蛋	J 1
0.016	0.0003	0.191	1.2 O	1.2 O	1.2 ±	1 O			Tan Pai	蛋白	J 2
0.532	0.0070	0.233	1.2 +++	1.2.33 +	1.2 O	1.37 ++	1.2 ++	1.2 ++	Tan Huang	蛋黄	J 3
0.271	0.0040	0.211	102.3 ++	3.1 ++	1.4 O	1.2 ++			Ta Chi Tan, Ch'üan	大鷄蛋,全	J 4
0.016	0.0003	0.157	2 O	1.2 O	1.2 ±	1 O			Tan Pai, Ta	蛋白,大	J 5
0.526	0.0078	0.266	1.2 +++	1.2 +	1.2 O	1 ++	1.2 ++	1.2 ++	Tan Huang, Ta	蛋黄,大	J 6
0.276	0.0061	0.382	18.33 ++		9 O				Ya Tan	鴨蛋	J 7
0.214	0.0036	0.252	33 +						Hsien Ya Tan	鹹鴨蛋	J 8
0.212	0.0030	0.755	37 ++	O		37 ++			Sung Hua, P'i Tan	松花,皮蛋	J 9
0.090	0.0001	0.149	1.2.4 +++	1.2.4 ++	1.2 +	1.2 +to++	1.2 ±to+	1.2 +++	Hsien Niu Ju	鮮牛乳	J 10

K. MEATS AND

No.	English Name	Scientific Name	Edible porton	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
K 1	Beef.	Bos Taurus, L.	100	57.03	17.70	20.33	4.06		278	0.88	0.005
K 2	Beef, fat.	,, ,,	100	43.30	15.14	34.50	6.38		409	0.68	0.007
K 3	Beef, lean.	,, ,,	100	70.75	20.26	6.17	1.73		148	1.09	0.006
K 4	Beef, pickled.	,, ,,	100	50.12	38.08	2.16	5.20		198	4.44	0.029
K 5	Beef, juice, "Bovril"	,, ,,	100	36.99	40.00	1.80	2.85		193	18.36	0.035
K 6	Cow's liver.	,, ,,	100	68.77	18.92	2.64	8.80		138	0.87	0.005
K 7	Duck	Anas domesticus, L.	51	80.13	13.05	5.98	0.13		110	0.71	0.011
K 8	Duck, pickled.	,, ,,	70	44.99	26.00	19.30	4.54		305	5.17	0.080
K 9	Duck, salted and pressed.	,, ,,	70	35.08	9.65	45.00	1.88		366	8.39	0.064
K 10	Duck, roasted.	,, ,,	68	65.38	21.90	9.90	0.91		186	1.91	0.029
K 11	Duck's blood.	,, ,,	100	93.47	6.13	0.03	0.20		26	0.17	0.010
K 12	Fowl	Gallus domesticus, Biss.	41	74.46	23.30	1.22	nil		107	1.02	0.013
K 13	Goose.	Anser domesticus, L.	66	77.10	10.80	11.20	nil		147	0.90	0.013
K 14	Ham.	Sus scrofa, L. var.	100	23.26	16.41	51.42	nil		545	8.91	0.088
K 15	Mutton.	Ovis aries, L. var.	100	50.65	13.32	34.65	0.65		379	0.73	0.011
K 16	Mutton, fat.	,, ,,	100	33.70	9.33	55.70	0.80		560	0.47	0.007
K 17	Mutton, lean.	,, ,,	100	67.59	17.31	13.60	0.50		199	1.00	0.015
K 18	Pig's blood.	Sus scrofa, L. var.	100	94.83	4.35	0.02	0.28		19	0.52	0.069
K 19	Pig's intestine.	,, ,,	100	63.31	0.98	27.53	7.55		291	0.63	0.012
K 20	Pig's heart.	Sus scrofa, L. var.	100	78.65	13.14	6.63	1.11		120	0.47	0.045
K 21	Pig's kidney.	,, ,,	100	78.13	15.95	3.57	1.17		103	1.18	nil
K 22	Pig's leg.	,, ,,	66	63.18	13.15	18.02	4.74		241	0.91	0.016
K 23	Pig's liver	,, ,,	100	71.18	20.09	4.04	2.88		132	1.81	0.006
K 24	Pig's fat, (Lard).	,, ,,	100	nil	nil	100	nil		930	nil	nil
K 25	Pig's skin, fried.	,, ,,	100	77.89	19.57	2.48	nil		103	0.06	0.011
K 26	Pig's stomach.	,, ,,	100	81.81	13.32	2.66	1.48		85	0.73	0.008
K 27	Pig's tongue.	,, ,,	70	70.22	15.42	11.80	1.66		180	0.90	0.020
K 28	Pork.	,, ,,	100	29.30	9.45	59.80	0.95		599	0.50	0.006

ANIMAL FATS.

P	Fe	K	VITAMINS A	B	C	D	E	G	Romanized Name	Chinese Name	No.
0.179	0.0021	0.378	4 +	31 ±	1.2 Oto+	1.2 ±to+	1. +	4 ++	Fei Shou Niu Jou	肥瘦牛肉	K 1
0.124	0.0010	0.267	2 ++	4 O		1.2 ±to+	1.2 ++		Fei Niu Jou	肥牛肉	K 2
0.233	0.0032	0.489	1.4 ±	2.31 +	1.2 Oto+		1.2 +	1.2 +	Shou Niu Jou	瘦牛肉	K 3
0.194	0.0035	0.529							Chiang Niu Jou	醬牛肉	K 4
0.950	0.0215	2.140						1. +to++	Niu Jou Chih	牛肉汁	K 5
0.148	0.0062	0.213	1.2.33 +++	2 ++	20.9 +		1.2 ++	1.2 ++	Niu Kan	牛肝	K 6
0.145	0.0041	0.239							Ya Jou	鴨肉	K 7
0.163	0.0046	0.325							Chiang Ya	醬鴨	K 8
0.149	0.0027	0.458							Pan Ya	板鴨	K 9
0.191	0.0057	0.265							Shao Ya	燒鴨	K 10
0.055	0.0118	0.093							Ya Hsüeh K'uai	鴨血塊	K 11
0.189	0.0028	0.413	1 ±						Chi Jou	鷄肉	K 12
0.023	0.0037	0.253							E Jou	鵝肉	K 13
0.146	0.0030	0.673	2.36 Oto+	1.2 ++	2 O			2 ++	Huo T'ui	火腿	K 14
0.129	0.0020	0.249	4 Oto+	2.4 ++	2.4 ±			2 ++	Fei Shou Yang Jou	肥瘦羊肉	K 15
0.090	0.0009	0.182							Fei Yang Jou	肥羊肉	K 16
0.168	0.0030	0.316							Shou Yang Jou	瘦羊肉	K 17
0.002	0.0150	0.029		1.2 O				1. +	Chu Hsüeh	猪血	K 18
0.055	0.0005	0.083							Chu Ch'ang	猪腸	K 19
0.102	0.0025	0.134	1 ++	1 ++	4 +		1.2 ++		Chu Hsin	猪心	K 20
0.229	0.0071	0.390	1 ++	1 ++	9.4 +		1.2 +		Chu Yao	猪腰	K 21
0.060	0.0013	0.268							Chu Chou	猪肘	K 22
0.283	0.0062	0.447	2.33 +++	2 ++	1.9. ++	2 +	1.2 ++	1.2 ++	Chu Kan	猪肝	K 23
0	0	0	4.33 Oto+	1.4 O	1.4 O	1 O	1.2 O	12. ±	Chu Yu	猪油	K 24
0.008	0.0004	0.011							Yu Chien Chu P'i	油煎猪皮	K 25
0.144	0.0014	0.225							Chu Tu	猪肚	K 26
0.118	0.0024	0.178							Chu She	猪舌	K 27
0.101	0.0014	0.162	2 Oto+	2 ++	2 Oto+		1.2 +	1.2 ++	Fei Shou Chu Jou	肥瘦猪肉	K 28

K. MEATS AND

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
K 29	Pork, fat.	Sus scrofa, L. var.	100	6.00	2.24	90.80	0.86		857	0.10	0.001
K 30	Pork, lean.	,, ,,	100	52.60	16.65	28.80	1.05		341	0.90	0.011
K 31	Pork, with skin.	,, ,,	81	31.72	12.18	54.15	1.26		559	0.69	0.013
K 32	Pork muscle dried.	,, ,,	100	17.11	54.10	12.40	7.15		366	9.24	0.074
K 33	Pork, pickled.	,, ,,	100	44.10	18.85	29.80	3.83		370	3.42	0.038
K 34	Pork, roasted.	,, ,,	100	54.40	26.24	14.57	1.50		249	3.29	0.034
K 35	Pork, salted.	,, ,,	100	52.78	14.38	21.80	3.37		275	7.67	0.031
K 36	Sheep's liver.	Ovis aries, L. var.	100	65.92	21.74	7.33	3.25		171	1.76	0.009

L.

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
L 1	Clam.	Cytherea meretrix, L.	17	81.62	10.32	1.41	4.42		74	2.23	0.097
L 2	Clam, Bloody.	Arca granosa, Linn.	30	80.85	12.86	0.82	4.72		80	0.75	0.037
L 3	Clam, White	Dosinia troscheli, Lisch.	29	81.05	9.93	1.39	5.22		75	2.41	0.154
L 4	Clam, Yellow.	Cyclina chinensis, Ch.	30	80.52	10.80	1.48	3.86		74	3.34	0.275
L 5	Cuttle fish.	Sepia esculenta, Hoyle.	59	78.84	18.00	1.76	0.25		91	1.16	0.048
L 6	Mussel, dried.	Mytilus edulis, L.	100	14.00	53.50	6.94	17.01		354	8.55	0.341
L 7	Mussel, Swan.	Anodonta chinensis.	59	84.84	7.48	1.11	5.90		65	0.67	0.146
L 8	Oyster.	Ostrea talienwahnensis, Cross.	10	82.74	8.70	1.97	5.19		75	1.40	0.107
L 9	Razor shell.	Solecurtus constricta, Lamarck.	51	87.97	7.11	1.10	2.56		50	1.26	0.133
L 10	Scallop, dried.	Pecten yessoensis, Jay.	100	16.76	61.80	2.50	7.57		307	11.37	0.029
L 11	Snails, river.	Vivipara quadrata, Benson.	47	78.44	12.24	1.38	4.27		81	3.67	1.357
L 12	Squid, dried.	Ommastrephes pacificus, App.	100	19.04	61.30	3.22	9.25		320	6.92	0.042
L 13	Whelks.	Eburna japonica, Reeve.	52	83.11	11.78	0.46	4.15		70	0.50	0.038

ANIMAL FATS.—*(Continued)*

P	Fe	K	Vitamins A	B	C	D	E	G	Romanized Name	Chinese Name	No.
0.026	0.0004	0.039	1. ±		4 O		1.2 +		Fei Chu Jou	肥猪肉	K 29
0.177	0.0024	0.284							Shou Chu Jou	瘦猪肉	K 30
0.090	0.0011	0.200	2 O to +	2 ++	1 +		1 +	1.2 ++	Wu Hua Chu Jou	五花猪肉	K 31
0.542	0.0168	0.771							Jou Sung	肉鬆	K 32
0.126	0.0015	0.243							Chiang Jou	醬肉	K 33
0.177	0.0025	0.658							Ch'a Shao	叉燒	K 34
0.109	0.0023	0.421							Hsien Jou	鹹肉	K 35
0.414	0.0066	0.420	1.2 +++	1 +	2 +	2 O	1.2 ++	1.2 ++	Yang Kan	羊肝	K 36

MOLLUSCS

P	Fe	K	A	B	C	D	E	G	Romanized Name	Chinese Name	No.
0.078	0.0245	0.173	1.2 +	1.2 O to +		1.2 +			Hou K'e Huang Ke	厚殼黃蛤	L 1
0.082	0.0142	0.149	1.2 +	1.2 O to +		1.2 +			K'uei Ke	魁蛤	L 2
0.126	0.0442	0.185	1.2 +	1.2 O to +	9 +	1.2 +			Pai Ke Li	白蛤蜊	L 3
0.183	0.0471	0.234	1.2 +	1.2 O to +	9 +	1.2 +			Huang Ke Li	黃蛤蜊	L 4
0.198	0.0011	0.273							Mo Yü, Wu Tsei	墨魚, 烏賊	L 5
0.607	0.0484	0.458			1 +				Tan Ts'ai	淡菜	L 6
0.089	0.0118	0.048			1 +				Peng	蚌	L 7
0.114	0.0069	0.209	1.2 ++	1.2 ++	1.2 +	1.2 ++		2 ++	Mu Li	牡蠣	L 8
0.114	0.0227	0.143			9 +				Ch'eng	蟶	L 9
1.153	0.0080	1.579			1 +				Kan Pei	干貝	L 10
0.191	0.0198	0.179							T'ien Lo	田蠃	L 11
0.682	0.0047	0.141							Yu Yü, Jou Yü (Kan)	鱿魚, 柔魚 (乾)	L 12
0.044	0.0019	0.038							Hsiang Lo	香螺	L 13

M. CRUSTACEA

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
M 1	Bird's nest.	Callocalia brevirostris, L.	100	13.41	49.85	0	30.55		330	6.19	0.429
M 2	Crab.	Eriocheia chinensis, ME.	30	76.96	11.10	4.66	5.91		113	1.37	0.129
M 3	Crab, salted.	,, ,,	23	65.61	11.27	7.03	4.29		129	11.80	0.378
M 4	Crab, sea.	Neptunes pelagicus, M.	33	80.25	13.00	2.81	1.48		85	2.46	0.400
M 5	Crab, sea, salted.	,, ,,	42	54.57	21.76	6.68	nil		151	16.99	0.148
M 6	Fish maws, (Air bladder).	Ichthyocolla, Isinglass.	100	21.20	78.22	0.50	nil		325	0.08	0.007
M 7	Frog.	Rana nigromaculata, Hall.	41	82.71	15.92	0.39	0.17		70	0.81	0.022
M 8	Jelly fish.	Rhopilema esculanta, Kish.	100	88.24	4.95	0.05	1.25		26	5.51	0.019
M 9	Jelly fish, salted-	,, ,,	100	84.09	5.64	0.07	1.18		29	9.02	0.093
M10	Prawn.	Penaeus carinatus, Dana.	67	83.01	13.38	1.56	1.05		74	1.00	0.077
M11	Sea slug, soaked. (Bicho de mar)	Stichopus japonicus, Selenka.	100	75.78	21.45	0.27	1.37		96	1.13	0.118
M12	Shark's fin, dried.	Selachoidei et Batoidei.	100	13.76	83.53	0.28	0.20		345	2.24	0.146
M13	Shrimp.	Macrobrachium nipponensis, de Hana.	39	82.62	15.02	1.15	0.11		73	1.10	0.099
M14	Shrimp, river.	Palaemon sp.	26	80.48	17.54	0.61	nil		78	1.37	0.040
M15	Shrimp, small, salted.	Leander annandalei, Remp.	100	56.19	18.25	2.50	4.26		116	18.80	0.855
M16	Shrimp, small, salted.	,, ,,	100	37.93	35.48	1.14	2.66		167	22.79	0.829
M17	Shrimp, dried.	,, ,,	100	20.74	58.10	2.16	4.50		277	14.50	0.577
M18	Shrimp, eggs.	,, ,,	100	16.84	44.95	2.00	24.26		303	11.95	0.244
M19	Turtle.	Trionyx chinensis T. et S.	30	80.44	16.22	1.00	1.49		82	0.85	0.107

N. FISH: FISHES AND

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
N 1	Anchovy, Chinese.	Coilia ectenes, J. et S.	60	74.94	19.02	3.44	1.45		116	1.15	0.037
N 2	Anchovy, long tailed.	Coilia nasus, T. et S.	70	79.33	15.55	2.33	0.10		86	2.69	0.109
N 3	Bass, Sea.	Lateolabrax japonica, C. et V.	70	79.24	17.82	1.62	0.29		89	1.03	0.042
N 4	"Big-head"	Aristichthys nobelies, Richardson.	60	83.70	14.51	0.58	nil		65	1.21	0.040

&c.

P	Fe	K	Vitamins A	B	C	D	E	G	Romanized Name	Chinese Name	No.
0.030	0.0049	0.043							Yen Wo	燕窩	M 1
0.145	0.0130	0.259							Ho P'ang Hsieh	河螃蟹	M 2
0.203	0.0029	0.669							Hsien Ho Hsieh	鹹河蟹	M 3
0.147	0.0009	0.177							So Tzu Hsieh, Chieh	梭子蟹，蠘	M 4
0.322	0.0022	0.437							Ch'iang Hsieh	搶蟹	M 5
0.018	0.0003	0.023							Yü Tu, Yü Piao	魚肚，魚鰾	M 6
0.159	0.0013	0.243							T'ien Chi	田雞	M 7
0.013	0.0088	0.085							Hai Che P'i	海蜇皮	M 8
0.107	0.0123	0.076							Hsien Hai Che	鹹海蜇	M 9
0.181	0.0033	0.172	1.33 +		9 O				Ming Hsia, Ta Hsia	明蝦，大蝦	M10
0.022	0.0014	0.070							Hai Shen (Ch'in)	海參（浸）	M11
0.194	0.0152	0.177							Yü Ch'ih (Kan)	魚翅（乾）	M12
0.205	0.0013	0.232	1.2 +		9 ±	++			Ch'ing Hsia	青蝦	M13
0.161	0.0007	0.467	1 +		9 ±				Ho Hsia	河蝦	M14
0.376	0.0082	0.351	1 +		9 ±				Pai Mi Hsia	白米蝦	M15
0.522	0.0144	0.600	1 +						Hsien Pai Mi Hsia	鹹白米蝦	M16
0.614	0.0131	0.886	1 +						K'ai Yang	開洋	M17
0.801	0.0698	0.283							Hsia Tzu	蝦子	M18
0.135	0.0014	0.235							Chia Yü, Pieh	甲魚，鱉	M19

OTHER MARINE PRODUCTS.

P	Fe	K	A	B	C	D	E	G	Romanized Name	Chinese Name	No.
0.205	0.0011	0.439							Tao Yü	刀魚	N 1
0.374	0.0006	0.458							Ch'i, K'ao Tzu Yü	鱭，烤子魚	N 2
0.216	0.0011	0.327							Lu Yü	鱸魚	N 3
0.201	0.0018	0.376							Yung, Hua Lien Yü	鱅，花鰱魚	N 4

N. FISH: FISHES AND

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
N 5	Bream, freshwater.	Parabramis terminalis, Richardson.	60	73.72	18.45	6.61	0.22		138	1.00	0.076
N 6	Bream, sea, salted.	Sparus macrocephalus, Basil.	43	15.25	54.70	0.31	8.45		262	21.29	0.183
N 7	Carp, common.	Cyprinus carpio, Linn.	50	79.07	18.12	1.59	0.17		90	1.05	0.028
N 8	Carp, golden.	Carassius auratus, Linn.	41	82.67	15.55	0.73	0.09		71	0.96	0.054
N 9	Carp, silver.	Hypophthalmichthys molitrix, C. et V.	58	78.48	17.30	1.65	1.39		92	1.18	0.051
N10	Carp, black.	Mylopharyngodon aethiops, Basil.	53	79.73	16.80	2.10	0.12		89	1.25	0.029
N11	Carp, black, smoked.	,, ,,	92	46.73	25.82	12.12	10.35		261	4.98	0.147
N12	Chin hsien yü,	Euthyopteroma virgatum, Hout.	45	77.94	18.82	1.48	0.82		94	0.94	0.046
N13	Ch'ing chuan yü, salted,	——	70	46.11	25.57	8.46	2.10		192	17.76	0.147
N14	Dogfish.	Squalus mitsukurii, J. & S.	54	77.09	21.29	0.66	nil		93	0.96	0.037
N15	Eel, marine.	Muraenesox cinereus, Forskl.	70	78.23	17.18	2.75	0.12		97	1.72	.0110
N16	Eel field.	Fluta alba, Zuiew.	70	84.59	14.49	0.44	nil		64	0.48	0.027
N17	Eel, fresh Water.	Anguilla japonica, T. et S.	61	76.13	14.48	7.98	nil		134	1.41	0.166
N18	Fry, salted and mixed.	——	100	21.15	54.04	3.57	3.24		267	18.00	0.306
N19	Hair-tail.	Trichiurus japonica, T. et S.	63	77.52	16.33	3.51	1.54		106	1.10	0.048
N20	Hair-tail, salted.	Trichiurus japonica, T. et S.	60	48.39	25.80	6.22	3.02		176	16.57	0.210
N21	Herring.	Ilisha elongata, Bennett	52	76.80	11.90	3.02	6.56		106	1.54	0.060
N22	Herring, salted.	,, ,,	60	47.94	30.75	2.19	2.19		155	16.93	0.283
N23	Loach.	Misgurnus angiullicaudatus, Can.	36	83.17	9.60	3.68	2.39		83	1.16	0.028
N24	Mackerel.	Scomber niphonius, C. & V.	64	76.99	17.85	3.83	0.15		89	1.18	0.007
N25	Mackerel, Spanish, salted.	Scomber japonica Houttuyn.	55	46.51	32.44	3.19	1.14		167	16·72	0.134
N26	Maigre (Lesser yellow-fish).	Pseudosciaena undovittata, J. et S.	47	79.15	18.80	0.76	0.25		86	1.04	0.031
N27	Maigre, salted, (yellow-fish).	Pseudosciaena schlegeli, Blkr.	55	12.75	54.17	1.06	5.39		252	26.63	0.266
N28	Maigre, Japanese.	Sciaena japonica, Schlegel.	66	79.91	17.03	1.65	0.07		86	1.34	0.060
N29	Ma-kao-yü	——	74	74.30	20.02	4.28	nil		122	1.40	0.051
N30	Mandarin fish.	Siniperca chuatsi, Basil.	50	78.74	19.29	0.82	nil		87	1.15	0.045
N31	Paikuotze, salted.	Nibea sina, Cuvier.	40	55.54	25.00	1.84	1.49		126	16.13	0.069
N32	Pomfret, salted.	Stromateoides argenteus, Euphrasen.	64	76.25	15.63	6.57	nil		125	1.55	0.019

OTHER MARINE PRODUCTS.—*(Continued)*

P	Fe	K	VITAMINS A	B	C	D	E	G	Romanized Name	Chinese Name	No.
0.211	0.0022	0.334							Pien Yü	鯿魚	N 5
0.199	0.0054	0.552							Ta T'ou Hsiang (Yen)	大頭鯗(鹽)	N 6
0.176	0.0013	0.397							Li	鯉	N 7
0.203	0.0025	0.335							Fu, Chi Yü	鮒, 鯽魚	N 8
0.218	0.0010	0.435							Pai Yü (Lien)	白魚(鰱)	N 9
0.266	0.0013	0.460							Ch'ing Yü	青魚	N10
0.338	0.0025	0.551							Hsün Ch'ing Yü, Hsün Yü	燻青魚, 燻魚	N11
0.187	0.0009	0.329							Chin Hsien Yü	金綫魚	N12
0.137	0.0032	0.504							Yen Ch'ing Chuan Yü	鹽青專魚	N13
0.151	0.0020	0.174							Chüeh Chiao	角鮫	N14
0.235	0.0012	0.578	35.1.2 ++						Hai Man Li	海鰻鱺	N15
0.053	0.0046	0.085							Shan Yü	鱔魚	N16
0.211	0.0018	0.712							Ho Man Li	河鰻鱺	N17
1.050	0.0091	1.085							Hai Yen	海鰋	N18
0.204	0.0023	0.304							Tai Yü	帶魚	N19
0.241	0.0030	0.307							Hsien Tai Yü	鹹帶魚	N20
0.169	0.0007	0.500							Le, Hsiang Yü	鰳, 鯗魚	N21
0.278	0.0063	0.371							Le, Hsiang Yü (Yen)	鰳, 鯗魚(鹽)	N22
0.072	0.0009	0.140							Kuang Ch'iu Yü	廣鰍魚	N23
0.215	0.0025	0.273							Ch'ing Yü	鯖魚	N24
0.169	0.0020	0.368							Yu T'ung Yü (Yen)	油筒魚(鹽)	N25
0.152	0.0018	0.378							Hsiao Huang Yü	小黃魚	N26
0.395	0.0029	0.758							Huang Yü Hsiang (Yen)	黃魚鯗(鹽)	N27
0.122	0.0005	0.470							Mien, (Mi)	鮸 (鮇)	N28
0.226	0.0009	0.496							Ma Kao Yü	馬高魚	N29
0.226	0.0022	0.392							Kuei Yü	鱖魚	N30
0.171	0.0029	0.398							Pai Kuo Tzu Yü (Yen)	白果子魚(鹽)	N31
0.240	0.0003	0.517							Ch'ang Yü, Ch'uan Pien Yü, P'o Tzu Yü	鯧魚, 川扁魚, 婆子魚	N32

N. FISH: FISHES AND

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
N33	Red fish, salted.	——	70	47.68	34.76	0.96	nil		151	16.60	0.216
N34	Shad, Chinese.	Hilsa reeversii, Richardson.	70	72.47	14.44	11.14	0.18		164	1.70	0.058
N35	Sleeper (Bullhead).	Eleotris potamophila, Gunther.	50	82.22	15.90	0.49	0.21		71	1.16	0.108
N36	Snake head.	Ophiocephalus argus, Cantor.	52	79.98	18.29	0.67	nil		81	1.06	0.056
N37	Sole.	Cynoglossus abbreviatus, Gray.	64	79.43	17.42	1.45	0.48		87	1.22	0.036
N38	Sting ray.	Dasyatus akajei, M. & H.	43	77.67	20.51	0.56	nil		89	1.26	0.033
N39	Tiger fish.	Minous adamsi, Rch.	33	81.66	16.21	0.81	nil		74	1.32	0.016
N40	Wei yü (kind of shad. G.)	Leiocassis demerili, Bl.	40	79.65	13.65	4.70	1.05		104	0.95	0.039
N41	White-bait, Chinese.	Salanx microdon, Blkr.	100	91.63	6.33	0.18	1.11		32	0.75	0.258

O. CONDIMENTS.

No.	English Name	Scientific Name	Edible portion	Water	Protein	Fat	Carbohydrate	Crude fibre	Calories / 100 gm	Ash	Ca
O 1	Flavoring Essence A.	Wei fen brand.	100	2.13	28.07	0.58	23.99	nil	218	45.23	0.120
O 2	„ B.	Wei ching brand.	100	3.39	38.46	0.94	16.88	nil	235	40.33	0.073
O 3	„ C.	Wei pao brand.	100	4.90	28.36	0.30	35.18	nil	263	31.27	0.173
O 4	„ D.	Wei tsu brand.	100	0.69	23.15	0.29	54.25	nil	320	21.62	0.017
O 5	Pepper, Chinese.	Xanthoxylum piperitum, DC.	100	12.50	25.72	7.09	35.08	8.00	315	11.61	0.536
O 6	Rice flour, spiced.	——	100	6.99	6.12	1.07	84.84	0.61	383	0.37	0.036
O 7	Salt, common.	Sodii Chloridum.	100	7.49	—	—	—	nil	nil	92.51	0.351
O 8	Salt, refined.	Sodii Chloridum, Pure.	100	2.06	—	—	—	nil	nil	97.94	0.062
O 9	Vinegar.	Acetum.	100	94.39	1.30	0.72	2.47	nil	18	1.12	0.012
O10	Wine, Rice.	Vinum oryzae.	100	Alcohol	16.8% by	volume	3.75	nil	133	0.28	0.029

OTHER MARINE PRODUCTS.—*(Continued)*

P	Fe	K	VITAMINS A	VITAMINS B	VITAMINS C	VITAMINS D	VITAMINS E	VITAMINS G	Romanized Name	Chinese Name	No.
0.278	0.0038	0.649							Hsien Hung Hsiang Yü	鹹紅鯗魚	N33
0.265	0.0018	0.500							Shih Yü	鰣魚	N34
0.232	0.0019	0.349							Tang Li Yü	塘裏魚	N35
0.169	0.0005	0.328							Wu Yü (Hei Li)	烏魚(黑鱧)	N36
0.171	0.0010	0.489							Jo T'a Yü (Pi Mu)	箬鰨魚(比目)	N37
0.166	0.0016	0.277							Huang Tiao Yü	黃貂魚	N38
0.205	0.0013	0.361							Lao Hu Yü	老虎魚	N39
0.143	0.0009	0.245							Wei Yü (Hui)	鮠魚(鮰)	N40
0.102	0.0005	0.025							Yin Yü	銀魚	N41

BEVERAGES ETC.

P	Fe	K	A	B	C	D	E	G	Romanized Name	Chinese Name	No.
0.091	0.0017	0.400							Wei Fen	味粉	O 1
0.206	0.0015	0.507							Wei Ching	味精	O 2
0.120	0.0029	0.244							Wei Pao	味寶	O 3
nil	0.0046	0.647							Wei Tsu	味祖	O 4
0.292	0.0043	1.146							Hua Chiao	花椒	O 5
0.013	0.0100	0.124							Mi Fen	米粉	O 6
nil	0.0066	0.488							Ta Yen, T'su Yen	大鹽, 粗鹽	O 7
nil	0.0016	0.134							Ching Yen	精鹽	O 8
0.235	0.0263	0.074							Lao T'su	老醋	O 9
0.049	nil	0.070		5 ++				++	Lao Chiu	老酒	O10

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Chu Ch'ang	猪腸	Pig's intestine.	K 19	58
Chu Chou	猪肘	Pig's leg.	K 22	58
Chu Hsin	猪心	Pig's heart.	K 20	58
Chu Hsüeh	猪血	Pig's blood.	K 18	58
Chu Jou, Fei Shou	猪肉，肥瘦	Pork	K 28	58
Chu Kan	猪肝	Pig's liver.	K 23	58
Chu She	猪舌	Pig's tongue.	K 27	58
Chu Sun	竹筍	Bamboo shoots.	C 2	42.
Chu Tu	猪肚	Pig's stomach.	K 26	58
Chu Yao	猪腰	Pig's kidney.	K 21	58
Chu Yu	猪油	Lard.	K 24	58
Chung Kuo Hsiao Hua Sheng	中國小花生	Peanut, small.	G 17	54
Chung Kuo Wu Hua Kuo	中國無花果	Fig, Chinese.	F 7	50
Chü, Hsien Lo	橘,桔(暹羅)	Orange, Siam.	F 16	23,52
Chüan Hsin Ts'ai	捲心菜	Cabbage, foreign.	C 24	42
Chüeh Chiao	角鮫	Dogfish.	N 14	33,64
Ch'a Shao	叉燒	Pork, roasted.	K 34	60
Ch'ang Pai P'u T'ao	長白葡萄	Grape, long white.	F 9	23,50
Ch'ang Shu Pai Keng	常熟白粳	Rice, polished Ch'ang Shu.	A 8	8,36
Ch'ang Shu Wei Sheng Mi	常熟衞生米	Rice, whole Ch'ang Shu.	A 24	8,36
Ch'ang Yü	鯧魚	Pomfret, silver.	N 32	64
Ch'ao Shu Li Tzu	炒熟栗子	Chestnut, baked.	G 4	52
Ch'eng	蟶	Razor shell.	L 9	60
Ch'i	鱭	Anchovy, long tailed.	N 2	62
Ch'i Ts'ai	薺菜	Shepherds purse.	C 77	16,46
Ch'iang Hsieh	搶蟹	Crab, sea	M 5	62
Ch'ieh Tzu	茄子	Egg plant.	C 44	44
Ch'ien	芡	Foxnut.	G 5	52
Ch'ien Chang	千張	Soybean curd, sheet.	B 32	40
Ch'ih Hsiao Tou	赤小豆	Red gram bean.	B 19	40
Ch'in Ts'ai	芹菜	Celery	C 34	44
Ch'ing Chia Pien Tou Chia	青架扁豆莢	Flat beans, green fresh pods.	B 5	14,38
Ch'ing Hsi Chiang Tou Chia	青細豇豆莢	Cowpea pods, green & narrow.	B 2	15,38
Ch'ing Hsia	青蝦	Shrimp.	M 13	62.
Ch'ing Hsien Ts'ai	青莧菜	Amaranth, green.	C 2.	16,42
Ch'ing Kuo	青果	Canarium.	F 5	24,50

Romanized	Chinese	English	No.	Page
Ch'ing La Chiao	青辣椒	Peppers, green, Chillies.	C70	46
Ch'ing Lo Fu Kan	青蘿蔔乾	Turnip, green, salted.	C84	46
Ch'ing Mei	青梅	Plum.	F21	52
Ch'ing P'i T'ien Kua	青皮甜瓜	Cantaloupe.	D 2	48
Ch'ing P'u Po Chiao Mi	清浦薄椒米	Rice, polished Ch'ing P'u.	A 9	8,36
Ch'ing Suan	青蒜	Garlic, green.	C48	44
Ch'ing Ts'ai	青菜	Colza, large.	C39	44
Ch'ing Yü	青魚	Carp, black.	N10	64
Ch'ing Yü	鯖魚	Mackerel.	N24	33,64
Ch'ou Tou Fu	臭豆腐	Soybean curd, fermented.	B28	40
Ch'uan Pien Yü	川扁魚	Pomfret, Silver.	N32	64
Ch'un Chu Sun	春竹筍	Bamboo shoots, spring variety	C 9	42
E.				
E Jou	鵝肉	Goose	K13	58
Erh Hao Pai Mi	二號白米	Rice, 2nd grade.	A 4 A 5	8,36
F.				
Fa Ts'ai	髮菜	Seaweed, Nostoc.	E10	20,50
Fan Ch'ieh	番茄	Tomato.	C80	46
Fan Shu	番薯	Potato.	C72	46
Fei Chu Jou	肥猪肉	Pork, fat.	K29	60
Fei Niu Jou	肥牛肉	Beef, fat.	K 2	58
Fei Shou Chu Jou	肥瘦猪肉	Pork.	K28	58
Fei Shou Niu Jou	肥瘦牛肉	Beef.	K 1	58
Fei Shou Yang Jou	肥瘦羊肉	Mutton.	K15	58
Fei Yang Jou	肥羊肉	Mutton, fat.	K16	58
Fei Tzu	榧子	Yew seeds.	G23	54
Fen P'i	粉皮	Mung bean starch.	B15	40
Fu	鮒	Carp, golden.	N 8	64
Fukien Hsiao Hung Chü	福建小紅桔	Orange, Fukien.	F17	52
H.				
Hai Che P'i	海蜇皮	Jelly fish.	M 8	62
Hai Man Li	海鰻鱺	Eel, Marine.	N15	64
Hai Shen	海參	Sea slug, Bicho de mar.	M11	32,62
Hai Tai	海帶	Seagirdle.	E 9	50
Hai Ts'ai	海菜	Agar-agar.	E 1	48
Hai Tsao	海藻	Gulfweed.	E11	20,50

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Hai Yen	海蜒	Fry.	N18	64
Hei Li	黑鱧	Snake head.	N36	66
Hei Tsao	黑棗	Jujube, smoked.	G10	23,54
Ho Hsia	河蝦	Shrimp, river.	M14	62
Ho Man Li	河鰻鱺	Eel, fresh water.	N17	64
Ho P'ang Hsieh	河螃蟹	Crab.	M 2	62
Ho T'ao	核桃	Walnut.	G26	54
Hou K'e Huang Ke	厚殼黃蛤	Clam.	L 1	60
Hsi Hu Lu	西壺盧	Pumpkin.	D 9	19,48
Hsi K'ang	細糠	Rice polishings.	A29 A30	8,38
Hsi Kua	西瓜	Water melon.	D12	1,19,48
Hsi Kua Tzu	西瓜子	Water melon seeds.	G29	54
Hsi Yang Yang Mei	西洋楊梅	Strawberry.	F28	52
Hsia	蝦	Shrimp.	M15	62
Hsia Tzu	蝦子	Shrimp eggs.	M18	62
Hsiang Chiao	香蕉	Banana.	F 4	21,50
Hsiang Chün	香菌	Mushrooms.	E 5	20,50
Hsiang Ch'un T'ou	香椿頭	Cedar shoots.	C31	44
Hsiang Jih K'uei Tzu	向日葵子	Sunflower seed.	G25	54
Hsiang Kan	香乾	Soybean curd cake, spiced.	B27	40
Hsiang Lo	香螺	Whelks.	L13	60
Hsiang Ts'ai	香菜	Coriander.	C43	44
Hsiang Yü	鮝魚	Herring,	N21	33,64
Hsiang Yü, Yen	鮝魚(鹽)	Herring, salted.	N22	33,64
Hsiao Ch'ing Ts'ai	小青菜	Colza, small.	C38	44
Hsiao Huang Yü	小黃魚	Maigre, Lesser yellow-fish.	N26	33,64
Hsiao K'uai Yu Tou Fu	小塊油豆腐	Soybean curd, fried, small.	B30	40
Hsiao Mi	小米	Millet, short.	A 2	11,36
Hsiao Pai Ts'ai	小白菜	Cabbage, small.	C26	16,26,42
Hsiao Ts'ung	小葱	Onion, small.	C69	46
Hsien Ch'ing Ts'ai	鹹青菜	Colza, salted.	C40	44
Hsien Fen	綠粉	Mung bean starch.	B16	40
Hsien Hai Che	鹹海蜇	Jelly fish, salted.	M 9	62
Hsien Ho Hsieh	鹹河蟹	Crab, salted.	M 3	62
Hsien Hsiang Ch'un T'ou	鮮香椿頭	Cedar shoots.	C31	44
Hsien Hung Hsiang Yü	鹹紅鮝魚	Red fish, salted.	N33	66

Romanized	Chinese	English	No.	Page
Hsien Jou	鹹肉	Pork, salted.	K 35	60
Hsien Lao Yü Mi	鮮老玉米	Corn.	A 1	12,36
Hsien Niu Ju	鮮牛乳	Milk, cow's.	J 10	2,30,56
Hsien Pai Mi Hsia	鹹白米蝦	Shrimp, small, salted.	M16	62
Hsien Tai Yü	鹹帶魚	Hair-tail, salted.	N20	64
Hsien Ts'ai	莧菜	Amaranth.	C 2	16,42
Hsien Ts'ai	鹹菜	Mustard leaves, salted.	C63	46
Hsien Ts'an Tou	鮮蠶豆	Horse bean.	B 6	38
Hsien Ts'an Tou Ch'ü Nei P'i	鮮蠶豆去內皮	Horse bean, fresh peeled.	B 7	38
Hsien Wan Tou	鮮豌豆	Peas, green.	B17	40
Hsien Ya Tan	鹹鴨蛋	Egg, duck's, salted.	J 8	29,56
Hsing, Hangchow	杏(杭州)	Apricot, Hangchow.	F 3	50
Hsing, Ts'ingtao	杏(青島)	Apricot, Ts'ingtao.	F 2	50
Hsing Jen	杏仁	Apricot kernels.	G 1	24,52
Hsüeh Li Hung	雪裏紅	Mustard leaves, salted.	C63	46
Hsün Ch'ing Yü	薰青魚	Carp, black, smoked.	N11	64
Hsün Yü	薰魚	Carp, black, smoked.	N11	64
Hu Lo Fu	胡蘿蔔	Carrot.	C29	17,44
Hu Tzu	瓠子	Calabash.	D 1	18,48
Hua Chiao	花椒	Pepper, Chinese.	O 5	34,66
Hua Lien Yü	花鰱魚	"Big-head"	N 4	62
Hua Sheng Yu	花生油	Peanut oil.	I 1	28,56
Huai Tzu	槐子	Locust seeds.	G12	25,54
Huang Chin Kua	黃金瓜	Musk melon.	D 8	19,48
Huang Chiu Ya	黃韭芽	Leek shoots.	C54	44
Huang Hua Ts'ai	黃花菜	Lily flowers.	C58	46
Huang Ke Li	黃蛤蜊	Clam, yellow.	L 4	60
Huang Kua	黃瓜	Cucumber.	D 3	19,48
Huang Tiao Yü	黃貂魚	String ray.	N38	66
Huang Tou	黃豆	Soybean.	B20	12,40
Huang Tou Ya	黃豆芽	Soybean, sprouted.	B36	14,40
Huang Yen Chü	黃巖桔	Orange, Wenchow.	F19	23,52
Huang Yü Hsiang	黃魚鯗	Maigre, or yellow-fish.	N27	64
Hui	鮰	Wei yü, kind of shad.	N40	66
Hui Hsiang Ts'ai	茴香菜	Fennel.	C45	44
Hui Hsiang Ts'ai, Nen	茴香菜(嫩)	Fennel, young.	C46	44
Hung Ch'ü Mi	紅麴米	Rice, fermented.	A28	36
Hung Hsien Ts'ai	紅莧菜	Amaranth, red.	C 3	16,42
Hung Hu Lo Fu	紅胡蘿蔔	Carrot, red.	C28	42
Hung Kuo	紅果	"Red fruit," Haws.	F27	23,52

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Hung Mi	紅米	Rice, red.	A27	36
Hung Shih Hsing La Chiao	紅柿形辣椒	Peppers, red.	C71	17,46
Hung Shui Ling	紅水菱	Water calthrop, red.	G28	54
Hung Tsao	紅棗	Jujube, Chinese date.	G 8	25,52
Huo T'ui	火腿	Ham.	K14	58
J.				
Jo T'a Yü	箬鰨魚	Sole.	N37	33,66
Jou Sung	肉鬆	Pork, muscle dried.	K32	60
Jou Yü	柔魚	Squid.	L12	60
K.				
Kan Che	甘蔗	Sugar cane.	F29	52
Kan Chieh Ts'ai Yeh	乾芥菜葉	Mustard leaves, dried.	C61	46
Kan Lan	橄欖	Canarium.	F 5	24,50
Kan Lien Tzu	乾蓮子	Lotus seeds, dried.	G13	26,54
Kan Pei	干貝	Scallop, dried.	L10	31,60
Kan Ts'an Tou Ch'ü P'i	乾蠶豆去皮	Horse bean, dried peeled.	B 8	38
Kan Yu Ts'ai T'ai	乾油菜苔	Colza, dried flowering top.	C42	44
Kao Liang	高粱	Sorghum.		2
Ke Hsien Mi	葛仙米	Fungus.	E 2	48
Ke Li	蛤蜊	Clam.	L 3	60
Ken Tao Ts'ai	根刀菜	Beet, sugar, tops.	C20	42
Kiangsi Chien Mi	江西尖米	Rice, Kiangsi pointed.	A10	8,36
Kiang Yin Pai Keng	江陰白粳	Rice, polished, Kiangyin.	A11	8,36
Kuan T'ou Chu Sun	罐頭竹筍	Bamboo shoots, pickled.	C17	42
Kuang Ch'iu Yü	廣鰍魚	Loach.	N23	64
Kuei Yü	鱖魚	Mandarin fish.	N30	64
Kuei Yüan	桂圓	Lungngans.	G15	26,54
Kwangtung Ta Yü T'ou	廣東大芋頭	Aroid, large Cantonese.	C 5	42
K.'				
K'ai Yang	開洋	Shrimp, dried.	M17	62
K'ao Tzu Yü	烤子魚	Anchovy, long tailed.	N 2	62
K'u Kua	苦瓜	Gourd, bitter.	D 5	19,48
K'uei Ke	魁蛤	Clam, Bloody.	L 2	60
K'un Shan Pai Keng	崑山白粳	Rice, polished K'un shan	A12	8,36
K'un Shan Yang Chien Mi	崑山洋尖米	Rice, polished K'un shan pointed.	A13	8,36

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L.				
La Chiang	辣醬	Pepper paste.	H 5	28,56
La Chiao, Ch'ing	辣椒，青	Pepper, green, Chillies	C70	46
La Hung	辣紅	Radish.	C76	46
Lao Chiu	老酒	Wine, Rice.	O10	35,66
Lao Hu Yü	老虎魚	Tiger fish.	N39	66
Lao T'su	老醋	Vinegar.	O 9	35,66
Lao Yü Mi	老玉米	Maize.	A 1	36
Le	鰳	Herring.	N21	64
Le, Yen	鰳(鹽)	Herring, salted.	N22	64
Li	鯉	Carp, common.	N 7	64
Li Chih	荔枝	Litchi.	F12	22,50
Li Tzu	栗子	Chestnut.	G 3	52
Li Yang No Mi	溧陽糯米	Rice, glutinous Li yang.	A20	8,36
Lien	鰱	Carp, silver.	N 9	64
Ling Chüeh Mi	菱角米	Water calthrop.	G27	26,54
Ling Fen	菱粉	Water calthrop starch.	H 8	26,56
Lo Hua Sheng	落花生	Peanut.	G16	2,3,26,54
Lu Sun	蘆筍	Asparagus.	C 6	42
Lu Yü	鱸魚	Bass, Sea.	N 3	62
Lung Hsü Ts'ai	龍鬚菜	Asparagus.	C 6	42
Lung Hsü Ts'ai (Kan)	龍鬚菜(乾)	Asparagus, salted dried.	C 7	42
Lungngans	龍眼	Nephelium Longana, Camb.	G15	54
Lü Tou	綠豆	Mung bean.	B12	2,3,15,38
Lü Tou Liang Fen	綠豆涼粉	Mung bean, starch jelly.	B14	40
Lü Tou Ya	綠豆芽	Mung bean, sprouted.	B13	38
M.				
Ma Kao Yü	馬高魚	Ma-kao-yü	N29	64
Ma Lan T'ou	馬蘭頭	Aster shoots.	C 8	42
Ma Yu	蔴油	Sesame oil.	I 2	28,56
Mang Kuo	杧果	Mango.	F15	22,50
Mao Sun	毛筍	Bamboo shoots, hairy.	C10	42
Mao Tou	毛豆	Soybean fresh.	B21	12,40
Mi	鮸	Maigre, Japanese.	N28	64
Mi Chien Lien Tzu	蜜餞蓮子	Lotus seeds, preserved.	G14	26,54
Mi Fan	米飯	Rice, cooked.	A31	8,38

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Mi Fen	米粉	Rice flour, spiced.	O 6	66
Mien	麩	Maigre, Japanese.	N28	64
Mien Chin	麵筋	Wheat gluten.	A38	38
Mien Pao	麵包	Wheat bread.	A33	11,38
Mien T'iao	麵條	Spaghetti.	A37	38
Ming Hsia	明蝦	Prawn.	M10	62
Mo Ku Chün	蘑菇菌	Mushrooms.	E 6	20,50
Mo Ku Tou Fu Kan	蘑菇豆腐乾	Soybean curd cake, with mushroom.	B26	40
Mo Yü	墨魚	Cuttle fish.	L 5	60
Mu Erh	木耳	Mushrooms, Jew's ear.	E 7	20,50
Mu Hsü	苜蓿	Alfalfa.	C 1	16,17,42
Mu Li	牡蠣	Oyster.	L 8	31,60
N.				
Nan Kua	南瓜	Squash.	D10	19,48
Nan Kua, Lao	南瓜(老)	Squash, old.	D11	19,48
Ning Meng	檸檬	Lemon	F11	50
Niu Ju	牛乳	Milk, Cow's	J10	2,30,56
Niu Jou, Fei Shou	牛肉肥瘦	Beef.	K 1	58
Niu Jou Chih	牛肉汁	Beef, juice. "Bovril."	K 5	58
Niu Kan	牛肝	Cow's liver.	K 6	58
O.				
Ou	藕	Lotus Root	C59	46
Ou Fen	藕粉	Lotus root starch	H 4	56
P.				
Pai Chia Pien Tou Chia	白架扁豆莢	Flat bean, runners.	B 4	14,38
Pai Chiang Tou Chia	白豇豆莢(鮮)	Cowpea pods, white.	B 1	15,38
Pai Ke Li	白蛤蜊	Clam, white.	L 3	60
Pai Kuo	白果	Ginkgo seeds.	G 6	25,52
Pai Kuo Tzu Yü, Yen	白果子魚(鹽)	Paikuotze, salted fish.	N31	64
Pai Lo Fu	白蘿蔔	Turnip, white.	C81	17,46
Pai Mi.	白米	Rice, polished.	A 3	8,36,62
Pai Mi Chou	白米粥	Rice Congee.	A32	8,38
Pai Mi Hsia	白米蝦	Shrimp, small.	M15	62
Pai Mu Erh	白木耳	Fungus,	E 3	50
Pai P'i Pa, Tung T'ing	白枇杷(洞庭)	Loquat, white.	F14	50

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Pai Pien Tou Chia	白扁豆莢	Flat bean, fresh pods.	B 3	14,38
Pai Shu	白薯	Potato, sweet.	C73	18,46
Pai Shu, Kwangtung	白薯(廣東)	Potato, sweet, Canton.	C74	18,46
Pai T'ang	白糖	Cane sugar.	H 2	56
Pai Ts'ai	白菜	Cabbage, Chinese.	C21	16,17,42
Pai Yeh	百頁	Soybean curd, sheet.	B32	40
Pai Yü	白魚	Carp, silver.	N 9	64
Pan Ya	板鴨	Duck, salted and pressed.	K 9	58
Pang Kua	浜瓜	Water melon, small.	D13	48
Peng	蚌	Mussel, Swan.	L 7	31,60
Pi Ch'i	荸薺	Water chestnut.	C87	48
Pi Mu	比目	Sole.	N37	33,66
Pieh	鼈	Turtle.	M19	62
Pien Lo Fu	變羅蔔	Radish.	C76	46
Pien Sun	鞭筍	Bamboo shoots, young.	C12	42
Pien Sun Kan	鞭筍乾	Bamboo shoots, young dried.	C14	42
Pien Yü	鯿魚	Bream, fresh-water.	N 5	64
Po Ts'ai	菠菜	Spinach.	C79	17,46
P.				
P'i Pa	枇杷	Loquat.	F13	50
P'i Tan	皮蛋	Egg, duck's, limed.	J 9	29,60
P'ieh La	撇拉	Kohl-rabi.	C52	16,44
P'ieh Lan	苤藍	Kohl-rabi.	C52	16,44
P'ing Kuo	蘋果	Apple, Chinese.	F 1	50
P'o Tzu Yü	婆子魚	Pomfret, Silver.	N32	64
P'u T'ao	葡萄	Grape	F 9	23,50
P'u T'ao Kan	葡萄乾	Raisin.	G24	23,54
S.				
San Hao Pai Mi	三號白米	Rice, 3rd grade.	A 6	8,36
Shan Li Hung	山裏紅	"Red fruit," Haws.	F27	23,52
Shan T'ou Mi Chu	汕頭蜜桔	Orange, Swatow.	F18	52
Shan Yao	山藥	Yam.	C88	48
Shan Yü	山芋	Potato, sweet.	C73	18,46
Shan Yü	鱔魚	Eel, field.	N16	64
Shao Hsing Kan Ts'ai	紹興乾菜	Mustard leaves, Shao-shing.	C62	46
Shao Ya	燒鴨	Duck, roasted.	K10	58
Sheng Li Kua	生梨瓜	Pear.	F22	52

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Sheng Ts'ai	生菜	Lettuce.	C55	44
Shih	柿	Persimmon	F23	52
Shih Hsien Ts'ai	鹽鹹菜	Cabbage, salted.	C25	42
Shih Liu	石榴	Pomegranate.	F 25	52
Shih Ping	柿餅	Persimmon, dried.	G20	23,54
Shih Yü	鰣魚	Shad, Chinese.	N34	66
Shou Chu Jou	瘦豬肉	Pork, lean.	K30	60
Shou Niu Jou	瘦牛肉	Beef, lean.	K 3	58
Shou Yang Jou	瘦羊肉	Mutton, lean.	K17	58
Shui Ch'in Kan Mao Sun	水浸乾毛筍	Bamboo shoots, soaked and dried.	C11	42
Shui Ch'in Ts'ai	水芹菜	Celery, water.	C36	44
So Tzu Hsieh	梭子蟹	Crab, sea.	M 4	62
Suchow Hsiang Keng	蘇州香粳	Rice, polished Suchow	A14	8,36
Suchow Tung Shuang Mi	蘇州冬舂米	Rice, Suchow winter	A15	8,36
Suchow Wei Sheng Mi	蘇州衛生米	Rice, whole Suchow.	A25	8,36
Sung Hua	松花	Egg, duck's, limed.	J 9	29,56
Sung Jen	松仁	Pine seed.	G21	54
Szu Kua	絲瓜	Loofah.	D 7	19,48
T.				
Ta Chi Tan	大鷄蛋	Egg, large.	J 4	56
Ta Hsia	大蝦	Prawn.	M10	62
Ta K'uai Yu Tou Fu	大塊油豆腐	Soybean curd, fried, large.	B29	40
Ta Suan	大蒜	Garlic.	C47	44
Ta T'ou Hsiang, Yen	大頭鯗(鹽)	Bream, sea, salted.	N 6	64
Ta T'ou Ts'ai	大頭菜	Mustard root, pickled.	C66	46
Ta T'ou Ts'ai Ken	大頭菜根	Mustard root.	C64	46
Ta Ts'ung	大葱	Onion, Chinese.	C67	46
Ta Yen	大鹽	Salt, common.	O 7	34,66
Tai Yü	帶魚	Hair-tail	N19	64
Tan Huang	蛋黃	Egg yolk.	J 3	28,56
Tan Huang, Ta.	蛋黃，大	Egg, large, yolk.	J 6	28,56
Tan Pai	蛋白	Egg white.	J 2	3,28,56
Tan Pai, Ta	蛋白，大	Egg, large, white.	J 5	3,28,56
Tan Ts'ai	淡菜	Mussel, dried.	L 6	31,60
Tao Yü	刀魚	Anchovy, Chinese.	N 1	62
Tou Fu	豆腐	Soybean curd.	B23	2,12,13 14,40
Tou Fu Kan	豆腐乾	Soybean curd cake.	B25	40

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Tou Pan Chiang	豆瓣醬	Bean paste.	H 1	27,56
Tou Yu	豆油	Soybean oil.	I 3	28,56
Tung Ku	冬菇	Mushrooms.	E 4	50
Tung Kua	冬瓜	Gourd, white.	D 6	19,48
Tung Sun	冬筍	Bamboo shoots, winter variety.	C15	42
Tzu P'u T'ao	紫葡萄	Grape, purple.	F10	23,50
Tzu Ts'ai	紫菜	Seaweed, Laver.	E 8	50
T.				
T'ai Ku Ts'ai	太古菜	Cabbage, flat.	C23	16,42
T'ang Li Yü	塘裏魚	Sleeper, Bull head.	N35	66
T'ao	桃	Peach.	F20	52
T'ien Chi	田鷄	Frog.	M 7	62
T'ien Hsi Kua Tzu	甜西瓜子	Watermelon seed, sugared.	G32	54
T'ien Lo	田贏	Snails, river.	L11	60
T'ien Mien Chiang	甜麵醬	Sweet flour paste.	H 7	27,56
T'ien Ts'ai	菾菜	Beet, sugar, tops.	C20	16,42
T'ien Ts'ai Ken	菾菜根	Beet root.	C18	16,42
T'ien Ts'ai Yeh Ching	菾菜葉莖	Beet, tops.	C19	16,42
T'ou Hao Hsien Mi	頭號秈米	Rice, 1st grade upland.	A21	8,36
T'ou Hao Pai Mi	頭號白米	Rice, polished 1st grade.	A 3	8,36
Ts'ai Hua	菜花	Cauliflower.	C30	16,44
T'san Tou	蠶豆	Horse bean.	B 6	38
Ts'an Tou Pan	蠶豆瓣	Horse bean, soaked	B10	38
Ts'an Tou Ya	蠶豆芽	Horse bean, sprouted.	B11	38
Ts'ao Ch'iao Pai Keng	漕橋白粳	Rice, polished Ts'ao Chiao.	A16	8,36
Ts'ao Mi	糙米	Rice, whole.	A22	8,36
Ts'ao T'ou	草頭	Alfalfa.	C 1	16,17,42
Ts'u Yen	粗鹽	Salt, common.	O 7	66
T'ung Hao Ts'ai	茼蒿菜	Chrysanthemum.	C37	44
W.				
Wai Yang Wu Hua Kuo	外洋無花果	Fig, foreign.	F 8	50
Wan Tou Miao	豌豆苗	Pea sprouts.	B18	40
Wei Ching	味精	Flavoring Essence B.	O 2	34,66
Wei Fen	味粉	Flavoring Essence A.	O 1	66
Wei Pao	味寶	Flavoring Essence C.	O 3	66
Wei Sheng Kua Mien	衛生掛麵	Vermicelli, wrapped.	A38	38

Romanized	Chinese	English	No.	Page
Wei Tsu	味祖	Flavoring Essence D.	O 4	66
Wei Yü	鮠魚	"Wei Yü," kind of shad.	N40	66
Wo Sun	萵筍	Lettuce stems, Chinese.	C56	44
Wo Sun Yeh	萵筍葉	Lettuce leaf, Chinese.	C57	46
Wu Hsiang Hua Sheng	五香花生	Peanut, salted.	G19	54
Wu Hua Chu Jou	五花猪肉	Pork, with skin.	K31	60
Wu Hua Kuo	無花果	Fig.	F 7	22,55
Wu Ts'ei	烏賊	Cuttle fish.	L 5	60
Wu T'ung Tzu	梧桐子	Kolanut, Dryandra.	G11	54
Wu Yü	烏魚	Snake head.	N36	66
Wusi Fu Chien Mi	無錫埠尖米	Rice, pointed Wusi.	A18	8,36
Wusi Pai Keng	無錫白粳	Rice, polished Wusi.	A17	8,36
Wusi Ts'ao Mi	無錫糙米	Rice, whole Wusi.	A23	8,36
Y.				
Ya Hsüeh K'uai	鴨血塊	Duck's blood.	K11	58
Ya Jou	鴨肉	Duck.	K 7	58
Ya Li, Tientsin.	鴨梨(天津)	Pear, Chinese.	F21	52
Ya Tan	鴨蛋	Duck's Egg.	J 7	29,56
Yang Ch'in Ts'ai	洋芹菜	Celery, Foreign.	C35	44
Yang Fang Feng	洋防風	Parsnip.	C75	46
Yang Fen	洋粉	Agar-agar.	E 1	48
Yang Jou, Fei Shou	羊肉肥瘦	Mutton.	K15	58
Yang Kan	洋肝	Sheep's liver.	K36	60
Yang Ts'ung T'ou	洋葱頭	Onion, foreign.	C68	46
Yeh K'ai Hua	夜開花	Calabash.	D 1	18,48.
Yeh Ts'ai	野菜	Shepherds purse.	C78	16,46.
Yen Ch'ing Chuan Yü	鹽青串魚	Ch'ing chuan yü, salted.	N13	64
Yen Ch'ing Tou	鹽青豆	Soybean, green, salted.	B24	40
Yen Hsi Kua Tzu	鹽西瓜子	Water melon seed, salted.	G31	54
Yen Hsiang Ch'un T'ou	鹽香椿頭	Cedar, salted.	C33	44
Yen Hsien Hsiang Ch'un T'ou	鹽鮮香椿頭	Cedar, salted, fresh.	C32	44
Yen Kan Lan	鹽橄欖	Canarium, salted, Chinese olive.	G 2	52
Yen Pai Kua Tzu	鹽白瓜子	Pumpkin seeed, salted.	G22	54
Yen Pai Lo Fu Kan	鹽白蘿蔔乾	Turnip, salted.	C82	17,46
Yen Pieh Sun	鹽鞭筍	Bamboo shoots, salted.	C13	42
Yen Wo	燕窩	Bird's nest.	M 1	31,62
Yi Hsing Pai Keng	宜興白粳	Rice, Yi Hsing.	A19	8,36

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Yin Erh	銀耳	Fungus.	E 3	48
Yin Hsing	銀杏	Ginkgo seeds.	G 6	25,52
Yin Yü	銀魚	White-bait, Chinese	N41	66
Ying T'ao	櫻桃	Cherry.	F 6	50
Yu	柚	Pumelo.	F26	23,52
Yu Cha Fen Mien Chin	柚炸粉麵筋	Wheat gluten and flour, fried.	A36	38
Yu Cha Hua Sheng Jen	油花炸生仁	Peanut, fried.	G18	54
Yu Cha Mien Chin	油炸麵筋	Wheat gluten, fried.	A35	38
Yu Chien Chu P'i	油煎猪皮	Pig's skin, fried.	K25	58
Yu Huang Tou	油黃豆	Soybean, fried.	B22	40
Yu Men Sun	油燜筍	Bamboo shoots, steeped in hot oil.	C16	42
Yu P'i	油皮	Soybean milk clot.	B33	40
Yu T'iao	油條	Wheat fritters, twisted and fried.	A39	38
Yu Ts'ai Chieh	油菜節	Colza shoots.	C41	16,44
Yu T'ung Yü	油筒魚	Mackerel, Spanish.	N25	33,64
Yu Yü	魷魚	Squid.	L12	60
Yung	鱅	Big-head	N 4	62
Yü Ch'ih	魚翅	Shark's fin.	M12	62
Yü Piao	魚鰾	Fish maws, Air bladder.	M 6	32,62
Yü T'ou	芋頭	Aroid; Taro.	C 4	42
Yü Tu	魚肚	Fish maws.	M 6	32,62
Yüan Sui	蒝荽	Coriander.	C43	44
Yün Pien Tou Chia	芸扁豆莢	String beans.	B37	40

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Beef	Bos Taurus, L.	肥瘦牛肉	K 1	58
Beef, fat	Bos Taurus, L.	肥牛肉	K 2	58
Beef, lean	Bos Taurus, L.	瘦牛肉	K 3	58
Beef, pickled	Bos Taurus, L.	醬牛肉	K 4	58
Beef juice, "Bovril"	Bos Taurus, L.	牛肉汁	K 5	58
Beet, sugar, tops	Beta vulgaris, L. var. rapa	蒸菜，根刀菜	C20	42
Beet root	Beta vulgaris, L.	蒸菜根	C18	42
Beet tops	Beta vulgaris, L.	蒸菜葉莖	C19	42
"Big-head"	Aristichthys nobelies, Rich.	鱅，花鰱魚	N 4	62
Bird's nest	Callocalia brevirostris L.	燕窩	M 1	31,62
Bream, fresh-water	Parabramis terminalis, Rich.	鯿魚	N 5	64
Bream, sea, salted	Sparus macrocephalus, Basil.	大頭鰲(鹽)	N 6	64
Bull head	Eleotris potamophila, Gunther.	塘裏魚	N35	66
C.				
Cabbage, Chinese	Brassica pekinensis, Rupr.	白菜(大)	C21	16.17.42
Cabbage, flat	Brassica narinosa, Bailey.	太古菜	C23	16,42
Cabbage, foreign	Brassica oleracea, L.	捲心菜	C24	42
Cabbage, salted	Brassica pekinensis, Rupr.	金冬菜	C22	42
Cabbage, salted, Haining	Brassica sp.	濕鹹菜(海寧)	C25	42
Cabbage, small	Brassica chinensis, L.	小白菜	C26	16,26,42
Cabbage, small, sprouts	Brassica chinensis, L.	鷄毛菜	C27	42
Calabash	Lagenaria vulgaris, Ser.	夜開花，瓢子	D 1	18,48
Cane sugar	Saccharum.	白糖	H 2	56
Canarium	Canarium album, Raeusch.	橄欖，青果	F 5	24,50
Canarium, salted	Canarium album, Raeusch.	鹽橄欖	G 2	52
Cantaloupe	Cucumis melo, L.	青皮甜瓜	D 2	48
Carp, black	Mylopharyngodon aethiops, Basil.	青魚	N10	64
Carp, black, smoked	Mylopharyngodon aethiops, Basil.	薰青魚，薰魚	N11	64
Carp, common	Cyprinus carpio, Linn.	鯉	N 7	64

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Carp, golden	Carassius auratus, Linn.	鮒，鯽魚	N 8	64
Carp, silver	Hypophthalmichthys molitrix, C. et V.	白魚(鰱)	N 9	64
Carrot, red.	Daucus Carota, L.	紅胡蘿蔔	C28	42
Carrot, yellow	Daucus Carota, L.	胡蘿蔔	C29	17,44
Cauliflower	Brassica oleracea, var botrytis, L.	菜花	C30	16,44
Cedar, salted	Cedrela sinensis, Juss	鹽鮮香椿頭	C32	44
Cedar, salted, dried	Cedrela sinensis, Juss	鹽香椿頭(乾)	C33	44
Cedar shoots	Cedrela sinensis, Juss.	鮮香椿頭	C31	44
Celery, Chinese	Apium graveolens, L.	芹菜	C34	44
Celery, Foreign	Apium graveolens, L.	洋芹菜	C35	44
Celery, water	Oenanthe stolonifera, D. C.	水芹菜	C36	44
Cherry	Prunus pseudocerasus Lindl.	櫻桃	F 6	50
Chestnut	Castanea vulgaris, Lam.	栗子	G 3	52
Chestnut, baked	Castanea vulgaris, Lam.	炒熟栗子	G 4	52
Chillies	Capsicum annuum, L. var.	辣椒	C70	46
"Chin hsien yü"	Euthyopteroma virgatum, Hout.	金線魚	N12	64
Chinese date	Zizyphus vulgaris, Lam.	紅棗	G 8	25,52
Chinese olive	Canarium album, Raeusch	鹽橄欖	G 2	52
"Ch'ing chuan yü," salted		鹽青專魚	N13	64
Chrysanthemum	Chrysanthemum coronarium, L.	茼蒿菜	C37	44
Clam	Cytherea meretrix, L.	厚殼黃蛤	L 1	60
Clam, Bloody	Arca granosa, Linn.	魁蛤	L 2	60
Clam, white	Dosinia troscheli, Lisch.	白蛤蜊	L 3	60
Clam, yellow	Cyclina chinensis, Ch.	黃蛤蜊	L 4	60
Colza, flowering top	Brassica juncea, H. F. var. oleifera.	乾油菜薹	C42	44
Colza, large	Brassica juncea, H. F. var. oleifera.	青菜	C39	44
Colza, salted	Brassica juncea, H. F var. oleifera.	鹹青菜	C40	44
Colza, small	Brassica campestris, L. var. oleifera.	小青菜	C38	44

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Colza shoots	Brassica juncea, H. F var. oleifera.	油菜筋	C41	16,44
Coriander	Coriandrum sativum, L.	莞荽，香菜	C43	44
Corn	Zea Mays, L.	鮮老玉米	A 1	12,36
Cow's liver	Bos Taurus, L.	牛肝	K 6	58
Cowpea pods, green	Vigna Sinensis, Hassk.	青綠豇豆莢	B 2	15,38
Cowpea pods, white	Vigna Sinensis, Hassk.	白豇豆莢(鮮)	B 1	15,38
Crab	Eriocheia chinensis, ME.	河螃蟹	M 2	62
Crab, salted	Eriocheia chinensis, ME.	鹹河蟹	M 3	62
Crab, sea	Neptunes pelagicus, M	梭子蟹(蠘)	M 4	62
Crab, sea, salted	Neptunes pelagicus, M	搶蟹	M 5	62
Cucumber	Cucumis sativus, L.	黃瓜	D 3	19,48
Cucumber, pickled	Cucumis sativus, L.	醬黃瓜	D 4	19,48
Curry powder		咖喱粉	H 3	27,56
Cuttle fish	Sepia esculenta, Hoyle	墨魚，烏賊	L 5	60
D.				
Dogfish	Squalus mitsukurii, J. & S.	角鯊	N14	33,64
Dryandra	Sterculia platanifolia, L.f.	梧桐子	G11	54
Duck	Anas domesticus, L.	鴨肉	K 7	58
Duck's blood	Anas domesticus, L.	鴨血塊	K11	58
Duck, pickled	Anas domesticus, L.	醬鴨	K 8	58
Duck, roasted	Anas domesticus, L.	燒鴨	K10	58
Duck, salted & pressed	Anas domesticus, L.	板鴨	K 9	58
E.				
Eel, marine	Muraenesox cinereus, Forskl.	海鰻鱺	N15	64
Eel, field	Fluta alba, Zuiew.	鱔魚	N16	64
Eel, fresh water	Anguilla japonica, T. et S.	河鰻鱺	N17	64
Egg, duck's, limed	Anas domesticus, L.	松花，皮蛋	J 9	29,56
Egg, duck's, whole	Anas domesticus, L.	鴨蛋	J 7	29,56
Egg, duck's, salted	Anas domesticus, L.	鹹鴨蛋	J 8	29,56
Egg, large, white	Gallus domesticus, Briss.	蛋白，大	J 5	3.28.56
Egg, large, whole	Gallus domesticus, Briss.	大鷄蛋，全	J 4	56

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Egg, large, yolk	Gallus domesticus, Briss.	蛋黃，大	J 6	28,56
Egg, small, white	Gallus domesticus, Briss.	蛋白	J 2	3,28,56
Egg, small, whole	Gallus domesticus, Briss.	鷄蛋	J 1	28,56
Egg, small, yolk	Gallus domesticus, Briss.	蛋黃	J 3	28,56
Egg plant	Solanum Melongena, L.	茄子	C4	44
F.				
Fennel	Foeniculum vulgare, L.	茴香菜(老)	C45	44
Fennel, young	Foeniculum vulgare, L.	茴香菜(嫩)	C46	44
Fig, Chinese	Ficus carica, L.	中國無花果	F 7	22,50
Fig, foreign	Ficus carica, L.	外洋無花果	F 8	50
Fish maws	Ichthyocolla.	魚肚，魚鰾	M 6	32,62
Flat bean, fresh pods	Dolichos Lablab, L.	白扁豆莢(鮮)	B 3	14,38
Flat bean, green	Dolichos Lablab, L.	青架扁豆莢(鮮)	B 5	14,38
Flat bean, runners	Dolichos Lablab, L.	白架扁豆莢(鮮)	B 4	14,38
Flavoring Essence A.	Wei fen brand	味粉	O 1	66
Flavoring Essence B	Wei ching brand	味精	O 2	34,66
Flavoring Essence C	Wei pao brand	味寶	O 3	66
Flavoring Essence D	Wei tsu brand.	味祖	O 4	66
Fowl	Gallus domesticus, Biss.	鷄肉	K12	58
Foxnut	Euryale ferox, Salisb.	鷄頭米，芡	G 5	25,52
Frog	Rana nigromaculata, Hall.	田鷄	M 7	62
Fry, salted and mixed	———	海蜒	N18	64
Fungus	———	葛仙米	E 2	48
Fungus	———	銀耳，白木耳	E 3	50
G.				
Garlic	Allium sativum, L.	大蒜	C47	44
Garlic, green	Allium sativum, L.	青蒜	C48	44
Ginger	Zingiber officinale, Rosc.	薑	C49	44
Ginger, pickled	Zingiber officinale, Rosc.	醬老薑	C50	44
Ginger shoots	Zingiber officinale, Rosc.	薑芽	C51	44
Ginkgo seeds	Ginkgo biloba, L.	白果，銀杏	G 6	25,52

English	Latin	Chinese	No.	Page
Goose	Anser domesticus, L.	鵝肉	K13	58
Gourd, bitter	Momordica charantia, L.	苦瓜	D 5	19,48
Gourd, white	Benincasa cerifera, Savi.	冬瓜	D 6	19,48
Grape, long white	Vitis vinifera, L. var.	長白葡萄	F 9	23,50
Grape, purple	Vitis vinifera, L. var.	紫葡萄	F10	23,50
H.				
Hair-tail	Trichiurus japonica, T. et S.	帶魚	N19	64
Hair-tail, salted	Trichiurus japonica, T. et S.	鹹帶魚	N20	64
Ham	Sus scrofa, L. var.	火腿	K14	58
Haws	Crataegus pinnatifida, Bge.	山裏紅，紅果	F27	23,52
Hazel nut	Corylus heterophylla, Fisch	榛子	G 7	52
Herring	Ilisha elongata, Bennett	鰳，鰲魚	N21	33,64
Herring, salted	Ilisha elongata, Bennett	鰳，鰲魚(鹽)	N22	33,64
Honey dates	Zizyphus vulgaris, Lam.	金絲蜜棗	G 9	25,52
Horse bean, dried peeled	Vicia Faba, L.	乾蠶豆去皮	B 8	38
Horse bean, fresh	Vicia Faba, L.	鮮蠶豆	B 6	38
Horse bean, fresh peeled	Vicia Faba, L.	鮮蠶豆去內皮	B 7	38
Horse bean, salted & fried	Vicia Faba, L.	炸鹹蠶豆瓣	B 9	38
Horse bean, soaked	Vicia Faba, L.	蠶豆瓣	B10	38
Horse bean, sprouted.	Vicia Faba, L.	蠶豆芽	B11	38
I.				
Isinglass	Ichthyocolla.	魚鰾	M 6	32,62
J.				
Jelly fish	Rhopilema esculanta, Kish.	海蜇皮	M 8	62
Jelly fish, salted	Rhopilema esculanta, Kish.	鹹海蜇	M 9	62
Jujube	Zizyphus vulgaris, Lam.	紅棗	G 8	25,52
Jujube, preserved	Zizyphus vulgaris, Lam.	金絲蜜棗	G 9	25,52
Jujube, smoked	Zizyphus vulgaris, Lam.	黑棗	G10	23,54

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K.				
Kohl-rabi	Brassica caulorapa, Pasq.	茎藍，擷拉	C52	16,44
Kolanut	Sterculia platanifolia, L.f.	梧桐子	G11	54
L.				
Lard	Sus scrofa, L. var.	猪油	K24	58
Leeks	Allium odorum, L.	韮菜	C53	44
Leek shoots	Allium odorum, L.	黃韮芽	C54	44
Lemon	Citrus medica, L. var Limonum, Hoak.	檸檬	F11	50
Lesser yellow-fish	Pseudosciaena undovitata, J. et S.	小黃魚	N26	33,64
Lettuce	Lactuca sativa, L.	生菜	C55	44
Lettuce leaf, Chinese	Lactuca Scariola, L. var. sativa	萵筍葉	C57	46
Lettuce stems, Chinese	Lactuca Scariola, L. var. sativa	萵筍	C56	44
Lily flowers (dried)	Hemerocallis fulva, L.	金針菜，黃花菜	C58	46
Litchi	Litchi chinensis, Sonn.	荔枝	F12	22,50
Loach	Misgurnus angiullicaudatus, Can.	廣鰍魚	N23	64
Locust seeds	Sophora japonica, L.	槐子	G12	25,54
Loofah	Luffa cylindrica, Roem.	絲瓜	D 7	48
Loquat	Eriobotrya japonica, Lindl	枇杷	F13	50
Lotus root	Nelumbium nucifera, Gaertn.	藕	C59	46
Lotus root starch	"Chinese arrowroot"	藕粉	H 4	56
Lotus seeds, dried	Nelumbium nucifera, Gaertn.	乾蓮子	G13	26,54
Lotus seeds, preserved	Nelumbium nucifera, Gaertn.	蜜餞蓮子	G14	26,54
Lungngans	Nephelium longana, Camb.	桂圓	G15	26,54
M.				
Mackerel	Scomber niphonius, C. & V.	鯖魚	N24	33,64
Mackerel, Spanish, salted	Scomber japonica, Houttuyn.	油筒魚(鹽)	N25	33,64
Maigre	Pseudosciaena undovit tata, J. et S.	小黃魚	N26	33,64
Maigre, Japanese	Sciaena japonica, Schlegel.	鮸(鮢)	N28	64

English	Latin	Chinese	No.	Page
Maigre, salted	Pseudosciaena schlegeli, Blkr.	黃魚鯗(鱉)	N27	33,64
"Ma-kao-yü		馬高魚	N29	64
Mandarin fish	Siniperca chuatsi, Basil.	鱖魚	N30	64
Mango	Mangifera indica, L.	杧果	F15	22,50
Milk, Cow's	Bos taurus, L.	鮮牛乳	J 10	2.30,56
Millet, short	Setaria italica, Kth. var. germanica, Trin.	小米	A 2	11,36
Mung bean	Phaseolus mungo, L. var. radiatus, Bak.	綠豆	B12	2,3,15,38
Mung bean, sprouted	Phaseolus mungo, L.	綠豆芽	B13	38
Mung bean, starch jelly	Phaseolus mungo, L.	綠豆涼粉	B14	40
Mung bean, starch sheet	Phaseolus mungo, L.	粉皮	B15	40
Mung bean, starch strip	Phaseolus mungo, L.	線粉	B16	40
Mushrooms	Russula sp.	冬菇	E 4	50
Mushrooms	Agaricus Bretschneideri K. & T.	香菌	E 5	20,50
Mushrooms	Agaricus campestris, L.	蘑菇菌	E 6	20,50
Mushrooms, Jew's ear	Auricularia auricula-Judae, Schöt	木耳	E 7	20,50
Musk melon	Cucumis conomon, Mak.	黃金瓜	D 8	19,48
Mussel, dried	Mytilus edulis, L.	淡菜	L 6	31,60
Mussel, Swan	Anodonta chinensis,	蚌	L 7	31,60
Mustard leaves	Brassica juncea, Thoms.	芥菜葉(鮮)	C60	17,46
Mustard leaves, dried	Brassica juncea, Thoms.	乾芥菜葉	C61	46
Mustard leaves, salted	Brassica juncea, Thoms.	鹹菜，雪裏紅	C63	46
Mustard leaves, Shaoshing	Brassica juncea, Thoms.	紹興乾菜	C62	46
Mustard root	Brassica juncea, Thoms.	大頭菜根(鮮)	C64	46
Mustard root, pickled	Brassica juncea, Thoms.	大頭菜	C66	46
Mustard root, spiced	Brassica juncea, Thoms.	榨菜	C65	46
Mutton	Ovis aries, L. var.	肥瘦羊肉	K15	58
Mutton, fat	Ovis aries, L. var.	肥羊肉	K16	58
Mutton, lean	Ovis aries, L. var.	瘦羊肉	K17	58

English	Latin	Chinese	No.	Page
O.				
Onion, Chinese	Allium fistulosum, L.	大葱	C67	46
Onion, Foreign	Allium Cepa, L.	洋葱頭	C68	46
Onion, small	Allium fistulosum, L.	小葱	C69	46
Orange (Fukien)	Citrus nobili, Lour. var.	福建小紅桔	F17	52
Orange (Siam)	Citrus Tankan, Hoyada	橘(桔)(暹羅)	F16	23,52
Orange (Swatow)	Citrus poonensis, Hort ex Tankan	汕頭蜜桔	F18	52
Orange (Wenchow)	Citrus nobilis, Lour. var.	黃巖桔	F19	23,52
Oyster	Ostrea talienwahnensis Cross.	牡蠣	L 8	31,60
P.				
"Paikuotze," salted	Nibea sina, Cuvier	白果子魚(鹽)	N31	64
Parsnip	Peucedanum sativum, L.	金深蘿蔔(洋防風)	C75	46
Peas, green,	Pisum sativum, L.	鮮豌豆	B17	40
Pea sprouts	Pisum sativum, L.	豌豆苗	B18	40
Peach	Prunus persica, S. et Z. var. vulgaris, Maxim.	桃	F20	52
Peanut	Arachis hypogoea, L.	落花生	G16	2,3,26,54
Peanut, fried	Arachis hypogoea, L.	油炸花生仁	G18	54
Peanut, salted	Arachis hypogoea, L.	五香花生仁	G19	54
Peanut, small	Arachis hypogoea, L.	中國小花生	G17	54
Peanut oil	Arachis hypogoea, L.	花生油	I 1	28,56
Pear	Pirus sp.	生梨瓜	F22	52
Pear, Chinese	Pirus sinensis, Lindl.	鴨梨(天津)	F21	52
Pepper, Chinese	Xanthoxylum piperitum, DC.	花椒	O 5	34,66
Peppers, green	Capsicum annuum, L. var.	青辣椒	C70	46
Pepper paste		辣醬	H 5	28,56
Peppers, red	Capsicum annuum, L. var.	紅柿形辣椒	C71	17,46
Persimmon	Diospyros Kaki, L.	柿	F23	52
Persimmon, dried	Diospyros Kaki, L.	柿餅(山東)	G20	23,54
Pig's blood	Sus scrofa, L. var.	猪血	K18	58
Pig's intestine	Sus scrofa, L. var.	猪腸	K19	58
Pig's heart	Sus scrofa, L. var.	猪心	K20	58
Pig's kidney	Sus scrofa, L. var.	猪腰	K21	58

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Pig's leg	Sus scrofa, L. var.	猪肘	K22	58
Pig's liver	Sus scrofa, L. var.	猪肝	K23	58
Pig's oil (Lard)	Sus scrofa, L. var.	猪油	K24	58
Pig's skin, fried	Sus scrofa, L. var.	油煎猪皮	K25	58
Pig's stomach	Sus scrofa, L. var.	猪肚	K26	58
Pig's tongue	Sus scrofa, L. var.	猪舌	K27	58
Pine seed	Pinus tubulaeformis, Carr.	松仁	G21	54
Plum	Prunus mume, S. et Z var.	青梅	F24	52
Pomegranate	Punica granatum, L.	石榴	F25	52
Pomfret, Silver	Stromateoides argenteus, Puph.	鯧魚，川扁魚，婆子魚	N32	64
Pork	Sus scrofa, L. var.	肥瘦猪肉	K28	58
Pork, fat	Sus scrofa, L. var.	肥猪肉	K29	60
Pork, lean	Sus scrofa, L. var.	瘦猪肉	K30	60
Pork, muscle	Sus scrofa, L. var.	肉鬆	K32	60
Pork, pickled	Sus scrofa. L. var.	醬肉	K33	60
Pork, roasted	Sus scrofa, L. var.	叉燒	K34	60
Pork, salted	Sus scrofa, L. var.	鹹肉	K35	60
Pork, with skin	Sus scrofa. L. var.	五花猪肉	K31	60
Potato	Solanum tuberosum, L	番薯	C72	46
Potato, sweet	Ipomaea Batatas, Lam.	白藷，山芋	C73	18,46
Potato, sweet, Canton		白薯(廣東)	C74	18,46
Prawn	Penaeus carinatus, Dana.	明蝦，大蝦	M10	62
Pumelo	Citrus decumana, L.	柚	F26	23,52
Pumpkin	Cucurbita pepo, L.	西葫蘆(老)	D 9	19,48
Pumpkin seed, salted	Cucurbita pepo, L.	鹽白瓜子	G22	54
R.				
Radish	Raphanus sativus, L.	[illegible]蘿蔔，辣紅	C76	46
Raisin	Vitis vinifera, L.	葡萄乾(Boy牌)	G24	23,54
Razor shell	Solecurtus constricta, Lamarck	蟶	L 9	60
Red fish, salted		鹹紅鰲魚	N33	66
"Red fruit"	Crataegus pinnatifida, Bge.	山裏紅，紅果	F27	23,52
Red gram bean	Phaseolus mungo, L. var. subtrilobata, F. et S.	赤小豆	B19	40
Rice, cooked	Average sample	米飯	A31	8,38

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Scallop, dried	Pecten yessoensis, Jay.	干貝	L10	31,60
Sea slug, soaked (Bicho de mar)	Stichopus japonicus, Selenka.	海參(浸)	M11	32,62
Seaweed	Laminaria religiosa, Miyabe	海帶	E 9	50
Seaweed	Nostoc commune, Vauch.	髮菜	E10	20,50
Seaweed, gulfweed	Sargassum siliquastum, Ag.	海藻	E11	20,50
Seaweed, Laver	Porphyra laciniata, Ag.	紫菜	E 8	50
Sesame oil	Sesamum indicum, L.	蔴油	I 2	28,56
Sesame paste		芝蔴醬	H 6	28,56
Shad, Chinese	Hilsa reeversii, Richardson	鰣魚	N34	66
Shark's fin, dried	Selachoidei et Batoidei	魚翅(乾)	M12	62
Sheep's liver	Ovis aries, L. var.	羊肝	K36	60
Shepherds purse	Capsella bursapastoris Moench	薺菜，野菜	C77 C78	16,46
Shrimp	Macrobrachium nipponensis, de Hana	青蝦	M13	62
Shrimp, dried	Leander annandalei, Remp.	開洋	M17	62
Shrimp, eggs	Leander annandalei, Remp.	蝦子	M18	62
Shrimp, river	Palaemon sp.	河蝦	M14	62
Shrimp, small	Leander annandalei, Remp.	白米蝦	M15	8,36,62
Shrimp, small, salted	Leander annandalei, Remp.	鹹白米蝦	M16	62
Sleeper	Eleotris potamophila, Gunther.	塘鱧魚	N35	66
Snails, river	Vivipara quadrata, Benson.	田螺	L11	60
Snake head	Ophiocephalus argus, Cantor.	烏魚(黑鱧)	N36	66
Sole	Cynoglossus abbreviatus, Gray.	箬鰨魚，比目	N37	33,66
Soybean	Glycine soja, (S. et Z.)	黃豆	B20	12,40
Soybean in pod, fresh beans	Glycine soja, yellow variety (S. et Z.)	毛豆	B21	12,40
Soybean, fried	Glycine soja, yellow variety (S. et Z.)	油黃豆	B22	40
Soybean, green, salted	Glycine soja, green Variety (S. et Z.)	醃青豆	B24	40
Soybean, pickled	Glycine soja, S. et Z.	醬油黃豆	B34	40
Soybean curd	Glycine soja, S. et Z.	豆腐	B23	2,3,12,40

English	Latin	Chinese	No.	Page
Soybean curd cake	Glycine soja, S. et Z.	豆腐乾	B25	40
Soybean curd cake, spiced	Glycine soja, S. et Z.	香乾	B27	40
Soybean curd cake, with mushroom	Glycine soja, S. et Z.	蘑菇豆腐乾	B26	40
Soybean curd, fermented	Glycine soja, S. et Z.	臭豆腐	B28	40
Soybean curd, fried, large	Glycine soja, S. et Z.	大塊油豆腐	B29	40
Soybean curd, fried, small	Glycine soja, S. et Z.	小塊油豆腐	B30	40
Soybean curd, pickled	Glycine soja, S. et Z.	醬豆腐	B31	40
Soybean curd, sheet	Glycine soja, S. et Z.	千張，百頁	B32	40
Soybean milk clot	Glycine soja, S. et Z.	油皮	B33	40
Soybean oil	Glycine soia, S. et Z.	豆油	I 3	56
Soybean, sauce	Glycine soja, S. et Z.	醬油	B35	40
Soybean, sprouted	Glycine soja, S. et Z.	黃豆芽	B36	14,40
Spaghetti	Triticum vulgare, Vill.	麵條	A37	38
Spinach	Spinacea oleracea, Mill.	菠菜	C79	17,46
Squash	Cucubita maxima, L.	南瓜	D10	19,48
Squash, old	Cucubita maxima, L.	南瓜(老)	D11	19,48
Squid	Ommastrephes pacificus, App.	魷魚，柔魚	L12	60
String bean	Phaseolus vulgaris, L	芸扁豆莢	B37	40
String ray	Dasyatus akajei, M. & H.	黃貂魚	N38	66
Strawberry	Fragaria sp.	西洋楊梅	F28	52
Sugar cane	Saccharum officinarum. L.	甘蔗	F29	52
Sunflower seed	Helianthus annuus, L.	向日葵子	G25	54
Sweet flour paste	——	甜麵醬	H 7	27,56
T.				
Taro	Colocasia antiquorum, Schott	芋頭	C 4	42
Tiger fish	Minous adamsi, Rch.	老虎魚	N39	66
Tomato	Lycopersicum esculentum, Mill.	番茄	C80	46
Turnip, green, salted	Brassica Rapa, L. var	青蘿蔔乾	C84	46
Turnip, pickled	Brassica Rapa, L. var	醬白蘿蔔	C83	17,46
Turnip, salted	Brassica Rapa, L. var	鹽白蘿蔔乾	C82	46
Turnip, white	Brassica Rapa, L. var	白蘿蔔	C81	17,46
Turtle	Trionyx chinensis, T. et S.	甲魚，鱉	M19	62

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Vegetables, pickled	Brassica Rapa, L. var.	醬小菜	C85	48
Vermicelli, wrapped	Triticum vulgare, Vill	衛生掛麵	A38	38
Vinegar	Acetum	老醋	O 9	35,66
W.				
Walnut	Juglans regia, Lour.	核桃	G26	54
Water Bamboo	Zizania aquatica, L.	茭白	C86	48
Water calthrop	Trapa natans, L.	菱角米	G27	26,54
Water calthrop, red	Trapa natans, L.	紅水菱	G28	54
Water calthrop starch		菱粉	H 8	26,56
Water chestnut	Scirpus tuberosus, Roxb.	荸薺	C87	48
Watermelon	Citrullus vulgaris, L.	西瓜	D12	1,19,48
Watermelon, small	Citrullus vulgaris, var	浜瓜	D13	48
Watermelon seed	Citrullus vulgaris, Schrad.	西瓜子	G29	54
Watermelon seed, pickled	Citrullus vulgaris, Schrad.	醬油西瓜子	G30	54
Watermelon seed, salted	Citrullus vulgaris, Schrad.	鹽西瓜子	G31	54
Watermelon seed, sugared	Citrullus vulgaris, Schrad.	甜西瓜子	G32	54
"Wei yü" (Kind of shad.)	Leiocassis demerili, El.	鮠魚(鮰)	N40	66
Wheat Bread	Triticum vulgare, Vill	麵包	A33	11,38
Wheat fritters	Triticum vulgare, Vill.	油條	A39	38
Wheat gluten	Triticum vulgare, Vill.	麵筋	A34	38
Wheat gluten, fried	Triticum vulgare, Vill.	油炸麵筋	A35	38
Wheat gluten and flour,	Triticum vulgare, Vill.	油炸粉麵筋	A36	38
Whelks	Eburna japonica, Reeve.	香螺	L13	60
White-bait, Chinese	Salanx microdon, Blkr.	銀魚	N41	66
Wine, Rice.	Vinum oryzae	老酒	O10	35,66
Y.				
Yam	Dioscorea Batatas, Dcne.	山藥	C88	48
Yellow-fish	Pseudosciaena schlegeli, Blkr.	黃魚鯗	N27	64
Yew seeds	Torreya nucifera, S. et Z.	榧子	G23	54

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Henry Lester Institute of Medical Research,
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CONTENTS

1. INTRODUCTION

This report fulfils a double purpose. It provides further data upon the diets of workers in Shanghai, and it gives the necessary factual basis for studies of industrial health especially as it is related to deficiency disease.

In a recent publication entitled "The Next Five Years," appearing under the aegis of 150 leading intellectuals of Great

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Britain, attention is drawn to the unhealth, uneconomic and socially undesirable conditions caused by the crowding of the population into the industrial centres created during the last century. From the two reports already issued in this series, (Gear 1935, Read 1936), it is clear that a repetition of these deplorable conditions is taking place in industry in the Orient, and there is urgent need to study the local situation. There are many angles to the problem as a whole, individual, national and international, but few people will deny that nutrition is one of the very basic factors. Sir Gowland Hopkins (1935) in referring to the above essay, compares the urgency of the problem with the conservative views of other writers who consider that it should await the arrival of more knowledge, and states that while, "there is doubtless much more scientific knowledge to be gained about nutrition and food production, we know enough to guide administration on to the right lines."

The local problem however has to deal with a different set of economic, agricultural and racial conditions. The low economic level in China is not just a matter of degree, lower than that in Western countries, it is a major problem which by the very nature of the case produces conditions under which the nutritional state of the majority of individuals is low, and every one of the essentials in foods are at one time or another at a subminimal level, and, with so many famine areas, even the caloric intake is inadequate. Agricultural conditions are different, in that dairy farms are non-existent except in an occasional place promoted by foreigners; the crops are different, rice being the chief cereal produced in central and southern China; and while fruits and vegetables are plentiful in some areas, communications are so poor that there is not the same transfer of these food materials seen in Western countries. Burnet and Aykroyd (1935) consider that race has little influence on diet, and that man adapts his dietary habits to his surroundings in which the geographical and climatic conditions determine the production of his foodstuffs. The latter is true, but one is impressed by the large place which inherited custom has in man's behaviour, dietary habits especially so. Even if dairy farms were developed in China it would take many years of intensive propaganda to overcome the inherent dislike of cow's milk. If economic conditions improved, it would be a most difficult task to replace pork and lard by beef and butter, the latter so rich in vitamins in which lard is totally deficient.

Physiologically, appetite is considered to depend on memory, hence in these days of radical change the reformer may hope to change unsatisfactory dietary habits in two or three generations, but there are other factors which may be considered racial. We have evidence to show that beef protein is not well tolerated by Chinese. In the evolution of diet remarkable changes are taking place in some parts of the modern world with respect to dietary habits. The desired change from a bulky carbohydrate diet to one more nutritious can scarcely be effected without due consideration for the psychological, physiological or even anatomical changes involved, which indicate an evolutionary rather than a revolutionary programme. These and other aspects of the problem have been discussed by Burnet and Aykroyd (1935) as these apply to western dietaries, concerning even which they agree that the fundamental principles are debatable. Therefore to apply the science of nutrition, which has been built up from Western experience, to Chinese diets is a difficult task, and far more knowledge is required than at present obtains before one can go beyond the chemical standards so far established which deal almost entirely with the intake of certain essentials with little regard for the greater problems of the assimilation, utilization, function and quantitative interrelationship of these essentials, together with a different psychological and physiological background.

2. PHYSICAL STANDARDS

The international standards set forth by the League of Nations (1932, 1935a, 1935b) regard both physical and dietary standards as necessary, the former being of value in assessing the effect of any particular dietary regime on any given group of people. Lacking established standards for the Orient, and confronted by so many debatable issues and illdefined deficiencies this intimate connection may prove of considerable help in establishing ultimately some index of the state of nutrition as it is related to health and general physique.

Physical standards include both clinical and anthropometric methods. This study is limited to measurements of the height and weight, which we have compared with those by Shirokogoroff (1925) upon students from the same locality. The student class of China in general partake of a much better diet than the working classes, as reported by Wu and Wu (1928). Weight in relation to height has been extensively used in assessing the nutritional status and while there are liable to be numerous fallacies in such indices of nutrition, (Faber 1923), there are interesting comparisons to be made with other races or similar groups, though it is realised that our numbers are too small for any dogmatic conclusions to be drawn. In assessing the state of nutrition of various groups in Ceylon, Nicholls (1936) has used Kaup's ratio, and compared his results with those from Africa and Britain. Burnet and Aykroyd (1935) give examples of other indices, we have used Kaup's ratio in order to compare our results with those published by Nicholls and others.

3. DIETARY STANDARDS

Various dietary surveys have been made in China, and their evaluation based upon the analysis of the foods eaten, as published by Wu (1928) or by Sherman (1932), and the assessment of the diets has been made from the old standards set up by the League of Nations in Europe (1935a), or those of Sherman (1932) based upon American experience.

The latest report of the League of Nations (1935b) is a step forward in the due recognition of the needs of the growing boy. Seeing that the majority of the workers studied were minors, these new standards gave us a sounder basis of evaluation. Owing to the local character of our foodstuffs and the fact that the same foods show differences in their composition according to the climatic and soil conditions in the areas studied, one could not expect the composition of our Shanghai foods to have the same values as those reported either in Peiping, Tokyo or New York. We found large differences especially with regard to the mineral salt content.

The international standards established have so disregarded conditions in Asia, that it is important to keep in mind the data collected in Asia. In China one is dealing with a lower basal metabolic rate, the diets are largely vegetarian, bean products are largely consumed, and there are numerous vegetables and fruits not eaten in Western countries. The apparently remarkable energy of the Chinese porters and rickshaw men requires some other explanation than the nutritional standards so far established, which only deal with the elementary chemical analyses of the food eaten. On the other hand dietary standards set up on an ideal plane, cannot eventually ignore the state of the individual in whom a low nutritional state may show an apparently satisfactory balance. The one fact that parasitic infection of the alimentary canal is widespread affects the proper evaluation of the food intake necessary for the individual. Such pathological considerations cannot be dealt with until more debatable factors have been settled.

Wu and Wu (1928) studied the diets of various Peiping groups and drew the conclusion that the North China diets while adequate in fuel value, were sub-optional in protein, and in vitamins A and D, probably adequate in vitamins B and C, and low in calcium and phosphorus. Dietaries in Central China, especially Shanghai, have interested a few workers in recent years. Powell (1928) found that the coolies in Changsha required more energy per kilogram body weight than Westerners and considered it as due to the low co-efficient of digestibility of rice which constituted the bulk of the diet. Yang and Tao (1930), as a part of a large social research, surveyed the diets of Shanghai mill workers and concluded that they consumed an undue amount of carbohydrate and too small an amount of fat. Chu (1934) studied the diets of eighteen Shanghai families and his conclusions did not differ considerably from the observations of others. Dietary studies in Nanking by Cheng Tao and Chu (1935) upon 120 families showed that the average Nanking winter dietary contained higher percentages of rice, meats, leafy vegetables and fat but lower percentages of wheat, fruits and legumes than that of Peiping (Wu and Wu 1928), and the percentages of fat and eggs were slightly lower than the Shanghai figures published by Chu (1934). The international standards of the League (1935b) put an entirely different evaluation to their facts. In the absence of details concerning the age of the children, the condition of the women, pregnant, nursing or otherwise, one is not able to assess their results, but the energy, protein and mineral requirements for such groups are subject to an entirely different interpretation.

The new standards are summarized in table I.

TABLE 1. *Dietary Standards.*

League of Nations 1935 (for 70 Kilogrm body weight)

Age (years)	Coefficient (male *and* female)	Caloric requirement at rest	*Additions for activities of*		*Protein* gms per kilo body wt
			males	females	
1—2	0.3	720	—	—	3.5
2-3	0.4	960	—	—	3.5
3—5	0.5	1200	—	—	3.0
5—7	0.6	1440	—	—	2.5
7—9	0.7	1680	* 600	* 600	2.5
9—11	0.8	1920	* 600	* 600	2.5
11—12	0.9	2160	*1200	* 600	2.5
12—15	1.0	2400	*1200	* 600	2.5
15—17	1.0	2400	† +	† +	2.0
17—21	1.0	2400	† +	† +	1.5
21 and up	1.0	2400	† +	† +	1.0
Light work (or household duties)	—	—	50 per hr	50 per hr	—
Moderate work	—	—	50—100 ,,	50—100 ,,	—
Hard work	—	—	100—200 ,,	100—200 ,,	—
Very hard work	—	—	200 up ,,	200 up ,,	—
Pregnant	1.0	2400	—	Yes	2.0
Nursing	1.25	3000	—	Yes	2.0

Salts §	Gms.	Vitamins	International units
Calcium	0.600	A	4200
Phosphorus	1.320	B 1	300
Iron	0.015	C	500 to 600 (50 mg)
Ca/P ratio	0.515	D	1000 to 2000

* These additions are for the normal activities of children
† Additions needed according to the work done
§ Children are considered to need 50 per cent. more than these amounts

This shows that growing boys in their teens should receive a greater allowance of food than an adult man doing light work eight hours a day; and the relatively greater amount of protein required is of particular note. Gross surveys such as those made upon Nanking families reduce children and women to a man value decidedly lower than that now regarded as necessary. For instance by the new standard a European boy 12 years of age requires at least 3600 calories, and 75 gm. of protein. By the old standards (1935a) the allowance for a boy of 12 was 80 percent, of the adult doing moderate work for whom 3000 calories was considered adequate; this for the boy amounts to 2400 calories; and the protein is proportionately less. The mineral salts instead of being reduced to 80 percent of the adult should be increased. The authors adopted Sherman's standard of 3256 calories for the American male of 70 kilos, this does not alter the fact that growing boys require more than was allowed by the old statistical methods. The same applies to pregnant and nursing women, the number of which in our present study is too small to be of any significance.

4. THE GROUPS STUDIED

Group A. Factory workers. Workers in seven local factories together with the administrative staffs and their families were included in our survey of the diets of 428 individuals. The workers were mostly apprentices around the age of 15, the age of maximum basal energy requirement. About one tenth of the group consisted of owners, their wives and children, and clerks who were not engaged in muscular work in the factories. A survey of three other factories covered 264 people. This supplementary factory survey only considered the dietary factors, which are condensed in table 11. We have already reported upon the diets in eight chromium plating factories, covering 281 people, Read et al. (1936). This survey included a clinical study of the workers.

The living conditions of all the regular workers were all poor, twenty to thirty workers being crowded in one room about 12 by 14 feet, with a window on only one side of the room, in cheaply built residences not suitable for use as factories. Both fresh air and light were deficient, and the floors consisted of damp earth. The bad effects of the metal dusts were especially noticeable in the case of the iron and chromium workers. The conditions in the chromium plating trade have been more fully described by us, Read (1936). In general the owners of all the factories showed a complete ignorance of, hence an indifference to, industrial hygiene.

The age distribution among the factory workers and staffs is given in table 2. The number of individuals under the age of 12 is so small, that for practical purposes we regard the total man value as equal to the total number of people studied. A large proportion of the men over 20 years of age were staff members in the general administration of the factories. As in the chromium plating factories previously reported the workers were chiefly minors of similar age distribution, though a few younger children both boys and girls were employed in the making of glass bulbs and aluminium shoe moulds.

For comparative purposes we have included in this report our surveys of three other non-factory groups as follows.

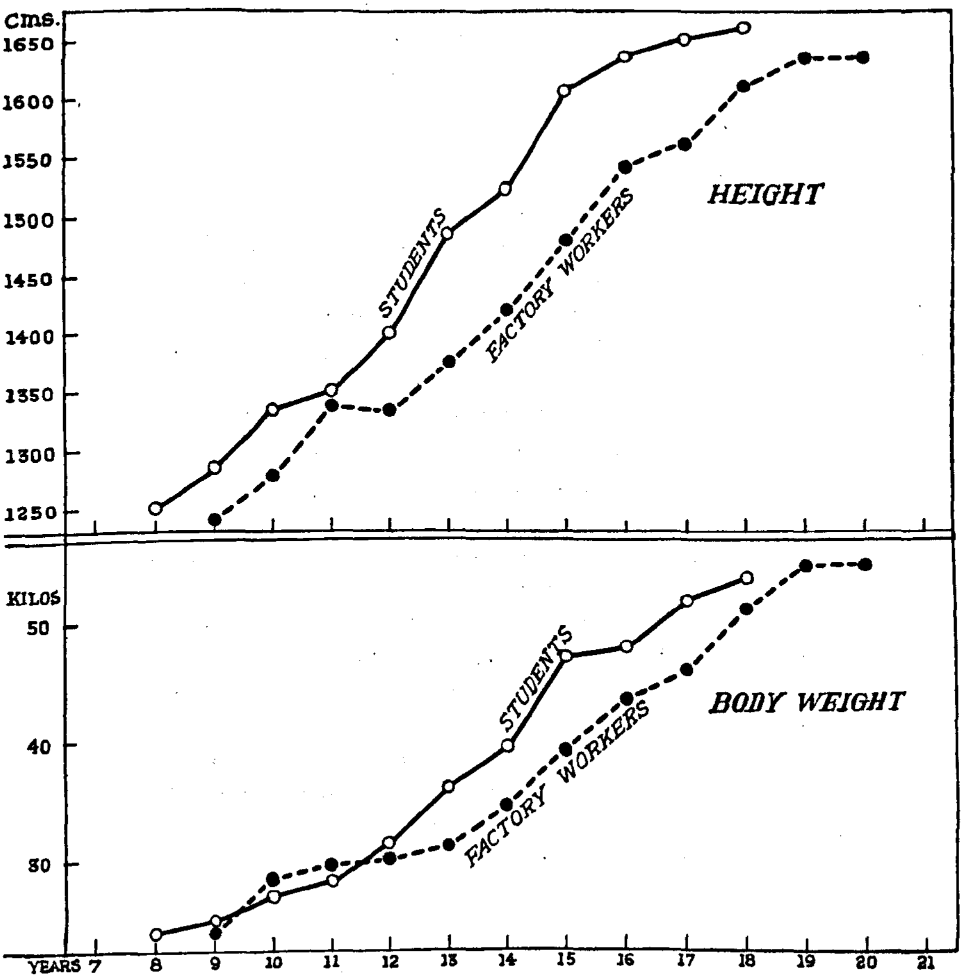
Group B. Skilled workers. This group consisted of technical assistants of adult age working in a modern institution under ideal conditions of light, air, space and general housing conditions. They were engaged in light work for about 7 hours daily, with some hard outdoor exercise, and good sleeping quarters. Individually their conditions were of a far more even character than any of the other groups studied.

Group C. Hospital Staff workers. This was a mixed group of adult men and women, including resident doctors, nurses, and manual workers, living indoors and doing light or moderate work. They all partook of the meals supplied by one kitchen readily accessible for dietary survey. The communal character of Chinese meals compels surveys of mixed groups in a way different from European custom.

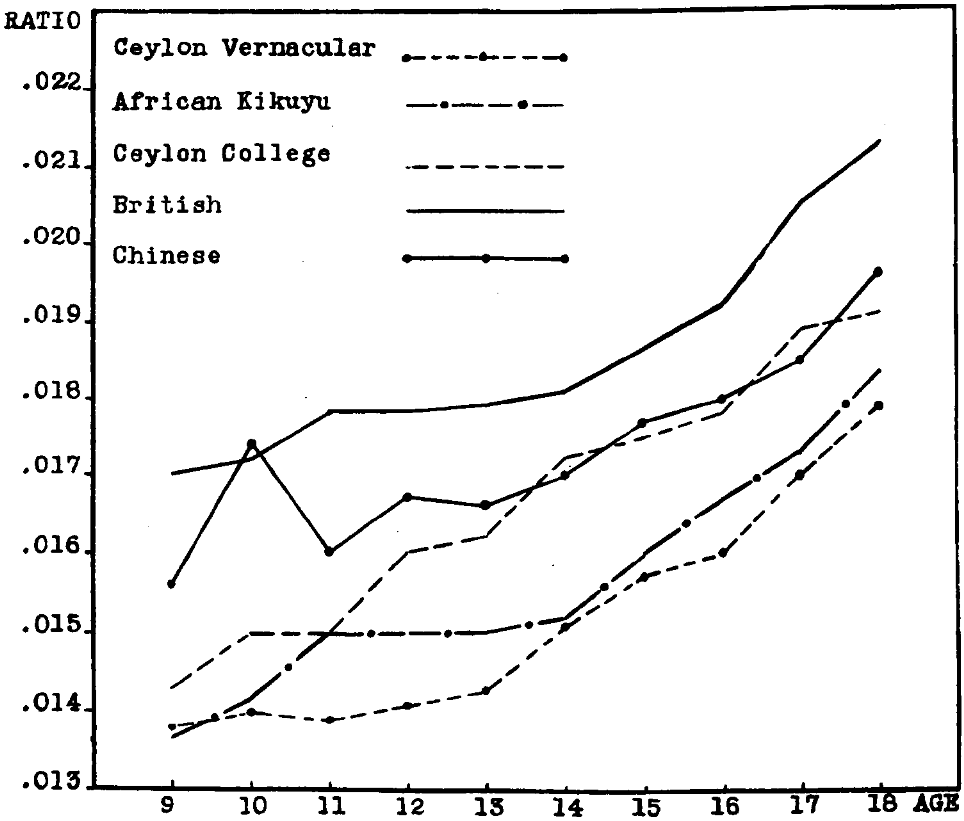
Group D. Hospital Patients. The study was limited to patients under surgical treatment for a relatively long time, with little change among the occupants of the wards concerned. As a group their energy requirement while lying down in a resting state was lower than all the other groups. There is not enough definite knowledge of the requirements of convalescents concerning their special needs for tissue forming proteins, vitamin supplies for dealing with infections, etc., to survey their diets other than by the standards laid down for normal individuals, but it is certain that these particular factors should be at their optimum, or perhaps more than the amounts usually considered necessary.

5. HEIGHT AND WEIGHT MEASUREMENTS

The height and weight measurements were taken of the workers in 6 of the factories, and the averages given in table 3. In computing the calorie requirement of the Shanghai worker we have taken the average weight of 55 kilograms as our figure, in place of the standard weight of 57 kilos for Northern Chinese adopted by Wu and Wu (1928). To these we have added the gross figures of the workers in the supplementary survey upon



GRAPH 1. *Relation between Age and Height and between Age and Body Weight of Students and Factory Workers.*



GRAPH 2. *Ratio of Height and Weight (Kaup's formula).*

whom we were able to make measurements. The total number of people in this table is lower than in the age distribution table 2, because our observations were limited to those people undertaking manual work, and of those it was found inconvenient in a few cases to disturb their work.

Our numbers are too small for us to make the comprehensive analysis undertaken with larger groups, as has been done by Nicholls (1936) in Ceylon. In general the height measurements are almost identical with those of the poorest vernacular class of Ceylon, but the weight curve is similar to the secondary school children of Ceylon. In neither case do they approach the measurements for the better fed Ceylon boys of the Ceylon Royal College, nor the measurements of children in the general population of Great Britain. Compared with the African tribes studied by Orr and Gilks (1931) the heights are similar to the Kikuyu who live on an almost exclusively vegetarian diet and the weights more nearly approach those of the heavier Masai tribe who live on a soured milk and meat diet. It would be of interest to compare them with the Mongols who live under similar dietary conditions to the Masai.

In comparing races the hereditary factors are important, whether one regards certain physical measurements as perpetually inherent in the organism or due to circumstances under which a race is living or has lived for many generations. For immediate practical purposes there is greater value in comparing groups from the same race and area, in which the most variable factor is the diet. This we have attempted to do by comparing our limited measurements with those made by Shirokogoroff (1925) upon students living in the same province. Graph 1 shows that both in height and weight these factory workers are far behind the better fed student class. The younger apprentices fresh from the country both in these and in the chromium plating factories appear to be better developed, not having spent any great length of time under the unhygienic factory conditions. There are too few of them for this observation to be statistically correct, without further measurements of an adequate number of country boys.

The state of nutrition has been assessed by various means. Graph 2 shows a comparison based upon Kaup's

$$\text{formula} = \frac{\text{Weight in lbs.}}{\text{Height in inches}} \times 0.07$$

in which it is seen that Chinese factory hands have a ratio similar to the Ceylon Royal College boys, superior to the African vegetarian Kikuyu tribe and the poor class Ceylonese, but much lower than the general British ratio. Shirokogoroff's figure for local students works out about the same as the Chinese factory workers and Ceylon college boys. It should again be observed that, although the numbers are few, in the younger years the Chinese factory boys show a decidedly higher ratio, which tends to confirm the conclusion made above with regard to their superior height weight measurements.

6. EVALUATION OF THE DIETS

Each dietary survey occupied a period of seven consecutive days, during which time the actual amount of each food article was weighed by us in the kitchens before cooking. Corrections were made for the inedible refuse, also for the food left in the dishes after each meal. Analyses of the articles as purchased were undertaken in our laboratories, though many of the foods had been already analysed for their seasonal differences.

The main bulk of the diet consisted of rice with a little meat. From season to season there is naturally considerable variation in the vegetables and fruits eaten, altogether numbering several hundred articles, the detailed analyses of which follow in our next bulletin. Diets typical for the four groups studied are given in the appendix, the factory food is striking in its lack of variety and the paucity of green vegetables.

(a) **Energy requirement.** The energy requirement per diem varies considerably with the age, sex and kind of work done. The kind and amount of food consumed also measurably affects the energy metabolism. However we are only dealing with the gross assessment of the intake of food of a group of individuals of whom more than two-thirds were growing boys requiring optimal conditions, for whom the basal calorie requirement, calculated from table 1 for 55 kilograms body-weight, would be 1886 plus 600 to 1200 calories, equals 2486 to 3086 calories. Table 4 shows the actual daily intake of protein, fat and carbohydrate in the daily diets of the various factory workers, from which the total calorie intake has been calculated. The average total is 2660 calories. This is equal to the basal requirement of an adult at rest of 1886 calories plus 774 calories, which in a twelve hour working day is little more than adequate for a man to undertake light work at 65 calories an hour, but is only about equal to the needs of a growing boy not engaged in factory work. With the exception of the youths in the printing factory, whose height weight measurements we did not obtain, in general the physical measurements of the other groups corresponded with their high or low intake of food. The youths in the printing factory were obviously ill nourished receiving too small an amount of food, and not one of the groups was receiving enough food to do efficient work. This quantitative measurement is dependent on the quality of the food eaten. As pointed out in our previous survey there was not likely to be a lack in the quantity of food provided, but diets deficient in vitamins would produce a lack of appetite.

The above evaluation would appear in a different light if judged by some of the older standards. The British Ministry of Health (1934) standard, adapted to the need of a 55 kilograms individual, provided 2360 calories, Sherman's standard works out at 2558 calories. These figures appear to show adequacy in all the factory diets except the printing factory. However they both overlook the special needs of the growing youth, which are now rightly recognised by the new international standard. Some may regard this as still a debatable question, hence the value of our further comparative surveys of groups B, C and D, and a comparison with other oriental diets.

COMPARATIVE SURVEYS

Table 5 gives the detailed analyses of the diets of the four groups studied, which are summarized comparatively in table 6. Groups B, C and D all show an adequate intake of energy. Further studies are needed to show to what extent these intakes are utilized. The extra outdoor exercise undertaken by Group B will use up any slight excess of available energy in their diet, but group C showed a decided excess in the amount of food eaten necessary to provide energy for the type of work done, that is if digestion and absorption be of a high order, in which case the transport and elimination of the excess must be a decided burden on the system. A reduction in the number of dishes offered would probably beneficially reduce the amount of food eaten, give a saving financially, and produce better work. One thing is exceedingly clear, that is if the

Oriental is able to secure a better diet his intake in no way falls short of the high standards laid down internationally as necessary for the well being of the individual.

Table 6 also gives the comparative figures for studies made in other parts of China, all of which have been computed on the old basis without due regard for the special needs of the growing child. On an adult basis they are adequate in their intake of energy for the performance of light or moderate work, in fact go beyond the old standard of the League of Nations which was the same as that adopted by the British Ministry of Health, though none of them quite come up to the number of calories per kilo bodyweight published by Orr (1930), which was gleaned from a survey of working class families in 7 cities in Scotland.

Adolph (1929) reported an experiment on a large scale undertaken in the China famine of 1921, in which 2400 calories were necessary for the needs of men doing famine relief work, usually roadmaking, but 1200 calories were found adequate for those doing no work. However he concluded his report with the observation that dietary studies in China indicate widespread conditions of undernutrition. We are of the opinion that while the adult Chinese worker may be able to subsist on a low number of calories, a well developed individual who received adequate nutrition during his growing years would require far more, and have a greater capacity for work.

The very thorough general survey made by Nicholls in Ceylon (1936) states that the average intake for the Ceylon labourer is 1942 calories, which he compared with Donath's work (1934) upon the Javanese peasant, who consumes an average of 2116 calories. He concludes that a diet of about 2200 calories is adequate for the requirements of an agricultural labourer belonging to the smaller races of the tropics, provided the diet is well balanced in necessary constituents. The average weights of the Ceylonese and Javanese are 111 and 101 pounds respectively. The average weight of Shanghai men is about 121 lbs, which compared with the Javanese would require 2636 calories in the tropics, which is approximately the same figure obtained by us for the Chinese worker in a sub-tropical climate.

(b) **Percentage derivation of energy.** The British standard put forward by the Ministry of Health (1934) suggests that in a well balanced diet the percentage derivation of energy from proteins, fats and carbohydrates is 13.8, 31.2 and 55 percent, respectively. From these figures it is seen in table 6 that none of the diets studied could be considered well balanced, the factory workers in particular receiving too much carbohydrate and far too little fat, and their protein intake proportionately low.

Orr and Clark's (1930) survey of 607 Scottish families showed 12, 23 and 65 percent. respectively for protein, fat and carbohydrate. These figures are very similar to the better diets studied by us in groups B, C and D. In comparison with these practical surveys our factory workers show an obvious lack of balance in the diet along the same lines already stated.

Yang and Tao (1931) pointed out that in the diet of Shanghai mill workers there was too much cereal and too little animal food, in particular meat, fish, milk and eggs. The distribution of energy therefore among the different types of food is worthy of study. Table 8 shows that in American diets less than 40 percent. of the energy is derived from cereals, while in all our Shanghai diets over 64 percent. is furnished by rice alone, the factory diets deriving more than three-quarters of their energy from rice. Animal foods are low in all our diets, the factory workers consuming only one sixth the American value. It is true that the legumes especially soybeans in the local dietaries take the place of animal foods to some extent by their high content of protein and fat, but the total energy furnished by these two classes of food is still below the value of animal food alone in the American diets. Vegetables and fruits were both on a lower level than in the U.S.A. While one would not look to this class of food as a source of energy, these figures show the need of a more liberal supply in the local dietaries to provide adequate amounts of essential vitamins and mineral salts.

(c) **Proteins.** The quantity of protein required varies between 55 gm. for the Chinese adult and nearly 100 gm. for youths 15 years old. In an evenly mixed group of adults and youths this would average about the same as the old British standard of 78.6 gm. Our factories varied considerably in their age distribution. From our weight and age distribution tables we calculate the average protein requirement for our factories to be 67.1 gm, which is slightly greater than the average amount consumed. Table 4 shows the intake of the individual factories which should be assessed with due regard for the age distribution in each factory. With the exception of the silk weavers and felt hat makers none of the factories consumed enough protein, the printers were the worst cared for, and the chromium platers with a higher percentage of youths 14 to 17 years old requiring an average of 77 gm. received only 57 gm. It follows naturally that their physical measurements are poor.

As important as the quantity is the quality of the protein consumed, Read (1936). Sherman considered that one third to one half should be of animal origin. In none of the factories was this the case. The aluminium shoe mould makers received less than 3 gm. and the chromium platers very little more. Osborne and Mendel (1917) concluded from their experiments that soybean protein reacted like animal protein and could actually replace it. Berczeller (1924) confirmed their conclusions and calculated that the 80 gm. daily of soybean protein was adequate for people in East Asia, as the sole source of protein. Much work has been done to show from its chemical composition, its coefficient of digestibility, and from its vitamin and lecithin content, Oshima (1905), Mitchell (1923) and others, that the soybean is unique as a vegetable food. Even so our workers did not receive adequate amounts of this protein.

As pointed out by Adolph (1929) the value for protein in Chinese labourers diets though low is in effect still lower when one considered the bulky character of the oriental diet and the lowering of the coefficient of digestibility of the protein accordingly. McCay' (1912) in studying the bulky rice diets of India, showed that consumption of 766 gm of rice a day lowered the coefficient of digestibility of the protein to 52 percent. In other words our 63.6 gm of ingested protein may only represent an effective 33.1 gm, for the workers consumed about the same amount of rice as studied by McCay.

The comparative studies made upon groups B, C and D all show adequate protein intakes, both quantitatively and qualitatively allowing legume protein, chiefly soybean products, to rank of equal value with animal protein. However in Groups B and C the bulky carbohydrate will considerably lessen the coefficient of digestibility. The hospital staff diet is burdened with excess protein to be eliminated either unabsorbed through the bowel or not utilized through the kidney.

Cheng Tao and Chu (1935) report figures for protein consumption very similar to our findings for the poor and better class individuals, too low and high with bulky carbohydrate intake. According to Nicholls (1936) the Ceylon labourer only receives 55.5 gm of protein. The evidence concerning the relationship of the quality and quantity of protein upon physical development is indisputable for the laboratory animal, and it would appear to be a fact of major importance in these Oriental diets.

(d) **Fats and Carbohydrates.** The undue amount of carbohydrate and the low fat content of the Shanghai worker's diet as observed by Tao, we have already noted in our own surveys. Tables 4, 5, 6 and 7 present our results in various ways already discussed. The quantity of fat should be increased both in the workers food and in that of the hospital patients. Lard, the chief fat in all of the diets, is notoriously deficient in fat soluble vitamins as compared with other animal fats, which should be added.

It should be recognised that fat is not only a more concentrated form of energy than carbohydrate, it also carries essential elements of great significance in the regulation of the physiological processes in the body. The indispensibility of certain unsaturated fatty acids is shown in the work of Burr and Burr (1932), and extended by the studies of Evans and Lepkovsky (1932). Failure to grow, tail necrosis, malnutrition, hematuria, increased water intake, and a favourable response to small amounts of the necessary fats were used as an index of the "fat deficiency disease" observed in rats.

The food fats include lecithin, cholesterol and other ether soluble constituents, the essential character of which requires more evidence. Recently Best (1936) has shown choline to be an essential factor in the diet. The part played by choline and its esters in all the body cells and in the transmission of nerve impulses is of great importance.

While it is quite certain that the quality and quantity of the fat in the diet must be sustained, the amounts necessary are so far only established on an empirical basis.

(e) **Mineral Salts.** Among the Mineral elements known to be essential to the body there are three in particular liable to be deficient, namely calcium, phosphorus and iron, for which our foods were specially analysed. The daily gross intakes of the workers in each of the factories and the same expressed as milligrams per kilogram bodyweight are given in table 9. To these have been added the results from the comparative surveys in groups B, C and D, and those standards which have general acceptance internationally. Recent experiments have shown magnesium to be an indispensable dietary factor. It is generally accepted that there is a relation between certain types of goitre and iodine deficiency. In fact no diet is adequate unless it contains a sufficiency of all the mineral elements normally found in human tissues, which are constantly being excreted from the body and need to be replaced. Excessive intake of certain elements such as fluorine causing dire results are the subjects of special study, particularly when a pronounced pathological state has been observed.

These factory diets are very similar to those reported in the chromium plating factories, Read et al (1936), with regard to the distribution of the mineral elements among the different types of food, vegetables being the chief source of iron and cereals providing the majority of the lime and phosphorus. The significance of this will be discussed under each element concerned.

Calcium. Sherman's standard of 9.7 milligrams per kilogram bodyweight is somewhat more than the minimum requirement found necessary in a wide range of calcium balance experiments. Seeing that calcium constitutes a larger proportion of the body weight than any other inorganic element, and that deficiencies of this element produce physiological effects of a very complex character, outlined briefly in the Annual Report of the Chief Medical Officer of the British Ministry of Health (1933), it is important to provide an optimum amount. Deficiency of this element during the growing period results in defective development of the bony skeleton, so the need of the growing boy is considered to be at least 50 per cent. greater than the adult.

Judged by the figure for adult requirement only one factory, namely the printers, was short of this element, but more than half of the people in the factory were under adult age with inadequate provision at all ages for the special needs of the growing skeleton. Sherman and others have advocated 1.0 gm for the growing child which is 50 per cent. more than for the adult, this we calculate for the lighter weight oriental boy to be about 0.8, though this figure would be greater if the individual were raised on a more ideal diet with better physical development. This amount 0.8 gm is greater than that consumed in any of the factories. Assuming that irrespective of age the amount of food consumed by each indivdual was the same, which generally speaking would present a fair average of the conditions, though individually there must be considerable variation, it can be said that while these diets were adequate in their calcium supply for the adults, the growing boys did not receive enough, the chemical glass workers besides the printers being particularly low.

The comparative studies in groups B, C and D all show in these groups an adequate lime intake.

Phosphorus. The phosphorus intake, so intimately bound up with calcium metabolism, in these diets demands careful study. Both in quality and quantity they do not appear to be adequate for the workers in any of the factories. Western diets with their high content of animal and dairy products usually contain ample amounts of well utilised phosphorus. Oriental diets with their high cereal content are apt to be deficient, and the phosphorus is present in a form which is very poorly utilised, Bruce and Callow (1934). Ranganathan (1935) studying whole wheat, sorghum, ragi and polished rice found the last mentioned gave the poorest growth and there was only 66.4 per cent retention of the phosphorus ingested. From Mellanby's work (1932) it appears that diets rich in cereals hinder the calcification of bone, and this is virtually due to phosphorus deficiency.

This matter is relative to the amount of calcium available, the calcium phosphorus ratio being in one sense more important than their absolute amounts, for faulty bone formation may occur either on a calcium poor, or on a phosphorus poor diet. This ratio for the adult is 0.515. There is evidence to show that in growing children the best retention occurs when the ratio of calcium to phosphorus is equal to 1, Stearns and Jeans (1934). From the work of Cox and Imboden (1934) it is seen that while the ratio of 1 was optimal when the calcium level was high, a ratio of 0.5 gave the best results when the calcium intake was low.

The diets of all our groups showed a ratio higher than 0.5, due in the factories to too small amounts of phosphorus, and in groups B and C due to high calcium intakes. All of the factories needed more phosphorus. Owing to the fact that more than 85 per cent. was from cereals and legumes the absorption would be low, and the actual amount utilized would be even less than appears.

The hospital patients in group D needed a little more, both to raise the phosphorus intake to standard and to balance the calcium intake up to a ratio of 0.5 instead of 0.63. Milk and eggs are the natural additions to these diets so rich in rice, the protein of which requires a high lime intake to produce satisfactory growth, and beancurd so rich in magnesium is another important factor likely to interfere with a satisfactory balance of the calcium phosphorus ratio.

Iron. From the generally accepted standards all of the diets studied appeared to have adequate amounts of iron. There are few facts available concerning the exact needs of growing boys in their teens for mineral salts. Leichsenring and Flor (1932) from their studies upon children of pre-school age conclude that the requirement for maintenance and growth is about half a milligram per kilo of body weight. On this basis the amounts ingested by the growing factory boys was not in any great excess.

Their ability to utilise the amount given is open to question. Coons (1932) showed that meat, eggs and green vegetables exerted a more favorable influence on iron retention than did other foods, our diets consisted chiefly of other foods. Fontés and Thivolle (1932) found in dogs very poor retention of the iron from a diet of cooked rice and raw milk.

As pointed out by Nicholls (1936) the requirements of iron by the body are increased in persons suffering from malaria or hookworm infection. The prevalence of these diseases in China is too common for this fact to be omitted from the assessment of Shanghai diets.

(f) **Vitamins.** Deficiencies of vitamins A, B, C and D are associated in the minds of all educated people with night blindness, beri-beri, scurvy and rickets respectively, but this is an entirely too limited viewpoint. Reference has already been made in this report to the effect upon appetite, and the way in which a very low intake of vitamins A, B or C may influence the whole nutritional intake. A multitude of untoward effects have been observed in work upon animals, much of which has been correlated with clinical conditions in the human. Whilst this report does not include a clinical study of these workers, which has yet to be done, for the assistance of such a survey and such others as may be carried out we have added at the end of this report a list abstracted from Browning's monograph, of the various pathological conditions associated with deficiencies of the chief vitamins.

Vitamin A. According to the report of Burnet and Aykroyd (1935a) to the League of Nations Health Organization, the dietary standard requirement for vitamin A per man per day from Rose's figures is 4,200 international units. The vitamin A content in the local dietaries were evaluated from the figures available, the main sources being from Sherman (1931, 1932 and 1934). Only a small fraction of the foodstuffs were left without estimation of their vitamin A values, which fact is not likely to influence appreciably the gross figure. The figures in table 10 give an approximate idea of the vitamin A present in the diet, estimated on a conservative basis. The vitamin A content in the dietaries of Hospital staff and patients and Institute technicians are all adequate but the factory dietaries, except that of the chromium platers, are probably all below the standard requirement. Brown rice took the place of polished rice in the chromium platers' diet. The vitamin A values in the factory diets would lead one to expect poor general health and poor resistance to disease, particularly among the child workers. An increased intake of green vegetables would give a higher content of vitamin A in their diets at a low cost. This change would undoubtedly be beneficial to their general health.

Vitamin B. In evaluating the vitamin B content of the diets, we used both the figures and method of interpretation of Cowgill (1934). The vitamin B intake in each of the dietaries studied, and the degrees of protection against beriberi as calculated, are shown in table 10. The vitamin B content of the dietaries of Hospital staff and patients and Institute technicians are all adequate to protect against beriberi, the body weight of the Shanghai adult being only 55 kg. The Vitamin calorie ratio in North China dietaries (Cowgill) of 2.01 has been proved to afford a moderate degree of safety against beriberi. The vitamin B content of factory dietaries, as a group, were suboptimal, except the chromium platers who took brown rice instead of the polished grain.

Calculated from Cowgill's chart the workers in the chemical glass and silk weaving factories were on the borderline of vitamin B deficiency. The workers of other factories received a ration with inadequate vitamin B values and are liable to have beriberi. A few beriberi cases among the factory workers reported to the authors, confirmed the theoretical calculation of the deficiency in vitamin B. The huge amount of polished rice, the only cereal eaten, constitutes the main cause of vitamin B deficiency.

Vitamin C. (Ascorbic acid) The vitamin C in the Shanghai dietaries was evaluated from the chemical titrations of Chi and Read (1935). These figures do not represent the biological values which are generally much lower. They give a fair idea of the intake, but as is true for all the components of these diets diverse factors influence absorption and utilization. The total amount in each diet per man per day is shown in table 10. According to the most recent standard the requirement of ascorbic acid per man per day reported by the League, is 50 mgm (Burnet and Aykroyd 1935). Excepting the four factories listed in the table, the dietaries all contained an adequate supply of vitamin C. The amount present in the diet is mainly accounted for by the quantity of green vegetables, which are the only source of vitamin C in the diet.

Vitamin D. Owing to the lack of numerical figures of vitamin D present in local foodstuffs, we are not able to give an exact idea of the amount in each diet. The standard requirement of vitamin D has recently been set at 1,000-2,000 international units per man per day (Burnet and Aykroyd). The diets studied show only a small amount of animal food. Sea fish containing fat is practically absent in the factory diets, and there is no exposure to the sunlight. Most probably the factory workers do not get sufficient vitamin D. However no deficiency diseases likely to be caused by a great lack of vitamin D were reported in the chromium plating factories, which were given physical and clinical examinations and were taking similar diets,

7. GENERAL FINDINGS

In the absence of carefully controlled metabolism experiments it is impossible to estimate the exact value of the diets studied. The coefficient of digestibility and the degree of utilization of the various food stuffs can be individually studied, see Powell 1928 for rice in Changsha. The application of the present international standards has been made with the knowledge that these are partly empirical and based largely upon Western dietary habits. By these standards Eskimos have too little carbohydrate and tropical races too much carbohydrate. Until far more is known it appears unwise to conclude more than we have already indicated, except by comparing our results with data gathered in a similar environment. Shirokogoroff's (1925) measurements for the height and weight of Kiangsu students clearly indicate that our factory workers are lacking in adequate nutrition, see figure 1.

The factory diets would be vastly improved by the addition or increased intake of one or two cheap vegetables, such as amaranth and alfalfa. The substitution of brown unpolished rice for the polished article would be of great value as an adequate source of vitamins A and B which are seriously deficient in nearly all the diets. They also need the addition of good quality fats to improve the health of the eye and skin. Lard should be replaced largely by other animal fats. Where financial conditions allow, the addition of milk, eggs and meat is likely to produce a better developed individual whose capacity for work would be better than that existing at present.

8. SUMMARY

1. Dietary survey of 10 groups of factory workers have been made, and the results compared with surveys made upon two groups of professional workers and one group of hospital patients.

2. The quantity and quality of the food taken by the juvenile factory workers were in many respects decidedly below standard requirements, and compared poorly with the diets of the other groups in Shanghai.

3. An excessive intake of carbohydrate was noted in all the diets, producing an unbalanced and inefficient bulky diet.

4. There was a very low intake of good animal fats and there was too little animal protein.

5. With regard to the mineral elements, the factory diets were adequate for adults, but not adequate in their supplies of calcium and phosphorus for juvenile workers.

6. Vitamin A was deficient in 70 per cent, vitamin B in 80 per cent, and vitamin C in 40 per cent. In the absence of a supply of good fat, vitamin D was probably not adequate.

7. The height-weight measurements of the factory workers compared with measurements upon local students clearly indicated that their state of nutrition was low. Comparison with other races showed them to be similar to the ill developed tropical races of Ceylon and Africa living on poor vegetarian diets.

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TABLE 2. *Age Distribution Among Factory Workers and Staffs*

Age	No. of people	MALE							FEMALE					
		8-9	10-11	12-13	14-15	16-17	18-19	20+	10-11	12-13	14-15	16-17	18-19	20+
Man Value L. of N. (1935b)	—	0.7	0.8	1.0	1.0	1.0	1.0	1.0	0.8	1.0	1.0	1.0	1.0	1.0
Chromium Platers	48				13	14	4	17						
Glass-bulbs	74		2	7	17	14	9	9	3	5	5	3		
Chemical glass	58			5	13	11	9	20						
Silk weavers	43			1	1	6	3	21			2	2	2	5
Felt hat makers	105			1	20	15	15	54						
Aluminium shoe-moulds	55	2	2	2	12	11	8	18						
Printers	45				4	13	6	22						
Supplementary Survey, Table 11	168	—	—	2	15	26	22	130	—	—	—	—	—	—
Totals	696	2	4	18	95	110	76	291	3	5	7	5	2	5

TABLE 3. *Height Weight Measurements of Shanghai Factory Workers*

Factory	No. of workers	9	10	11	12	13	14	15	16	17	18	19	20-29	30-39	40-49	50-59
Age Males — Weight in Kilograms																
Chromium platers	45						34.6	37.3	42.8	42.9	59.1	52.4	50.0	67		
Glass-bulbs	50		28.6	29.6	31.4	33.0	32.6	39.7	44.1	46.0	47.5	57.2	52.2			
Chemical glass	53				26.8	30.7	36.5	37.8	46.0	50.6	51.4	52.8	57.5			
Silk weavers	29					32.8		41.4	40.1	44.3		48.6	54.5	55.8	55.8	
Felt Hat makers	86					30.9	35.4	40.0	45.7	44.3	52.6	52.9	55.0	60.6	64.2	71.8
Aluminium shoe-moulds	41	24.1		29.3	31.8	29.6	33.7	37.9	39.2	45.3	49.0	53.6	52.1			
Averages		24.1	28.6	29.4	30.0	31.8	34.5	39.1	43.3	45.6	51.1	54.9	55.0	60.8	60.0	71.8
Shanghai students (Shirokogoroff 1925)		25.0	26.7	28.0	31.2	36.0	39.3	47.1	47.6	51.9	53.7	—				
Height in Meters																
Chromium platers	45						1.40	1.44	1.52	1.51	1.66	1.63	1.62	1.63		
Glass-bulbs	50		1.28	1.30	1.31	1.36	1.38	1.46	1.53	1.54	1.57	1.64	1.68			
Chemical glass	53				1.24	1.39	1.44	1.48	1.56	1.60	1.58	1.66	1.63			
Silk weavers	29					1.45		1.52	1.51	1.56		1.60	1.66	1.65	1.60	
Felt hat makers	86					1.37	1.42	1.49	1.58	1.57	1.64	1.63	1.65	1.65	1.67	1.78
Aluminium shoe-moulds	41	1.24		1.36	1.44	1.35	1.45	1.49	1.52	1.58	1.61	1.65	1.58			
Averages		1.24	1.28	1.34	1.33	1.38	1.42	1.48	1.54	1.56	1.61	1.63	1.64	1.65	1.62	1.78
Shanghai students (Shirokogoroff 1925)		1.29	1.33	1.35	1.40	1.49	1.52	1.61	1.64	1.65	1.66	—				
Females — Weights and Heights																
Glass bulbs	16		24.6 1.19		29.7 1.31	38.9 1.37	35.8 1.37	44.3 1.43	46.4 1.51							
Silk weavers	11						35.5 1.41			49.8 1.56	45.0 1.51		48.7 1.52	51.8 1.51	51.3 1.54	
Averages			24.6 1.19		29.7 1.31	38.9 1.37	35.6 1.39	44.3 1.43	46.4 1.51	49.8 1.56	45.0 1.51		48.7 1.52	51.8 1.51	51.3 1.54	

TABLE 4. *Daily Intake of Protein, Fat, Carbohydrate and Total Calories in Different Factory Workers*

Factory	Man value	Total Protein gm	Animal Protein gm	Fat gm	Carbohydrate gm	Total Calories
Chromium Plating	48	57.3	3.3	37.5	461	2411
Printing	45	48.6	7.6	47.3	412	2267
Glass-bulbs	74	61.3	5.5	34.8	556	2782
Chemical glass	58	63.1	10.6	35.9	523	2666
Felt Hat Making	105	72.0	16.2	64.3	501	2869
Silk Weaving	43	78.7	19.2	71.6	486	2904
Aluminium Shoe Moulds	55	62.8	2.6	28.3	544	2694
Averages	—	63.6	9.3	46.7	498	2660
British Ministry of Health Standard for adult man value of 55 kilos.		78.6	29.1	78.6	314	2360
L. of N. standard requirement. Age 14 to 15		92.0	31.0 ?	78.6 ±	314 +	2486 to 3086
For moderate work add		600 to 1200 calories, equals				3086 to 4286

Table 5. *Distribution of Proximate Principles.*

A. AVERAGE OF SEVEN FACTORIES

Man value 428

Kind of Food	Protein		Fat		Carbohydrate		Total Calorie
	gm	Calorie	gm	Calorie	gm	Calorie	
Animal Food	9.3	37.2	14.4	130	1	4	171.2
Legumes and Products	13.8	55.2	22.6	203	19.5	78	336.2
Tubers and Vegetables	2.4	9.6	0.45	4	7	28	41.6
Cereals and Products	37.0	148.0	5.1	46	464	1856	2050.0
Miscellaneous	1.0	4.0	4.1	37	5.0	20.0	61.0
Total	63.5	254.0	46.65	420	496.5	1986.0	2660.0

B. SKILLED WORKERS

Man value 34

Kind of Food	Protein gm	Protein Calorie	Fat gm	Fat Calorie	Carbohydrate gm	Carbohydrate Calorie	Total Calorie
Animal Food	22.9	92	32.7	294	1.6	6	392
Legumes and Products	18	72	41.2	371	9.9	40	483
Tubers and Vegetables	6	24	0.7	6	9.5	38	68
Cereals and Products	35.7	143	4.9	44	473	1892	2079
Miscellaneous	3	12	5.5	50	14.7	59	121
Total	85.6	343	85.0	765	508.7	2035	3143

TABLE 5.—*(Continued)*

C. HOSPITAL STAFF

Man value 183

Kind of Food	Protein		Fat		Carbohydrate		Total Calorie
	gm	Calorie	gm	Calorie	gm	Calorie	
Animal Food	30.85	123	56.7	510	2.6	10	643
Legumes and Products	13.52	54	39	351	11.1	44	449
Tubers, Roots and Vegetables	4.76	19	0.8	7	9.6	38	64
Cereals and Products	45.00	180	5	45	540	2160	2385
Miscellaneous	3.80	15	6	54	22	88	157
Total	97.93	391	107.5	967	585.3	2340	3698

D. HOSPITAL PATIENTS

Man value 54

Animal Food	17.5	70	32.2	290	6.1	24	384
Legumes and Products	11.6	46	18	162	18.8	75	283
Tubers and Vegetables	3.4	14	0.9	8	8.5	34	56
Cereals and Products	27.6	110	3.4	31	302	1208	1349
Miscellaneous	0.2	1	0.6	5	4.5	18	24
Total	60.3	241	55.1	496	339.9	1359	2096

TABLE 6. *Daily Intake of Energy, Shanghai Diets*

Group	Protein gm	Fat gm	CHO gm	Total Calories	Calories per kilo body wt
A. Factory Workers	63.6	46.7	498	2660	48.4
B. Technical staff	85.6	85	509	3143	57.1
C. Hospital staff	97.9	107.5	585	3698	67.2
D. Resting patients	60.3	55.1	340	2096	38.2
Family diets					
Shanghai (Chu)	86.6	54.4	427	2544	46.3
Nanking (Cheng, Tao & Chu)	86.3	48.2	409	2801	49.1
Peiping diets (Wu)	91.7	40	562	2977	49.7
North China (Adolph)	77.9	21	493	2471	43.4
American (Pearl)	95	113	447	3185	45.5
Scotland, 7 cities (Orr)	107.4	86.8	573	3503	50.0
Ministry of Health (British standard) reduced to 55 kilos	78.6	78.6	314	2360	42.9
League of Nations (1935b) Adult basal requirement	55.0	78 ±	241	1886	34.3
For moderate work add	add 600 to 1200 calories			2486 to 3086	45.2 to 56.1

TABLE 7. *Percentage Derivation of Energy from Protein, Fat and Carbohydrate.*

	Protein		Fat		Carbohydrate	
	gm	%	gm	%	gm	%
Factory workers	63.6	9.5	46	15.4	506	75.3
Institute technicians	85.6	10.9	85	24.4	509	64.7
Hospital staff	97.9	10.6	107.5	26.2	585	63.2
Hospital patients	60.3	11.5	55.1	23.6	340	64.8
Ministry of Health (British standard)	78.6	13.8	78.6	31.2	314	55.0

TABLE 8. *Percentage Derivation of Energy among Different Types of Foods*

	Factory workers	Institute technicians	Hospital staff	Hospital patients	American (Sherman)
	%	%	%	%	%
Legumes and legume products	12.5	15.4	12.2	13.5	11.4
Tubers, roots and vegetables	1.5	2.2	1.7	2.7	
Cereals (rice etc.)	77.5	66.1	64.6	64.3	38.2
Miscellaneous	2.1	3.8	4.1	1.2	10.5
Animal products	6.4	12.5	17.4	18.3	39.2

TABLE 9. *Calcium, Phosphorus and Iron Daily Intake Per Man in Shanghai Dietaries.*

Group	Ca/P	Calcium		Phosphorus		Iron	
		gm	mgm per kg body wt	gm	mgm per kg body wt	gm	mgm per kg body wt
A. Factory workers:—							
Chromium plating workers	0.670	0.756		1.130		0.036	
Printing workers	0.731	0.523		0.716		0.024	
Glass-bulb workers	0.800	0.698		0.873		0.026	
Chemical glass workers	0.721	0.550		0.763		0.030	
Felt hat workers	0.662	0.621		0.938		0.029	
Silk weaving workers	0.723	0.766		1.060		0.033	
Aluminium s oe-mould workers	0.744	0.711		0.956		0.036	
Average (seven factories)	0.722	0.661		0.918		0.030	
B. Technical workers	0.732	0.844	15.4	1.152	21	0.038	0.68
C. Hospital staff	0.558	0.823	15.0	1.477	26.8	0.046	0.83
D. Hospital patients (resting)	0.634	0.628	11.4	0.990	18	0.032	0.57
Sherman's Standard (League 1935a) for 55 kilos Adult	0.515	0.534	9.7	1.037	19.0	0.012	0.21
Growing boys	0.515 +	0.801		1.556		0.018	

TABLE 10. *Intake of vitamins A, B. and C per man per day.*

Group	Vit. A	Vitamin B1			Vit. C	Surveying date
	International units	International units	Vit mgm / Cal.	Body wt for which this vit/cal ratio is just adequate	mgms	
A. Factory workers:—						
Silk weavers	3.840	222	1.53	55 kg	51.1	July 8-15, 1935
Chemical glass	2.160	206	1.54	55 kg	55.5	June 20-28
Glass-bulbs	3.560	168	1.21	43 kg	52.2	May 30-June 7
Chromium platers	5.280	463	3.84	over 120 kg	32.3	June 11-18
Felt hat makers	1.020	206	1.44	51 kg	30.1	June 28-July 6
Printers	1.750	153	1.35	48 kg	43.1	May 21-28
Aluminium shoe-moulds	1.430	166	1.23	43 kg	25.8	Sept. 5-12
B. situte technicians	6.120	303	2.56	90 kg	80.8	May 1-8, 1935
C. Hospital staff	6.930	347	1.87	66 kg	86.3	April 3-10, 1935
D. Resting patients	8.800	214	2.04	72 kg	50.3	Dec. 3-9, 1934
International standard, Calculated for 55 kilos	3.300	221	1.50	55 kg	39.3	

TABLE 11. *Shanghai Factory Diets Additional Surveys*

Factory	Man value	Animal protein gm	Total protein gm	Fat gm	Carbohydrate gm	Total Calories	Calcium gm	Phosphorus gm	Iron gm
Paint makers	137	9.7	78.3	53.4	511	2845	0.610	1.530	0.031
Wool-weaving	77	13.1	57.8	43.9	414	2285	0.595	0.808	0.027
Iron Foundry	50	7.	59.6	48.9	465	2543	0.527	0.858	0.026

Factory	Date survey made	Vitamin A I. U.	Vitamin C mgm	Vitamin B_1 mgm-eq	Vitamin B_1 / Total calories
Paint makers	Sept. 24-Sept. 30	1502	64	4235	1.49
Wool-weaving	Oct. 1-7	3221	48	3960	1.73
Iron Foundry	Sept. 16-Sept. 22	1261	33	3879	1.52

APPENDIX 1. *Specimen of one day's survey.*

GROUP A

FACTORY DIET

	Gms	Calories
Breakfast:		
1. Rice for rice congée	122	425
2. Fried soybean	6	30
3. Fried horse bean	5	20
4. Salted and dried turnip	8	8
Dinner:		
1. Rice for cooked rice	400	1390
2. Pork	26	145
3. Fresh soybean with pod	32	43
4. Horse bean sprouted, whole	37	42
5. Salted mustard leaf	24	6
6. Black mushroom, soaked	6	3
Supper:		
1. Rice for rice congée	122	425
2. Duck's egg	10	21
3. Soybean sprouted	96	70
4. Potato	61	43
5. Yellow lily flower, soaked	9	4
6. Salted mustard leaf	18	49
Total		2724

APPENDIX 2.

GROUP B

SKILLED WORKERS DIET

	Gms	Calories
Breakfast:		
1. Rice for rice congée	70	242
2. Fried peanuts	12	74
3. Fried soybeans	10	51
4. Spiced mustard root	9	5
Dinner:		
1. Rice for cooked rice	272	940
2. Pork	52	290
3. Duck's eggs	6	13
4. Foreign cabbage	104	17
5. Water bamboo	31	6
6. Alfalfa	73	48
7. Bean curd sheet, partially dried	6	19
Supper:		
1. Rice for cooked rice	242	840
2. Fish (Bream 川扁魚)	110	60
3. Hen's eggs	5	10
4. Green capsicum, fresh	12	2
5. Bean curd cake, partially dried	33	56
6. Salted mustard leaves	10	3
7. Dried yellow lily flowers, soaked	5	3
Total		2679

APPENDIX 3.

GROUP C

HOSPITAL STAFF WORKERS DIET

	Gms	Calories
Breakfast:		
1. Fried peanut	15	92
2. Salted and dried green soybean	14	53
3. Celery	24	4
4. Pork	12	67
5. Salted mustard leaf	20	5
6. Rice congée	230	59
7. Cooked rice	100	167
Dinner:		
1. Carp	20	6
2. Potato	21	15
3. Mung bean starch in strip	8	27
4. Pork	44	245
5. Soybean curd sheet, partially dried	10	33
6. Soybean curd cake, partially dried	8	13
7. Chicken	33	14
8. Bamboo shoot, spring variety	14	3
9. Fresh green mustard leaf	59	12
10 Cooked rice	500	835
11. Rice congée	130	33
12. Soybean oil	16	148
Supper:		
1. Yellow fish	76	30
2. Chinese lettuce	44	6
3. Salted pork	38	100
4. Green colza, big	129	19
5. Hairy bamboo shoot, mountain variety	36	10
6. Celery	15	2
7. Pork	35	195
8. Duck's egg	31	65
9. Salted mustard leaf	40	11
10. Bean curd	26	16
11. Cooked rice	441	735
12. Rice congée	127	32
13. Soybean oil	16	148
Total		3200

APPENDIX 4. *Abstracted from E. Browning "The Vitamins"*

EFFECTS OF AVITAMINOSIS A

System	Physiologic or Pathologic Effects, observed in animals	Clinical Conditions, observed in man
General	Growth inhibited	
Specific tissue changes	Metaplasia and Hyperplasia Hypertrophy and proliferation Spontaneous Tumour Formation	
Eyes	Ulceration of cornea Xerophthalmia Hemeralopia, etc.	Hemeralopia Ophthalmias Keratomalacia
Alimentary	Atrophy and necrosis of villi Secretory and motor functions disturbed Liver and Pancreatic disturbances	Gastric and Duodenal ulcer Chronic diarrhoea Atony and increase in length of intestines Ulcerative colitis
Hemopoietic	Diminution of platelets Changes in blood cells Changes in bone marrow Changes in immunological prop.	Pernicious anaemia Chlorosis Secondary anaemia
Skeletal	Increased fragility	Spontaneous fractures Arthritis
Reproductive	Vaginal epithelium cornified Ovarian function arrested Disinclination for copulation	Sterility Sexual debility
Urinary	Calculi formation	Lithiasis
Urinary Respiratory Dermatological. Obstetrical	Lowered resistance to infections	Pyelitis. Tuberculosis, Otitis media, Accessory Sinusitis, Nasal and tracheal inflammation, Bronchitis, Pneumonia, etc. Pyoderma, Phrynoderma, Furunculosis, etc. Puerperal sepsis.

APPENDIX 5.

DERMATOSES DUE TO AVITAMINOSIS-A

Pathological Lesion	Resulting Condition
Hyperplasia and Hyperkeratinization of epithelium of epidermis and hair follicle	Xeroderma
Metaplasia of epithelium of sweat ducts to keratinizing type	Follicular keratosis
Degeneration of glands	Anidrosis
Hyperpigmentation	Pigmentation
Ulcerations	Sore mouth
Pustulation and Infection	Pyodermia Furunculosis

APPENDIX 6.

PHYSIOLOGICAL ASPECTS OF VITAMIN B. DEFICIENCY IN ANIMALS

(A) Beri-Beri. Multiple peripheral neuritis, oedema, cardiac disturbance, serous effusion, gastro-intestinal derangement.

FURTHER PHYSIOLOGICAL ASPECTS OF VITAMIN B. DEFICIENCY

(A) Anorexia:
  (1) Decrease of Gastric Motility.
  (2) Intestinal Stasis.
  (3) Depression of Endocrine Glands.
  (4) Specific Tissue Action weak.
(B) Loss of Weight.
(C) Fall of Body Temperature.
(D) Gastro-Intestinal Lesions.
(E) Pathological Changes in the Alimentary Canal:
  (1) In the Duodenum.
  (2) Descending Colon.
  (3) Ileocaecal Region.
  (4) Peyer's Patches.
(F) Functional Changes in Alimentary Tract.
  (1) Motility lessened.
  (2) Secretory Function weakened.
  (3) pH Concentration of the Intestinal Canal low.
(G) Changes in the Endocrines and other Organs:
  (1) The Adrenals:
    (a) Histological.
    (b) Adrenalin Content.
  (2) Thyroid and Parathyroids.
  (3) Thymus.
  (4) Sex Gland:
    (a) Testes—Histological Changes.
    (b) Ovaries—Oestrous Cycle.
  (5) Pituitary.
  (6) Spleen—Histological Changes.
  (7) Pancreas.
  (8) Liver changes regarding:—
    (a) Histological picture.
    (b) Glycogen Function.
    (c) Excretory Function.
    (d) Oxygen Consumption.
    (e) Lecithin Function.
    (f) Chlesterol Function.
    (g) Kidneys.
(H) Changes in the Blood:—Vessels, Cells, Haemoglobin, Blood Urea, Urea, Opsonic Index, Chloride content.
(I) Changes in the Bone Marrow.
(J) Changes in Lymphoid Tissues.
(K) Changes in Body and Muscular Tissues.
(L) Resistance to Bacterial Infection weakened.
(M) Resistance to Bacterial Infection weakened.
(N) Pathological Lesions in Nursing Young.
(O) Capacity for Muscular Work less.

APPENDIX 7.

PHYSIOLOGICAL ASPECTS OF VITAMIN C DEFICIENCY IN ANIMALS

(A) Scurvy. Gingivitis, hemorrhagic painful joint swellings, petechial ecchymoses of skin, and anaemia.
(B) Latent Scurvy. Fatigue, drowsiness, depression, irritability, palpitations, loss of appetite and later hemorrhages and swollen gums.
(C) Prescorbic Conditions. Debility, slight pains in lower limbs, bleeding gums, and intestinal disturbances.

FURTHER PHYSIOLOGICAL ASPECTS OF VITAMIN C DEFICIENCY

(A) Lowered Resistance to Infections from:—
    (1) Common Pathogenic Organisms.
    (2) *B. Anthracis.*
    (3) Common Intestinal Bacteria.
    (4) Tuberculosis.
(B) Lowered Resistance to Toxic Substances.
(C) Sensitisation to a Second Deficiency of Vitamin C.
(D) Congestion of the Bladder.
(E) Retardation of Healing of Tissues:
    (1) Fractures.
    (2) Wounds.
(F) Pathological Lesions in the Foetus.
(G) Non-Infective Rheumatoid Conditions.

APPENDIX 8.

PHYSIOLOGICAL ASPECTS OF VITAMIN D DEFICIENCY IN ANIMALS

(A) Bone Lesions in Rickets.

THERAPEUTIC USES OF VITAMIN D

in the treatment of:—

(A) Infantile Tetany.
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(C) Osteomalacia.
(D) Arrest of Growth and Marasmus.
(E) Calcification of Teeth.
(F) Antibacterial Resistance.
(G) Tuberculosis:
    (1) Calcification of Tubercular Lesions.
    (2) Advanced Tuberculosis.
(H) Resistance to Parasitism.
(I) Acidosis.
(J) Progressive Muscular Atrophy.
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Subsidiary Paper No. 3

No. 4

THE EFFECT OF LIGHT ON THE PRODUCTION AND DISTRIBUTION OF ASCORBIC ACID IN GERMINATED SOY-BEANS

BY

W. Y. LEE AND B. E. READ

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34. The Effct of Light on the Production and Distribution of Ascorbic Acid in Germinated Soy-Beans

BY W. Y. LEE (李維鑠) AND B. E. READ,
DIVISION OF PHYSIOLOGICAL SCIENCES,
HENRY LESTER INSTITUTE OF MEDICAL RESEARCH, SHANGHAI.

The formation of ascorbic acid by the germination of certain seeds has been demonstrated in the pea and oat by Harris and Ray (*8*). The existence of part of the vitamin in the reversibly oxidized form in some plant tissues has been shown by many workers (*12*, *13*, *10*, *11*). Recently Bogart and Hughes (*2*) have reported that there is little difference in the vitamin C content of oats sprouted in the light and those sprouted in the dark. However, in numerous experiments we have found the vitamin content to be greatest when chlorophyll is formed which fact points to a possible relationship to light and those factors involved in plant respiration. Seeing that Bogart and Hughes did not treat their material so as to estimate the reversibly oxidized ascorbic acid present their conclusions remain open to further experimentation.

For their practical value in China our experiments have been made upon germinated soy-beans. Chi and Read (*4*) in 1935, in testing a market sample of these bean sprouts, found by direct titration very little vitamin present. Other workers have reported a doubtful amount of vitamin in the sprouts (*5*, *3*). To elucidate this subject we have undertaken a chemical study of germinating soy-beans, both of the ordinary and revesibly oxidized forms of ascorbic acid present, and of the comparative amounts formed in the dark and under the influence of sunlight. Furthermore we have estimated the amounts present in the cotyledons and in the growing parts of the plant.

EXPERIMENTAL

Methods

Soy-beans (Glycine soja, S and Z. yellow variety), after very thorough washing in distilled water, were spread out on moist cotton in trays for germination under the conditions described. For each determination ten or twenty seedlings of equally full development were ground to a fine paste in a porcelain mortar with purified quartz sand 8 per cent acetic acid, and extracted according to Bessey and King's method (*1*). The material was then centrifuged, decanted and the residue washed twice with acetic acid. The clear extract and washings were made up to a standard volume. Twenty five ccs. were titrated with $\frac{N}{200}$ 2,6-dichlorophenolindophenol solution, standardized indirectly with iodine solution following the procedure of Chi and Read (*4*).

To estimate the reversibly oxidized ascorbic acid a further portion of the extract was treated with hydrogen sulphide gas for half an hour. By alternately passing in carbon dioxide gas and applying reduced pressure the excess H_2S was completely removed. This was confirmed by testing both with lead acetate and sodium nitroprusside. The reduced solution was then titrated with the dye.

In order to ensure that the increased reducing power of the seedlings after reduction with hydrogen sulphide was really due to ascorbic acid, the experiment was also conducted according to Emmerie and Eckelen's method (*6*), in which it is claimed that all interfering substances are removed before titration.

Having found that most of the ascorbic acid is present in the reversibly oxidized form and that other interfering substances are present in relatively small amounts we proceeded to make a study of the effect of sunlight. Following the same procedure as before, one control series was conducted in the dark, and a second series of tests were exposed to the midday sun for two hours daily and placed in a dark room during the remainder of the time. Careful measurements were made of the growing parts, and of the water content of the whole seedlings during the sixteen days of the experiment. After reduction with hydrogen sulphide of all the extracts titration was made of the ascorbic acid content of the whole seedlings and in a second sample of the sprouting part separated from the cotyledons. The sprouting part included the epicotyl, hypocotyl, and rootlets.

Results

(a) Ascorbic acid content before and after H_2S.

The results of ascorbic acid determinations on soy-beans germinated in the dark at a temperature of 24°-26° C. (May, 1934) before and after reduction with H_2S are given in table I and figure 1. The ascorbic acid in the seedling extract after treatment with H_2S is very high in comparison with that of the untreated extract, indicating the presence of a high percentage

Ascorbic Acid Content of Soy-beans Germinated in the Dark.

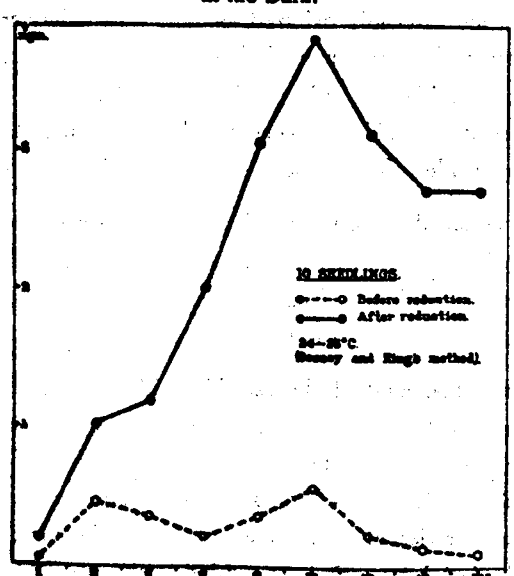

Figure 1

TABLE I

Ascorbic Acid Content in Soy-bean Seedlings Germinated in the Dark, at 24-26° C., before and after H_2S Treatment. May 15-31, 1934.

Whole Soy-bean Seedlings				
No. of days	% water content in seedlings	Length of hypocotyl, root-system and epicotyl (cm.)	mg. ascorbic acid in 10 seedlings	
			Before H_2S reduction	After H_2S reduction
1	60.20	0	0.07	0.20
3	64.65	3-4.5	0.47	1.02
5	68.30	4-7	0.36	1.20
7	76.65	10-16	0.23	2.02
9	83.20	12-20	0.36	3.04
11	85.60	25	0.57	3.90
13	84.70	25	0.24	3.10
15	88.10	25	0.15	2.70
17	89.48	25	0.11	2.70

of reversibly oxidized ascorbic acid. Throughout the period of germination, the ascorbic acid content of the seedlings increases continuously up to the 11th day, the increase being especially pronounced after reduction with H_2S. Before reduction with H_2S, the results are variable. There does appear, however, to be a slight increase in ascorbic acid up to the 11th day, even before reduction with H_2S. After the 11th day, a decrease in both reduced and reversibly oxidized ascorbic acid is observed. The ascorbic and content of soy-beans germinated in the dark, therefore, varies with the stage of development.

In order to ensure that the increased reducing power of the seedlings after reduction with H_2S was really due to the ascorbic acid present, the experiments were repeated, using Emmerie and Eekelen's method (6), in which, it is claimed, all interfering substances are removed before titration. The beans were germinated for a longer period (23 days, Feb.-March, 1935) at a temperature between 19 and 22° C. The maximal value, 0.3 mg ascorbic acid per seedling, occurred on the 15th. day of germination. Although the absolute values of the ascorbic acid per seedling was not the same as in the previous experiment, the increase of ascorbic acid in the seedlings at different stages of development, in both experiments, showed the same general trend.

(b) Effect of direct sunlight on the distribution of ascorbic acid in the germinating soy-bean.

In this experiment, the soy-beans were germinated under different conditions, one sample being exposed to direct sunlight for two hours daily, while the control was kept in the dark at room temperature with a variation of 19 to 21° C. during the daytime. The results are given in table 2 and figures 2, 3 and 4. The ascorbic acid content after reduction with H_2S is greater in the seedlings exposed to direct sunlight than in those kept in the dark. The slight increases in ascorbic acid in the sprouts show only a slight increase when influenced by light. It will be seen, therefore, that it is the ascorbic acid in the cotyledons which is increased by exposure to sunlight. In fact looked at from a percentage basis which is the one usually reported and discussed, the sprouting portion after the large initial percentage of the second day shows a rapid decline in its percentage content. It appears as if the ascorbic acid is formed in the cotyledons from reserve sugars and transported to the growing parts especially when chlorophyl is present. Remarks have been added to the table noting the particular changes in the seedlings, which may bear further significant relationships to the formation, utilization or function of this vitamin.

TABLE II

(a) Ascorbic Acid Content of Soy-beans Germinated in the *Dark*

Estimations made upon 19 seedlings, reduced with H_2S

Days	Whole seedlings		Sprouting part		Cotyledons		Remarks
	Weight (g.)	Ascorbic acid mg.	Weight (g.)	Ascorbic acid (mg.)	Weight (g.)	Ascorbic acid (mg.)	Length of seedling (cm.)
1	6.074	0.55	0.152	0.06	5.922	0.49	0
3	6.620	1.28	0.98	0.28	5.740	1.00	Hypocotyl showed. 4-5.5
5	8.000	2.06	3.10	0.50	4.900	1.56	Roots appeared. 8-9
7	10.422	2.02	5.22	0.79	5.202	1.23	Slightly green. 10-12
9	12.366	2.33	6.73	0.82	5.636	1.51	Root hairs form. 13-15
11	14.169	2.15	8.20	0.64	5.969	1.51	Epicotyl appeared. 15-16
14	19.450	1.75	11.60	0.92	7.850	0.83	Leaves projected. 20-26
16	16.200	2.27	9.70	0.85	6.500	1.32	All green 15-18.

(b) Germinated in the *Light*

Days	Whole seedlings weight (g.)	Ascorbic acid mg.	Sprouting part weight (g.)	Ascorbic acid (mg.)	Cotyledons weight (g.)	Ascorbic acid (mg.)	Length of seedling (cm.)
1	5.330	0.67	0.168	0.09	4.122	0.58	0
3	5.806	1.54	0.81	0.32	4.996	1.22	2.5 to 3.5
5	7.170	2.76	1.31	0.38	4.860	2.38	Green colour 3.5 to 4.5
7	7.216	2.33	2.14	0.49	5.076	1.84	7 to 8
9	8.599	3.02	3.68	0.86	4.919	2.16	7 to 8
11	11.199	3.34	5.39	0.90	5.809	2.44	All green 9 to 13
14	13.244	3.40	9.95	1.13	3.294	2.27	14 to 18
16	16.200	3.01	11.26	1.23	4.940	1.78	Epicotyl elongated 16 to 20

DISCUSSION

Compared with Bogart and Hughes' report on ascorbic acid in sprouted oats our results show very little parallel. Both show that ascorbic acid is formed by the germinating seed with a maximum production about the ninth day, but where the former found very little difference in the vitamin C content of oats

Effect of Sunlight on the Distribution of Ascorbic Acid
in Germinating Soy-beans.

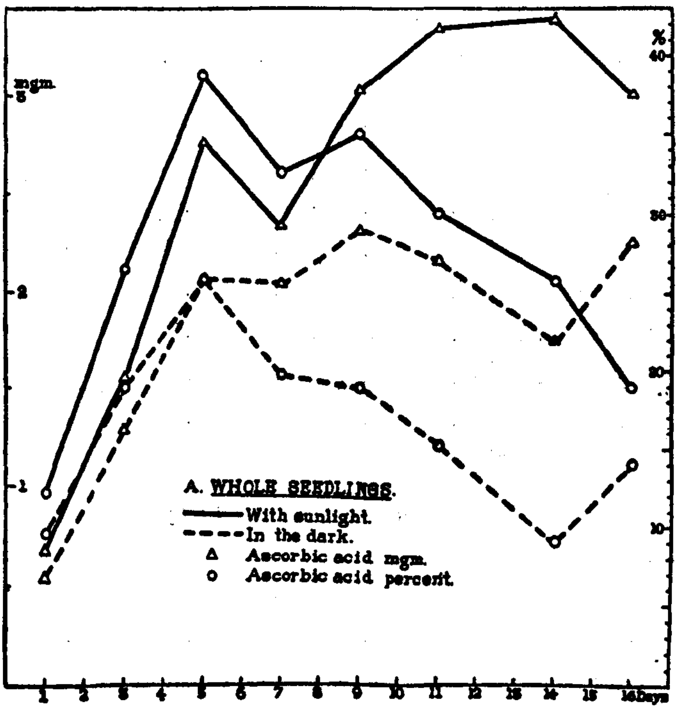

Figure 2

sprouted in the light and those sprouted in the dark, our results show that the soy-bean sprouted in the light has considerably more. This appears to be correlated with formation of chlorophyll which is more pronounced in the soy-bean. Moreover while the oat has more than 90 per cent of the vitamin in the epicotyl on the seventh day, with the exception of the fourteenth day of sprouting in the dark the soy-bean always shows a far higher content of vitamin in the cotyledons. This is so pronounced that it appears as if ascorbic acid is formed in the cotyledons from the reserve carbohydrate and transported to the growing sprout.

Effect of Sunlight on the Distribution of Ascorbic Acid in Germinating Soy-beans.

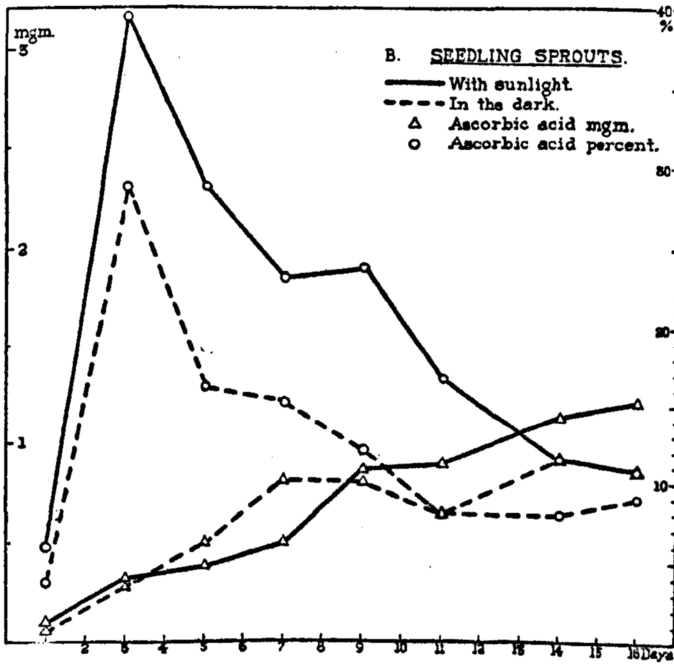

Figure 3

The percentage composition appears to bear some relationship to the growth of the various parts. When the hypocotyl appears the sprout has the highest percentage composition of ascorbic acid. On the fifth day the roots appear and the cotyledons reach their first high peak of production of vitamin. On the ninth day the root hairs form and there is another rise, and on the fourteenth day when the epicotyl is elongating very rapidly in the sunlight there is the highest peak of all.

Johnson (*11*), in examining peas germinated for 3 days, found almost five times as much reducing substance in the cotyledons as in the radicles, which is similar to the distribution we found in the soy-bean. Johnson found only 10 per cent more of the reversibly oxidized form of the vitamin in the pea. Our estimations on the third day show a somewhat greater difference

Effect of Sunlight on the Distribution of Ascorbic Acid
in Germinating Soy-beans.

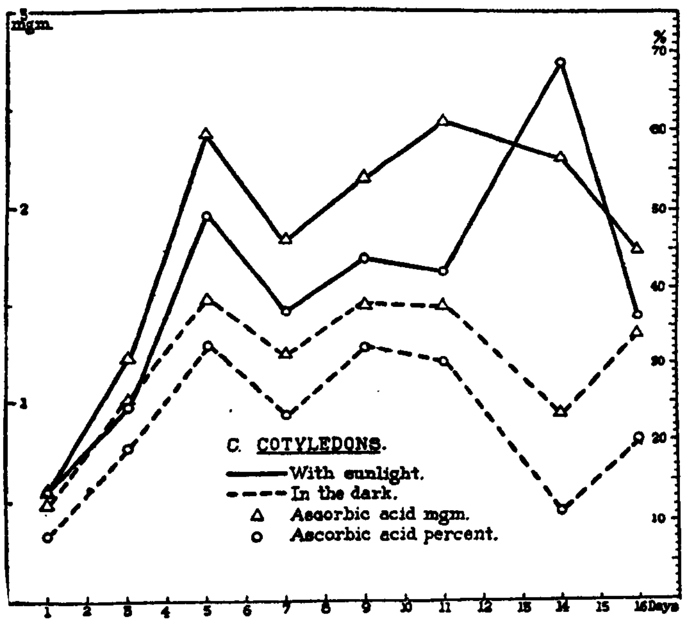

Figure 4

(figure 1), and as germination progressed there was an enormous change till on the seventeenth day only about 4 per cent remained in the ordinary reduced form.

In considering the possible function of vitamin C in the life processes of the plant regard is needed for both the actual amount formed and its relative percentage in the rapidly growing cells. Former studies by Harris and Ray (*8*) and Johnson (*11*) have only dealt with very young seedlings up to four days only, in which there is a progressive increase in all respects. Our results show that this increase in absolute amounts goes on till the ninth or eleventh day and then declines in the dark, or when submitted to sunlight it progresses to the fourteenth day and then has a sharp decline. On a percentage basis the highest content both in the dark and in the light is on the fifth day after which there is a marked decrease modified on the ninth day. The sharp rise noted on the sixteenth day of germination in the dark is associated with a definite shrivelling of the seedling and may be due entirely to the presence of decomposition products reducing in characters.

SUMMARY

(1) Soy-beans germinated in the dark form ascorbic acid in increasing amount up to the ninth to the eleventh day, at 25° nearly 0.4 mg. per seedling. This is present largely in the reversibly oxidized form.

(2) The ascorbic acid is present in largest amount in the cotyledons, where its higest value occurs on the fifth day of sprouting. The growing sprouts show a very high percentage composition on the third day, but while the absolute amount formed is increasing, the relative content becomes progressively less.

(3) Sunlight causes a greater production of ascorbic acid, about double the amount on the fourteenth day. The possible correlation of these results with the development of the plant and the formation of chlorophyll is discussed.

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(30) *Distribution of phosphorus in germinating soybeans.* W. Y. LEE AND HSING-LUNG LI.

Previous work on plant phosphorus has been chiefly concerned with either the phosphatides of seeds or the growth of the plant in a phosphate medium. In the present investigation the distribution of total phosphorus, lipoid phosphorus and acid soluble phosphorus has been studied in the two parts of a germinating bean, the cotyledons and the actively growing embryo.

The technique of germination follows the method which has already been reported. The seed-coat was detached at the beginning of germination which was carried out at 28°C and in each determination, the cotyledons were separated from the other parts and dried separately. Total phosphorus, lipoid phosphorus, and acid soluble phosphorus were determined. Total fat was first obtained by extracting with alcohol-ether and re-extracting with petroleum ether while lipoid phosphorus was determined from the total fat. Acid soluble phosphorus was obtained by grinding the material with quartz sand and 10 per cent trichloroacetic acid, after filtering and washing, the acid solution was evaporated to dryness.

The estimation of phosphorus followed the micro-colorimetric method of Jenner and Kay (1932), the material being first digested with sulphuric acid and perchloric acid until colorless, then neutralised and diluted.

The cotyledons: There was a diminution of 53 per cent dry matter during a 15 day period of germination. The disappearance of total fat from the cotyledons was over 90 per cent, while the lipoid phosphorus only decreased 76 per cent. Total phosphorus and acid soluble phosphorus were reduced 46 per cent and 42 per cent respectively. Expressing the amount of phosphorus per g dry weight, there was a gain of total phosphorus, and a very slight increase of acid soluble phosphorus when the seedling was decaying, and a large loss of lipoid phosphorus, especially at the beginning of germination.

The embryo: This is the actively growing part of the plant, where tissues are formed, there being a transference of material equal to more than 6 g dry matter or 33 per cent of that in the cotyledons. This amount of material is used for the development of root, stem and leaves. Total phosphorus, acid soluble phosphorus, lipoid phosphorus and even total fat increased gradually as germination proceeded, although the relative rate of migration to the embryo varied. Comparatively less lipoid phosphorus was transferred to the embryo, yet the general trend of increase was the same. Calculated per g dry matter, there was little fluctuation in the amount of acid soluble phosphorus but total phosphorus and lipoid phosphorus varied at different stages of development.

The amount of total phosphorus and also acid soluble phosphorus contained in 100 seedlings, that is the sum in the cotyledons and the embryo, showed very little variation at different stages of development. Two thirds of the lipoid phosphorus disappeared within the first three days of germination.

The large loss of lipoid phosphorus at the beginning of germination is probably due to the rapid hydrolysis set up by the inhibition of water.

The acid soluble phosphorus constitutes the most essential fraction of all phosphorus compounds in the seeds. This fraction which excludes the phosphoproteins and phosphatides, consists mainly of phosphoric esters and forms more than 90 per cent of the total phosphorus. That the amount per g dry matter keeps quite constant throughout the period of development indicates that the acid soluble fraction forms an integral part of the material transferred to the embryo.

That there is always a higher concentration of all types of phosphorus compounds in the embryo than in the cotyledons affords evidence of a greater metabolic activity in the embryo. (Cockefair, 1931).