THE PREPARATION OF SPROUTED AND DRIED LEGUMES FOR THE INDIAN HOME

by

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INTRODUCTION

In India, plant foods are consumed in larger proportions than animal foods because the majority of Indians are vegetarians, some more strict than others. Therefore, it is important that the consumption of plant proteins be encouraged, and better and more nutritious plant foods be introduced.

Legumes play an important part in the diet of the Indian people. Their nutritive value has been studied in India and in other countries, but little attention has been given to the methods of preparation for serving them. Hence, they are often considered a monotonous and unpalatable food. To encourage those who can afford to use legumes in greater quantity, it seems desirable to make available directions for preparing and serving them in various ways.

Soybeans were introduced in Bengal but people did not like the flavor. Therefore, the use of this valuable legume was not encouraged. Aykroyd (1941) stated that soybeans are rich in protein and fat, but if they are to be widely used in India considerable attention will have to be given to methods of preparing them in a palatable form. Similarly, McCay (1943) wrote that the soybean is a very nutritive legume, but the big job is to familiarize people with this valuable food. It takes a few meals to develop a liking for soybeans.

Very few Indian people are acquainted with the methods of

sprouting beans, so it is seldom done. In this study, simple methods for sprouting beans are described, which can be followed easily by an average Indian woman. Navy beans, red kidney beans, and split peas, which are already available in India, were prepared in various ways. The navy beans and red kidney beans were also sprouted and the sprouts used in salads, soups and curries. Special attention was given to the preparation of dishes using dry soybeans, sprouted soybeans, and soybean flour. It was assumed that these products can be introduced into India and used by the people if they know how to prepare them.

REVIEW OF LITERATURE

Nutritive Constituents of Legumes

Proteins. Jones and Divine (1944) found that the soybean was one of the richest known sources of protein among naturally occurring foods, ranging, according to variety, from 30 to 45 percent protein. They found that there was considerable amount of evidence that the human species could satisfactorily digest and utilize soybean proteins. Mendel and Fine (1912) found that soybean nitrogen was well utilized by men and dogs. Later, Osborne and Mendel (1917) showed that the proteins of soybean meal supported normal growth of rats.

Swaminathan (1937) studied the biological values of the

proteins of five Indian pulses: red gram, Bengal gram, green gram, soybean, and black gram. He found that the protein of black gram had the highest biological value. When rats were fed the proteins of black gram they grew and gained weight, whereas those rats fed red gram died during the course of the experiment.

Shrewsbury and Bratzler (1933) and Zucker and Zucker (1943) demonstrated that the nutritive value of soybean protein was markedly improved by cooking. It was believed that this increase in biological value produced by heat was a result of an increase in the availability of sulfur-containing amino acids, cystine and methionine. Sherman and Albrecht (1942) stated that soybeans contained twice as much protein as other legumes such as cow peas and lima beans and the protein was of high quality. The protein of several of the cooked edible varieties very nearly equalled casein. Cow peas and most beans were found to be deficient in sulfur-containing amino acids. Therefore, when these two are used in the diet they should be supplemented by foods rich in cystine and methionine.

Everson and Heckert (1944) fed five varieties of soybeans, Illini, Mansoy, Dunfield, Virginia brown, and Mandarin, to male rats. They found that the beans fed in the raw state failed to support normal growth, but their value was greatly improved by autoclaving. Chemical determinations of the total sulfur by peroxide fusion indicated that the sulfur content of

these varieties did not differ widely. Cahill et al. (1944) found that the protein of autoclaved soybeans, soybean flour, and soybean milk had biological values of 96.5, 91.7, and 94.5 percent and digestibility value of 90.0, 93.9, and 86.6 percent, respectively. Soybean milk was a good substitute for cows' milk and was good for children and adults who were allergic to cows' milk.

Osborne and Clapp (1907) made chemical analysis of glycinin, the chief protein of soybeans. They found the amino acid content of glycinin similar to casein, the principal protein in milk. Niyogi et al. (1931) isolated globulins from pulses and analyzed them and found arginine, tyrosine, tryptophane and cystine to be present. In each case the globulins compared favorably with casein. They contained requisite amounts of arginine, histidine, and lysine, but were deficient in both cystine and tryptophane when compared with casein.

Carbohydrate and Fat. Bowman et al. (1945) stated that the total percentage of carbohydrates in soybeans is 30. Sugar gives flavor to soybeans and is the most important available carbohydrate. The approximate percentage of sugar found in soybeans is seven. Other legumes are also a good source of carbohydrate. Soybean oil was considered an important source of energy by Sherman and Albrecht (1942), as it contained essential fatty acids and lecithin.

Minerals. Sherman et al. (1934), in a study on the availability of iron in biological materials, fed dried soybeans,

both roasted and non-roasted to anemic rats at a level of 0.3 milligram of iron with the addition of 0.05 milligram of copper as copper sulfate. They found soybeans effective for producing hemoglobin.

Smith and Otis (1937) determined the availability of iron in dried peas and lima beans by feeding these to anemic rats and comparing their gain in hemoglobin after six weeks with that of another group of rats fed varying amounts of iron as ferric chloride. All groups received the same amount of copper manganese supplements. In this way, they ascertained the quantities of iron, as ferric chloride, required to produce the same gains in hemoglobin as that of the peas and beans. This was found to be 84 percent for peas and 88 percent for beans.

Ascham and LeClerc (1938) fed black peas and other vegetables to rats, using a similar technique as Smith and Otis (1937) only feeding more iron. They concluded that the availability of iron for hemoglobin regeneration was highest in black eyed peas. Sheets and Ward (1940) also fed different vegetables to rats. Their results showed that the anti-anemic potency of the legumes when fed at the same level of iron was much greater than that of the leafy vegetables. The legumes supplied more copper in the quantities fed than green leafy vegetables. The legumes fed at the same iron level, and the same or adequate copper level caused a significantly greater hemoglobin response.

Sherman and Albrecht (1942) stated that although soybeans do not compare with milk as a source of calcium, they do contain two or three times more of the bone-building element than do other beans and peas. One hundred grams of soybeans supply one-fourth of a day's requirement of calcium for an adult. Also, soybeans contain a calcium-phosphorus ratio nearly optimum for adults. Bowman et al. (1945) agreed that soybeans contained appreciable quantities of calcium, phosphorus, potassium, magnesium, and utilizable iron.

Vitamins. Sherman and Albrecht (1942) stated that fresh green soybeans are a good source of vitamin A, but when matured, the quantity of the vitamin is reduced. They were found to be a very good source of the vitamin B complex. An average serving of 100 grams of mature soybean supplied over half the daily requirement of this vitamin. Soybeans were not a very good source of riboflavin and pantothenic acid. Mature beans were a fair source of nicotinic acid, a very good source of vitamin E and also contained vitamin K.

Zucker and Zucker (1943) and Burkholder (1943) reported significant quantities of vitamin B in soybeans. Burkholder also stated that riboflavin and niacin were a little lower than in meat. Barnes and Maack (1943) said that soybeans were an excellent source of thiamine, nearly equalling that found in pork, they supplied more niacin than most of the vegetables and cereals.

Factors Affecting the Cooking Quality and Palatability of Legumes

Certain factors that affect the palatability of legumes are: (1) age and storage conditions, (2) water and chemicals, (3) pectic substances, (4) soaking, (5) length of cooking, and (6) time for adding salt.

Age and Storage Conditions. Snyder (1936) noticed that peas and dried beans cooked well when first matured, then certain successive environmental conditions appeared to affect their cooking quality. In her department of Home Economics, beans stored under laboratory conditions became so hard they could not be cooked satisfactorily. Laboratory temperature ranged from 70° F. to 80° F. and the humidity was generally low. When the beans were stored at 50° F. with conditions that prevent or reduce loss of moisture the results showed that age alone was not the only factor.

Snyder (1936) obtained beans which were 14 years old. These beans were dark in color and remained hard throughout various treatments. They gained weight in soaking and cooking, but did not become soft. Gloyer (1921) stated that the hardness of beans was a result of adverse temperature and moisture conditions in the field, during harvesting, or during storage. This type of hardness was known as "scleroma" which was produced from enzymatic changes resulting from storage in damp atmosphere at high temperature with no ventilation.

Water and Chemicals. Greenwood (1935) and Snyder (1936) described two types of hardness of water, temporary in the form of calcium and magnesium-bicarbonates which can be removed by boiling for a period of 20 to 30 minutes in a covered dish, and permanent which contains sulfates and chlorides of magnesium and calcium which cannot be removed by boiling. In their studies they used beans from the same lot and soaked and cooked them in water from the different localities. Their results showed that the water from different localities varied a great deal in its effect on the beans. The percentage of hardness of beans ranged from 22 percent for those soaked in water from the Nebraska Agricultural Experiment Station to 100 percent for beans cooked in water from Marshall County, Kansas. As the permanent hardness of water increased, the toughness of the seed coat also increased. They also used standard solutions of calcium and magnesium sulfates and chlorides in concentrations equivalent to 2,000, 1,000, 500, 250, and 100 parts per million of calcium carbonate. The results proved that calcium salts produced more pronounced hardness than did magnesium. They studied the hardening effect from solutions of calcium and magnesium salts on seed coats and cotyledons of the beans. The cotyledons were cooked to a pulp with the exception of those cooked in water from Marshall County, Kansas. In this sample, the form was retained and the beans were hard. Comparison of percentage of gain in the soaked weights of the bean cotyledons with those of the whole beans

showed the former to be considerably higher, indicating that the effect of the hard water was on the seed coat alone.

Sodium-Bicarbonate. Sodium-bicarbonate is used when cooking beans for two purposes, one for softening the seed coats, and another for softening the water. Snyder (1936) discussed the objections given to the use of sodium-bicarbonate. First, it decomposes the protiens in the beans and renders them less nutritious; second, it attacks vitamin B. Greenwood (1935), Snyder (1936), and Lowe (1943) found that when soda was used in soaking water it rendered the seed coat tender and did not decrease the water absorption. When soda was used for cooking it shortened the cooking time and impaired the color of the beans making them somewhat grayish. The product became mushy and possessed a characteristic flavor objectionable to some people.

Sherman (1937) stated "Cooking or canning is apt to be only a relatively small factor in destruction of vitamin B unless the natural acidity of the food has been reduced by the addition of alkali, any shifting of the hydrogen-ion activity toward the alkaline side whether the neutral point is passed or not, must be expected to increase the rate of destruction of the vitamin. The rate of destruction may be negligible at low temperatures but becomes serious on heating."

Lantz (1938) studied the effect of soda on the vitamin content of beans and showed that rats fed beans cooked in an

alkaline medium barely maintained themselves throughout the experiment. She also used a pressure cooker for cooking the beans and discovered that vitamin B was no more destroyed in the pressure cooker than when cooked for 2.75 hours in distilled water, and much less than when cooked for 2.75 hours after soaking the beans in a weak solution of baking soda. She recommended avoiding the use of baking soda in cooking pinto beans, and other foods if it was at all practicable to obtain a palatable product without it.

Johnston et al. (1943) examined the effect of soda on the cooking time of peas. They cooked 85 grams of peas with 180 milliliters of water and 0.22 gram of soda. The cooking time was reduced from 17 to 8 minutes for dried peas, and from 6 to 4 minutes for the fresh peas when soda was used in the cooking water. The peas were added to the boiling water and after cooking were filtered, homogenized in a Waring blender and the macerated tissues and cooking water were examined for vitamin content. They found that when beans were cooked in tap water, 20 percent of the thiamine leached out into the water. When the same products were cooked with sodium bicarbonate, peas showed negligible losses of thiamine and leaching into the water was identical with that found when tap water alone was used for cooking. When fresh peas were over cooked, large thiamine losses were obtained, 60 percent when soda was added and 45 percent when water alone was used.

With proper allowance for a shortened cooking time, the

use of small amounts of sodium bicarbonate in the cooking of dried peas did not affect the riboflavin or ascorbic acid content of the product as prepared for the table.

Snyder (1936) cooked beans in hydrochloric acid, and acetic acid in the following concentrations: 0.33, 0.1, 0.3, and 0.1 normal. The data showed that the acids tended to depress the imbibition of water and the depression generally increased with increased strength of acid. The effect on beans of the 0.1 normal acid was slight, but the seed coats were very tough with the 0.33 normal solution. Acetic acid produced a tougher seed coat than hydrochloric acid. The beans cooked in neutralized solutions were more broken and less desirable in appearance than those washed and cooked in distilled water. Snyder (1936) added molasses and tomato juice or pulp to the beans. Data showed that the hardness that was found in the cooked beans was due to calcium or magnesium present in molasses and acid present in tomato juice. When the beans were cooked first and molasses and tomato juice added later, the results were not objectionable.

Sugar Solutions. According to Snyder (1936), concentrated sugar solutions had a hardening effect on beans, but when sugar was used in small quantities the effects were not perceptible. She noticed that substances that dissolved the pectic substances shortened the soaking and cooking time. Beans with very hard skins neither soaked nor cooked satisfactorily. Their skins contained a higher percentage of pectic substances

than the skins of beans that soaked and cooked easily.

Soaking. Greenwood (1935) used both cold and boiling water for soaking. She found that when cold water was used, the beans remained hard even after 15 or 16 hours of soaking. Hot water hastened the process of water absorption and the beans became plump at the end of 10 or 12 hours. The beans swelled most in the early part of the soaking period but continued to swell an appreciable amount up to the tenth or twelfth hour. To obtain a superior product, soda was added to the soaking water. The soda did not affect the rapidity with which the beans swelled, but it made the beans much more tender. The effect of hard water was noticed in soaking and cooking beans.

Snyder (1936) used distilled water for both soaking and cooking. She found that in general the beans absorbed their own weight of water in 5 to 6 hours, provided the temperature of the water was considerably above room temperature. There was little increase in weight by longer soaking, and cooking time was not reduced. Lowe (1943) and Snyder (1936) both found that cooked beans which had been soaked were more pleasing in appearance, appeared light in color, and were more evenly cooked than those which had not been soaked. The cooking time was reduced considerably by soaking, but the weight of the cooked beans was the same whether soaked or not soaked. Pouring boiling water over soybeans and letting them soak for three or four hours shortened the cooking time the most.

Addition of soda to the soaking water further shortened the cooking time.

Sherman and Albrecht (1942) soaked soybeans over night to shorten the cooking time. Bowman et al. (1945) tested the cooking quality of 11 garden varieties and two field varieties of soybeans. When soybeans were soaked over night in twice their volume of water the cooking time was shortened. Childs et al. (1946) recommended soaking soybeans over night and discarding the water to reduce the pronounced flavor and taste of the beans.

Bean Sprouts

Nutritive Value. McCay (1943) has revealed that sprouted soybeans are high in protein, fat, and vitamin C, besides containing such minerals as calcium and utilizable iron and appreciable amounts of vitamin B. Sprouted beans rival meat in essential nutrients, and fresh tomatoes in vitamin C. As the sprouting process takes place, the soybeans acquire form, flavor, consistency, and food value of a fresh vegetable without losing their original high protein content. The bean changes, as one punster has observed, from a bean to a has-been.

As long ago as 1782, the use of germinated pulses as an anti-scorbutic for the British navy was suggested by Young. It, however, was not until the present century that Furst

(1912), working with guinea pigs in Host's laboratory in Oslo, showed that dry cereals and pulses developed anti-scorbutic properties after sprouting. This was confirmed for pulses by Chick and Delf (1919) who recommended germinated pulses as a source of vitamin C in army rations in the absence of fresh fruits and vegetables. Delf (1922) found that 2.5 grams of raw germinated cow peas fed daily protected guinea pigs from scurvy for 90 days. She also found that 15 to 20 grams of boiled germinated cow peas, 10 grams of steamed or 20 grams of simmered germinated cow peas fed daily gave protection against scurvy.

Santos (1922) studied togi.[1] He found that 5 grams of fresh togi fed daily protected guinea pigs from scurvy, but togi boiled 10 minutes in a covered vessel fed as 5 gram daily supplements to two guinea pigs did not prevent death from scurvy. In the Hawaiian Islands, Miller and Hair (1928) tested mung bean sprouts for their vitamin A, B, and C contents in the raw and cooked state. They found that sprouts both raw and cooked were a fair source of vitamin A, a very good source of B, and an excellent source of vitamin A in the raw state, and a good source in the cooked state.

Wats and Woodhouse (1934) studied the anti-scorbutic value of various kinds of sprouted mung beans as they protected guinea pigs from scurvy. The juice which was filtered

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[1] Japanese name for mung bean sprouts.

an hour after being expressed was only slightly active even in a dose of 10 milliliters. The fall in potency was attributed to the action of acidases and peroxidases present in the juice.

Ahmad (1935) determined the vitamin C content of many Indian foods by the chemical method. Foods studied were purchased in the markets and were considered typical products. He found that in the sprouts of green mung beans there were 0.23 milligram of ascorbic acid per gram of sprouts. The ascorbic acid value of many sprouts computed from guinea pig experiments was 0.15 milligram per gram. This value for ascorbic acid was higher than for any other sprouted legumes tested.

Burkholder (1943) found significant increases in the concentration of riboflavin, niacin, biotin, and pyridoxine during the germination of several kinds of seeds. They found little or no change in thiamine concentration. All analyses were made on the plant material after drying at 70° C. for 12 hours.

Everson et al. (1944) found that the protein of freshly germinated Illini beans was superior in nutritive value to the protein of the unheated mature beans.

Factors Affecting Sprouting

Many factors such as variety of the beans, age, soaking previous to sprouting or germinating, temperature, oxygen, carbon dioxide, light, weather, and technique affect the sprouting of beans. Each of these factors is discussed separately.

Variety of Beans. Beeskaw (1944) found that care should be taken in choosing the variety of soybeans. He selected Manchu, Viking, Mandarin, Chief, Illini, and Ebony and found that Ebony produced the best sprouts, but the other varieties were satisfactory for sprouting. Lee's (1936) experiment showed that available samples of Easycook soybeans did not germinate well, and could not be sprouted successfully. They also molded easily. The Illini soybeans behaved the same way, but Hongkong, Manchu, and A. K. soybeans produced good results.

Age. Laughland and Laughland (1939) found that age has a definite effect on the vitality of soybean seed. They carried on experiments on eight different samples of seeds ranging from a few months to eight years in age. They discovered that the youngest seeds yielded the highest percentage of sprouts, whereas the eight year old seeds did not sprout at all. Their experiment also proved that controlled heat and moisture gave greater germination. Sprouts should be used at a certain age because as the sprouted beans advance

in age the amount of fat, protein, carbohydrate, and caloric value per 100 grams decreased.

Soaking. Kidd and West (1919) claimed that bean seeds which are soaked in water showed a pronounced decrease in germination over those not soaked. The temperature of water produced a marked difference. Beans soaked in water at 20° C. had their germinating capacity less seriously injured than those soaked in water of higher and lower temperatures. The reduction of germination was also greater in room temperatures both higher and lower than a temperature of 25° C.

Tilford et al. (1924) concluded that bacterial activity was an important factor in the devitalization of bean seeds which were soaked in water. On the other hand, Baily (1933) found that soaked seeds showed a decrease in germination even though the soaking conditions were absolutely aseptic.

Eyster (1938) sterilized bean seeds, distilled water, and containers used in sprouting. The seeds were sterilized by putting them in potassium dichromate and sulphuric acid cleaning solution for two minutes, and then thoroughly washing them in distilled water twice. After being placed in 95 percent ethyl alcohol momentarily, they were put in a solution of mercuric chloride (one part mercuric chloride per 1000 parts water) for 20 minutes. The ethyl alcohol reduced the surface tension of the solution, thereby removing any air bubbles that might remain on the surface of the seeds or between adjacent seeds. After two washings in sterile distilled water, the seeds

were carefully aseptically placed in the sterile soaking water. The soaked seeds were then placed to germinate on moist porous blocks of fired clay, or were planted in the soil in the greenhouse bench at a uniform distance apart and at a uniform depth of one inch.

Eyster (1938) discovered that germination of seeds soaked under aseptic conditions is significantly higher than those soaked without regard to the sterilization of both seeds and water. The data indicated that the deleterious effects of soaking are due to: (1) bacterial action, (2) insufficient supply of oxygen, and (3) loss of essential cell constituents. It seemed likely that an insufficient supply of oxygen produced an alteration in the differential permeability of cytoplasmic membranes and accordingly brought about a loss of essential cell constituents. The loss of essential cell constituents was the fundamental cause for the deleterious effect of soaking.

On the other hand, many investigators have recommended soaking prior to sprouting beans. Lee (1936) and Beeskaw (1944) soaked beans over night before sprouting. Djou Yu Wen (1937) soaked beans until they became plump. French et al. (1944) and Williams (1947) soaked for 8 hours, and Vail (1945) for 15 to 18 hours.

Temperature. It has long been known that relatively high temperatures favor the germination of most seeds. However, a mass of sprouting beans will generate considerable heat which

may kill the seedlings. To prevent over heating, the germinating seeds must be ventilated. Beeskaw (1944) discovered that the temperature in the germinating room and that of the water used in sprinkling had a marked influence upon the growth and development of the sprouts. He considered the water at 70° F. most desirable for sprout production. Edwards (1934) showed that the optimum room temperature for germination of the soybean was 92° F. to 100° F. He believed that it is quite possible that there is an optimum temperature for each stage of germination. Too high a temperature during the early stage of the development of the seedlings leads to etiolated growth and rapid depletion of the food reserves which may be essential in the later stages of seedling development. The germinating seeds are very susceptible to molds and bacteria, especially if they are allowed to become over heated. No special precaution against the mold needed to be taken if the sprouts were sprinkled regularly. Hafenrichter (1928) reported that the response of two closely related varieties of soybeans to temperature was as different as is reported for two unrelated species.

Carbon Dioxide and Oxygen: During the germinating process, the seedling requires a considerable amount of oxygen and moisture. Carbon dioxide and heat are liberated as the young embryo grows. If the carbon dioxide is not removed by a ventilation process, germination is slow and the products of decomposition will accumulate. Most germinating seeds have a

relatively high oxygen requirement. Complete absence of atmospheric oxygen promotes anaerobic respiration and the subsequent accumulation of incompletely oxidized waste products such as alcohols and aldehydes. When oxygen is low putrefaction and slow growth result. Beeskaw (1943) wrote that an excessive supply of oxygen leads at first to a high rate of respiration which is soon followed by a drop in respiration or even death of the seeds.

Beeskaw (1944) found that in all cases when the beans were sprouted in high concentrations of carbon dioxide there was a markedly stunted growth. When the beans were allowed to germinate in a mixture of 30 percent air and 70 percent carbon dioxide, there was poor germination. Apparently, it is not the low concentration of the oxygen alone which causes the stunted growth but rather the presence of carbon dioxide.

Light, Weather, and Technique. In some countries sprouts are grown in the light to induce chlorophyl development. As a general rule, the hypocotyls are allowed to grow until just before the secondary roots appear. The most desirable sprouts are those which have no starch in the cotyledons and in which the hypocotyl contains a high amount of sugar. Beeskaw (1944) found such sprouts to be firm when cooked.

Beeskaw (1944) observed that on bright sunny days beans were not attacked by fungus, but on rainy and cloudy days the seeds and sprouts were badly attacked by fungus.

Many writers agree that the technique involved in the production of bean sprouts differs from that of ordinary seed germination in that an etiolated seedling is the desired product. A special effort should be made to produce a slow growth of the seedling so that the stored foods in the cotyledons are not respired but are slowly translocated to the elongated hypocotyl and there stored as sugar or consumed in the production of soft succulent tissues.

Methods of Sprouting

Methods of sprouting range from home devices to commercial processing which includes the canning of sprouts. For this study attention is paid to the home devices only.

A few points are common to most of the methods of sprouting suggested or used by various people. These are as follows:

1. For soybeans select small seeded, light colored beans of either vegetable type or field type beans.

2. Look over the discard all that are split, chipped or broken because these will not sprout and may start to decay.

3. Wash beans in tap water and let stand for a few minutes, the poor seeds or those that will not germinate will float, those that sink in the water can be used for sprouting.

4. Soak beans in clean water. If desirable add a pinch of chlorinated lime to the water.

Zahnley (1932) suggested a suitable method of sprouting beans for laboratory use and called it a "ragdoll" method. It requires a moistened piece of cotton flannel of about 10 x 27 inches. The seeds are distributed evenly in the center of the cloth, and the two sides are folded over about 2 inches and then the whole is rolled loosely in order to permit air to circulate. The roll, or "ragdoll" is then put in a place of suitable temperature and kept moistened. This method is suggested for ordinary household use in testing the germination of seeds because it requires little attention. Lee (1936) used this method and found that it cannot be adapted for quantity production of sprouts. The sprouts that were produced were not straight and even in length.

An experiment on sprouting beans was carried on in the seed laboratory of the Annual Crop Division of the Philippines (1935). The beans were washed in warm (70 F. to 80 F.) water for a few minutes to soften the seed coat and destroy the mold or insects on the beans. Next they were soaked over night and put into pots with a layer of rice straw in the bottom. The pots were kept in a dark corner of the room. For the first three days the beans were moistened twice a day. Beginning with the fourth day they were watered only in the morning. It was found that if light got to the sprouts, they became green and tough instead of blanched and tender.

Lee (1936) used large germinators. Flat tin milk pans 9 inches in diameter were used to hold the water. On the top was placed a piece of galvanized iron screen with meshes 0.5 inch square. This screen supported a piece of cotton flannel cut to fit the top of the pan. A wick sewed to the center of the flannel circle passed through the screen into the water. Beans to be sprouted were distributed evenly over the cloth and covered with another milk pan of the same size, with holes in it to provide ventilation. The beans sprouted successfully in these improvised germinators.

Djou Yu Wen (1937) used a large earthenware flower pot for washing and soaking the seeds and for floating the skins off the sprouts during harvesting. A bamboo basket with holes through which skins could pass was used for washing sprouts and a garden sprinkler was used for watering the sprouts. Sprouts were grown in a small earthen ware jar 14 inches deep and 11.75 inches in diameter, and in a larger wooden bucket 13.12 inches by 11.5 inches. In the bottom of each container was a hole covered with crockery for drainage. The seeds were washed and soaked for two or three hours and washed and soaked again until they were plump. The seeds were then transferred to containers in which no straw or sand was used. The seeds were watered every 4 to 6 hours. He used well and tap water, and found that when well water was used the percentage of sprouts obtained was a little higher than when tap water was used, but those grown in tap water were shiny, clear, pure

white in color, brittle texture and very sweet in taste. He recommended a wooden bucket for the winter and an earthenware vessel for the summer for sprouting beans.

A method for sprouting beans was published in Better Homes and Gardens (1942) for the use of homemakers. In this method, beans were soaked in warm water to which a pinch of chlorinated lime was added. The beans were put in a colander, fruit jar or flower pot, and covered with a moist cloth. The cloth was moistened three times a day, using chlorinated lime in the last rinse of the day if the temperature was 70° F. If a glass jar was used, it was kept in a dark place. A piece of cheesecloth was tied tightly over the mouth of the jar which was inverted and stood on a tilt for good drainage. Usually beans sprouted in three days. They were rinsed in warm water to remove the skins.

Another method designed especially for the homemaker was published in the Ladies Home Journal (Lonsbury, 1943). In this routine, beans were soaked over night in water containing some chlorinated lime. In the morning the beans were drained and rinsed in tap water. They were then placed between layers of moist cheesecloth in a flower pot and covered with a piece of damp cardboard, which served the purpose of restricting the light without excluding the air. The beans were held under the water tap and the water allowed to run in and drain out the bottom two or three times a day. They reported sprouts in three or four days.

French et al. (1944) sprouted beans by placing them in sterilized burlap bags in which they were soaked for a period of eight hours. At the end of this soaking period the bags were removed and hung in front of an open window. The bags were immersed in water for a short time at intervals of eight hours, three times a day. Some signs of germination could be observed at the end of the first day, but in most cases sprouting began two days from the time the beans were just soaked. The sprouts grew to about 2 inches during the summer in about 72 hours, and in the colder temperature of the winter, in about 120 hours.

Beeskaw (1944) selected about a cup full of good, sound, viable soy seeds and soaked them in water over night. The seeds were swollen twice their original size in 12 hours. He washed the seeds several times in running water, drained them completely and placed them in a quart milk bottle or Mason type jar. The bottle or jar was kept at a temperature between 65° F. and 75° F. Every 4 to 5 hours the bottle was filled with water at 72° F. several time and then drained. He recommended that the beans be watered avery 6 hours day and night. The seeds should be drained completely after each watering. About 36 hours after the seeds were set to soak, the seed coats burst and the young white sprouts appeared.

Beeskaw (1944) also advised that a germinating chamber be used for mung beans. A large flower pot was suggested as an excellent germinating chamber. A piece of cheesecloth

should be placed over the hole in the bottom of the pot to keep the seeds from falling through. He constructed a germinating chamber of wood. The base was about 8 inches square and the sides of the chamber sloped as in the flower pot. The chamber was 12 inches deep and there were holes in the bottom to allow for drainage. A metal cover was placed over the germinating chamber.

Another simple method of sprouting, somewhat similar, was published in Science News Letter (1944). The beans were placed in a flower pot. Water was poured and allowed to escape at the bottom. The beans were kept moist, dark, and in a clean condition.

Everson et al. (1944) sprouted soybeans by placing them between layers of moistened burlap contained in shallow porcelain pans. Water was added 6 to 8 times daily to keep them moist. By this method the beans sprouted in about 60 hours at 60° C.

Vail (1945) washed and soaked beans in luke-warm water from 15 to 18 hours allowing about three pints of water to one pound of beans. After soaking, the beans were put in a flower pot, which had the bottom covered with a cloth so that all light was excluded. The beans were flushed from three to five times a day. A container of fresh water was set above the beans with a "wick" (a strip of clean cloth) in it, which permitted the water to drip onto the beans. This was a precaution against the drying out of the beans. The beans were kept in a

warm place.

Williams (1947) soaked samples of pinto beans in tap water at room temperature (68 F. - 80 F.) for eight hours. At the end of this time the beans were drained and planted in moist saw dust in a flower pot. The saw dust was dampened so that when a handful was squeezed a small amount of water would run out. A layer of saw dust two inches deep was placed in the bottom of the pot and after that layers of beans and saw dust were placed alternately about an inch apart to within an inch and a half of the top of the flower pot. The pot was then filled with saw dust extending in a convex manner above the rim of the pot. Two of these flower pots were placed on inverted bowls in a large dish pan, and water added to just below the bottom of the pots. Thus the hole in the bottom of the pots was not submerged and there was a free channel for air through the pot. A large dish towel was then thoroughly dampened and placed over the flower pots, the edges extending into the water all around. The cloth absorbed the water and the saw dust in turn took moisture from the covering.

Soy Flour

Soy flour has been used in China and other countries of the Orient for many years. Germany was one of the first western countries to use soy flour for human beings. Dr. Laslo

Berczeller (1944) of Vienna, Germany began his work of adapting the soybean to the food habits of the western world so that the starving masses in Europe might be better fed. In 1922 he patented a process for removing the bitter taste and preventing development of rancidity of fat in the soybean.

Horvath (1935) pointed out that the acceptance of soy flour depended on correct processing, which has two main objectives: (1) the elimination of the beany flavoring substances, and (2) the inactivation of the enzymes which cause deterioration when flour is stored.

Horvath (1931) described lecithin as an important constituent of all organs of the human body and especially of the nervous tissue, the heart and liver. He found that the percentage of lecithin of those organs increased while the subject was on a soybean diet. Sprague (1940) translated from the German literature and reported that one pound of soy flour might contain as much lecithin as four to six eggs. He pointed out that the protein in the soy flour was so similar to the protein in meat that neither feeding tests nor the protein chemists were able to consistently distinguish between the two.

Johns and Finks (1921), Kon and Markuze (1931) found that rats fed wheat bread gained about 1.0 gram for each gram of protein consumed, whereas those fed wheat and soy flour bread gained 1.5 grams for each gram of protein consumed.

Jones and Divine (1944) and Volz (1945) studied the food

value of soy flour when mixed with wheat flour in the proportions of 10 parts soy flour to 90 parts of whole wheat flour. They found that soy flour showed practically the same supplementary value as skim milk powder and provided weight increases four times that of wheat flour alone. A mixture of 15 parts soy flour and 85 parts of wheat flour showed a growth-promoting value exceeding that obtained with a mixture of skim milk powder in same proportion. A mixture produced by addition of as little as five parts soy flour to 95 parts of wheat flour contained 16 to 19 percent more protein than the wheat flour alone and had a definitely greater growth-promoting value of protein. Lockhart (1944) found that a bread containing 2.3 percent skim milk solids and 3 percent of full fat soy flour was superior in protein content to a bread containing 6 percent skim milk solids.

Sherman and Albrecht (1942) suggested that soy flour could be used in the proportion of one part soy flour to three parts wheat flour. A recipe for muffins was given in which soy flour and whole wheat flour were used in equal parts. Salmon (1943) discovered that the most successful method of using soy flour was in combination with wheat flour or cornmeal and with yeast breads of all kinds.

Bowman et al. (1945), Childs et al. (1946) and Frantz and Simpson (1947) reported that four classes of soy flour are available in American markets: (1) full fat, 21.55; (2) high fat, 13.06; (3) low fat, 6.21; and (4) minimum fat, 0.57 per-

cent. However, the percentage of fat in soy flour is not standardized. Different mills might produce soy flours with different amounts of fat to sell under the above classes.

Bowman et al. (1945) showed that the substitution of full fat flour into a basic recipe required no liquid adjustment, but the liquid needed to be increased when low fat and minimum fat soy flour was used. Sometimes a little more salt was needed than called for in the recipe. Childs et al. (1946) agreed that minimum fat soy flour had a greater capacity to hold water than full fat soy flour. When high fat soy flour was used they reduced shortening but added more seasoning to cover any undesirable bean flavor which might be present. Cookies, muffins, coffee cakes, and cakes were made successfully using 24 to 100 percent soy flour for wheat flour. Brownies were satisfactory with a 100 percent substitution; plain cake, 24 percent; chocolate cake, 30 percent; and eggless spice cake, 50 percent. They suggested the following points to bear in mind when soy flour is used.

(1) Use lower oven temperatures as soy flour browns quickly.

(2) Increase the seasoning or flavoring.

(3) Increase the liquid.

(4) When using soy flour in sauces do not depend on it for thickening since it contains practically no starch.

(5) Adjust the other ingredients to the type of flour (high, low, or medium fat) being used.

(6) A slight decrease in volume in cakes is to be expected when using soy flour.

(7) Pie crust made with part soy flour is somewhat more difficult to handle than all-wheat flour doughs.

Frantz and Simpson (1947) made pastry wafers from all four classes of soy flour (20 percent soy flour and 80 percent wheat flour) and agreed with Childs et al. (1946) that full fat and high fat soy flour in pastry increased the shortness of the wafers.

Methods of Serving Beans

In the United States beans are usually baked with molasses and bacon. In India, they are cooked with curry powder and seasonings. Recent investigators, Sherman and Albrecht (1942), Salmon (1943), Bowman et al. (1945), and Childs et al. (1946), suggested that soybeans be fried and served with salt as nuts, that bean and meat loaf be prepared and served with parsley, and that beans be used for soups.

Recipes for serving sprouted beans in salads, soups and chop suey also have been made available by Vail (1945) and Beeskaw (1944). Soy flour was used in recipes for cakes, cookies, muffins, and pastry by Bowman et al. (1945), Childs et al. (1946), and Frantz and Simpson (1947).

EXPERIMENTAL PROCEDURE

The aim was to keep the experimental method as simple as possible so that an average Indian homemaker, teacher, or pupil can understand and follow the procedure. The work was divided into three parts. First, different cooking and soaking times for dried red kidney beans, navy beans, soybeans, and split peas were tried. These same legumes were prepared for serving in a variety of ways. In the second part of the work, three methods were used to sprout red kidney beans and two varieties of soybeans. The sprouted beans and sprouts were used in salads, curries and soups. Three varieties of Indian breads, chappatties, parathas, and purees were prepared with different percentages of soy flour substituted for part of whole wheat flour in the recipe comprised the third part of the experiment.

Brown's Best red kidney beans, Bansi soybeans and yellow soybeans were used throughout the experiment. E-Z Cooker split peas and little Daisy navy beans were used in the first part of the work. All legumes except the yellow soybeans were purchased from local stores. The yellow soybeans were purchased in Kansas City, Missouri.

The Preparation of Dried Legumes

Method of Cooking. All kinds of legumes were treated alike. For each experiment 50 grams or approximately one-fourth cup of legumes were weighed, examined and washed. For some experiments beans were soaked and for others soaking was omitted, but all were cooked on a gas range until tender. Pans of uniform size were used for soaking and cooking. Three hundred and fifty milliliters or approximately one and one-half cups of water were used for soaking and cooking the legumes. The legumes were drained and weighed after each soaking and cooking period, and the volume of the remaining water was recorded. The following variations were used for the study:

1. Legumes were cooked in tap water.

2. Legumes were soaked in tap water for 2 hours prior to cooking.

3. Legumes were soaked in hot water, which had been boiled 30 minutes for 2 hours. The same boiled water was used for cooking.

4. Legumes were soaked overnight in tap water, washed and cooked in fresh water.

5. Legumes were soaked overnight in tap water and salt was added to the legumes and water in the beginning of the cooking period.

6. Legumes were soaked in tap water containing one-

eighth teaspoon of sodium-bicarbonate for 2 hours, and were rinsed in tap water and cooked in tap water.

7. Legumes were cooked without soaking in tap water to which one-eighth teaspoon of sodium-bicarbonate was added.

The tests used for determining the degree of tenderness were subjective. The legumes were (1) pricked with a fork, (2) pressed between the thumb and the index finger, and (3) tasted and chewed. A panel of four judges tasted the beans and scored them for aroma, appearance, flavor, and texture. Form 1 was used for scoring all the products prepared in this study.

Dishes Prepared From Dried Legumes. Salads, soups, and curries were prepared from the dried legumes. Recipes for these are given in the Appendix. For curried beans, tumeric, garlic, onion, paprika, black and red pepper were browned in one tablespoon of hydrogenated fat on a low flame. Then previously soaked legumes were added and cooked until tender. At the end of the cooking period, tomatoes, salt, and molasses were added and cooking continued for 10 minutes.

Salads. Beans were soaked for 14 hours and cooked until tender. The hard cooked diced eggs, celery, onions, and chopped sweet pickles were blended with beans, salt, and mayonnaise. The salad was garnished with paprika and parsley before serving.

Soups. The beans were soaked overnight and cooked with diced celery and chopped onions until they became tender, then

tomatoes were added and the cooking continued. The whole product was put through a sieve, seasonings were added and the soup was simmered for 10 minutes.

Sprouted Beans

Methods of Sprouting Beans. Yellow and Bansi soybeans and Brown's Best red kidney beans were sprouted. The following three methods were used for sprouting all three kinds of beans.

1. The flower pot method with sawdust from Williams (1947).

2. The burlap bag method from Everson et al. (1944).

3. The germinating chamber method from Beeskaw (1944).

The Flower Pot Method With Sawdust. Sawdust was sifted twice through a coarse sieve. A medium size flower pot was washed and sterilized with boiling water. The beans were examined and chipped, split, or broken beans were discarded. Twenty-five grams of beans were weighed, washed in tap water, and let stand for 5 minutes. The beans that floated were removed and the rest were soaked in 150 milliliters of tap water for 15 hours. After soaking the beans were washed again.

Sawdust was dampened so that when a handful was squeezed, a small amount of water ran out. A layer of sawdust 2 inches deep was placed in the bottom of the pot and after that layers of beans and sawdust were placed alternately about one inch

apart to within an inch and a half of the top of the flower pot. The pot was then filled with sawdust extending in a convex manner above the rim of the pot. The pot was then placed on a small bowl, which was 2 inches high and inverted in a large pan. Water was poured into the pan up about one and one-half inches on the side of the small bowl, thus leaving the hole of the flower pot free for circulation of the air. Two large dish towels were then thoroughly dampened, folded and placed over the flower pot, extending the edges into the water all around. The water in the pan was changed every morning. Room temperature ranged from 65° F. to 80° F.

Burlap Bag Method. A burlap bag was soaked in water for 4 hours to loosen the dirt. Then it was washed with a brush and soap and rinsed several times in hot water. Finally boiling water was poured over the bag to sterilize it. It was then wrung and dried. A dish pan was also thoroughly washed. The beans were prepared as for the flower pot method and were placed between layers of the damp burlap bag spread in a dishpan. Water was sprinkled every 3 hours from eight o'clock in the morning until six o'clock in the evening. As the experiment was carried on in the research laboratory, the beans could not be watered during the night. Consequently, the beans did not sprout satisfactorily, and the sprouts were found entangled in the meshes of the bag. When the beans were removed from the bag, the sprouts broke.

It was decided that this method could be improved. Using

somewhat the same technique a modification of the method was developed. Old flour sacks, dish towels, and a cake rack were used in addition to the above equipment. The beans were picked, washed, and soaked as mentioned before. The cake rack was placed on the dish pan. The old flour sacks, dish towels, and the burlap bag were dipped in water and wrung to squeeze out the water. Half of the burlap bag was spread on the rack, then a layer of dish towel was spread over the bag and the beans were placed evenly on the towel. After this the cloth and beans were spread alternately. The other half of the burlap bag was spread on top of the entire setup. Water was then poured into the dishpan up to about three inches below the rack. The edges of the burlap bag and dish towels were immersed in water on both sides of the rack. Thus, the beans were kept damp and air circulated freely around them. Water in the dishpan was changed every morning. The temperature of the room varied between 70° F. and 80° F. Still the sprouts were not yet entirely satisfactory. Yellow soybeans became soft after soaking so it was decided that soaking be eliminated. Beans were picked, washed, and placed to sprout following exactly the same method. This improved the sprouts and increased the yield.

The Germinating Chamber. A germinating chamber was constructed from an old orange crate. The chamber was 12 inches long, 8 inches wide and 10 inches deep. Holes were made in the bottom piece, and the sides were nailed to the bottom leaving

a narrow crevice to facilitate drainage. Beans were selected, measured in a measuring cup, washed and soaked for 8 hours as recommended by Beeskaw (1944). They were then placed in the chamber which was covered with a cardboard. The chamber was placed on two bricks, one 3 inches high and the other 2 inches high. Thus, the chamber was kept in a slanting position to allow complete drainage of water. The beans were watered every 4 hours for the first 36 hours by pouring water into the chamber until it was about one inch deep. The water was completely drained in about five minutes. During the later part of the sprouting period, a clothes sprinkler was used to gently sprinkle the young sprouts. The chamber was kept in the basement of the Margaret Ahlborn Lodge where the temperature ranged from 70° F. to 80° F.

Preparation of Sprouted Legumes

Salads. In the beginning the sprouts were separated from the beans and served in salads. A long time was required to separate all the sprouts from the beans. Since the beans could not be wasted, they had to be prepared separately. It was decided that the beans could be served with the sprouts so for the recipes given in the Appendix soybeans were used with the sprouts. For salads they were served raw or cooked three or five minutes. Sprouted red kidney beans when served in the salads were separated from the sprouts and were cooked for 3 min-

utes. To loosen the skins from the beans, they were soaked in hot water at 60° F. for five minutes, then washed several times in water at about 40° F. until all the skins were removed. Salads were made with different combinations of vegetables.

Soups. Sprouts were separated from the beans. Beans, onions, carrots, celery, and tomatoes were cooked for one hour. Then the vegetables were pressed through a sieve with a wooden spoon. Seasonings and sprouts were added and cooked for 10 minutes. For meat soup, one pound brisket was simmered in one quart of water for one and one-half hours. Beans, carrots, and onions were added and cooking was continued for another one hour. The soup was strained, cooled and the fat layer was removed. Next the salt and the sprouts were added and the soup was cooked for another 10 minutes.

Method for Preparation of Curries. The seasonings given in the recipe were well browned in fat, then potatoes (0.75 inch cubes) and sprouted beans were added and fried for about 5 minutes. One hundred milliliters of water was then added and when the beans and potatoes became tender salt and tomatoes were added.

For the meat curry, shoulder lamb chops were cut in small pieces, and fat from the chops was melted and the seasonings were browned in it. The meat was added and cooked in its own juice until all the liquid was evaporated, then the meat was cooked until it was a rich brown in color. Sprouted

beans and 100 milliliters of water were then added and cooked for 30 minutes. At the end of the cooking period salt and tomatoes were added and cooking was continued for another 10 minutes.

Indian Bread

Soy flour containing 40.8 percent protein and 18.3 percent fat was blended with whole wheat flour to make three kinds of Indian bread. Chappatties were prepared with all whole wheat flour and using blends of whole wheat flour and soybean flour in the proportions of 1:1, 2:1, and 4:1 whole wheat flour and soy flour, respectively. Parathas and purees were made from whole wheat flour and soy flour in the ratio of 1:1 and 2:1 whole wheat flour and soy flour, respectively.

Chappatties. One hundred grams of each of the blends of soy and whole wheat flour were kneaded with salt and water until soft, smooth and slightly spongy. The amount of water and salt varied with each blend. For one hundred grams of whole wheat flour 60 milliliters of water and one-fourth teaspoon of salt were used. For blends in the proportions of 4:1, 2:1, and 1:1, the amount of water was 63, 68, and 73 milliliters, respectively. After kneading, the dough was covered with a damp cloth and set aside for one hour. At the end of this period the dough was kneaded again, with just enough water to dampen the hand, and divided into small balls. The balls were

then flattened and rolled into circular sheets about one-eighth inch thick. The skillet was heated and the temperature tested by pouring some dry flour on the skillet. If the flour became brown within 20 seconds, it was considered ready, the chappatti was then put on the skillet. After one minute it was turned and cooked on the other side for about one minute and 50 seconds, then it was turned again and cooked for about one minute and was lightly pressed with a cloth to spread the steam evenly so that the chappatti would puff up like a ball. The chappatties were scored by the palatability committee immediately after they were cooked.

Parathas. The parathas were made from the same dough as chappatties. The dough was divided into small balls, which were flattened and rolled like a chappatti. Melted butter was then spread over the chappatti and its diameter was divided into approximately three parts. One end was folded over the middle piece then the other was folded over this. More butter was spread on the rectangular piece and each end was folded over the center part, one on top of the other. The square was flattened again and rolled until one-eighth inch thick. The heat of the skillet was tested as for the chappatties, and the paratha was cooked first on one side and then on the other for one and one-half minutes. Butter was spread on both sides of the paratha and cooking was continued until it became a golden brown in color. The parathas were scored immediately.

Purees. To prepare the third kind of bread, one table-

spoon of butter was added to the flour mixture then the dough was kneaded as for chappatties. The dough for purees was divided into small balls which were flattened and rolled like a chappatti. Hydrogenated fat was used for deep fat frying purees. To test the temperature of the fat a small piece of dough was placed in it. When the fat did not foam, it was considered ready for frying purees, which were fried until a golden brown in color.

RESULTS AND DISCUSSION

The Preparation of Dried Legumes

Soaking and Cooking. The effect of soaking legumes on the cooking time is illustrated by the data given in Table 1. In general, split peas required the least amount of time to become tender and navy beans, kidney beans, yellow soybeans, and Bansi soybeans followed in the order given. All legumes required less time to become tender when soaked for two hours before cooking than those that were cooked without soaking, but in each case the duration of cooking was in the same order. Legumes were soaked in hot water which had been boiled vigorously for 30 minutes. The cooking time for all the legumes thus treated was reduced about a half hour when compared with the cooking time of the beans which were not soaked, and about 15 to 20 minutes when compared with those soaked in cold water.

The percentage increase in the weight of the legumes during the soaking and cooking period is given in Table 1. When the legumes were soaked over night they increased in weight almost as much as those soaked for two hours and cooked until they became tender. The cooking time of legumes soaked overnight was reduced to less than half the time required when legumes were not soaked at all. For the next experiment the legumes were soaked overnight but salt was added at the beginning of the cooking period. The percentage increase in weight was not altered appreciably, but the duration of cooking time was increased from 3 to 10 minutes for different legumes.

The effect of sodium-bicarbonate on the legumes during soaking and on cooking time was also studied. Legumes were soaked for two hours in water containing one-eighth teaspoon of sodium-bicarbonate. The percentage increase in weight of these legumes was just a little higher than that when the legumes were soaked for two hours in cold tap water. However, the time required for cooking was decreased about 15 to 20 minutes. When legumes were cooked in sodium-bicarbonate solution, the percentage increase in weight was lowest for all kinds of legumes and the least amount of time was required for the legumes to become tender.

The results of this study are similar to those of Greenwood (1935), Snyder (1936), and Lowe (1943). When they did not soak the legumes, a much longer time was required for cook-

ing them. As the duration of soaking time was increased the amount of time required for the legumes to become tender was reduced. The best results were obtained when beans were soaked overnight. They required less time to become tender and remained plump, whole, and light in color. Lowe (1943) used sodium-bicarbonate for soaking and cooking navy beans. She found that the beans became mushy and discolored and were undesirable.

The characteristics of well cooked beans discussed with the judges scoring the beans in this study were:

1. The beans should be thoroughly cooked, for a raw bean taste is very objectionable.

2. Both the interior of the beans and the skins should be tender.

3. The flavor should be distinctive but should not be too strong.

4. If they are to be served without mashing, they should be plump and whole.

Form 1 was used to score the legumes for palatability. Average scores for a panel of four judges are given in Table 2. The legumes that were soaked over night and cooked in salt water were scored desirable to very desirable in every respect. The beans cooked by other methods were scored acceptable to desirable except for those cooked in sodium-bicarbonate solution. These beans had become soft and were discolored, consequently they were scored from slightly undesirable to acceptable in every respect.

Table 1. Average cooking time and average percentage increase in weight of legumes during soaking, and during soaking and cooking.

Variations	Cooking time		Percentage increase in weight	
	hrs.	min.	During soaking	During soaking and cooking
Cooked without soaking				
Kidney beans	2	38		120
Navy beans	2	29		122
Yellow soybeans	2	35		118
Bansi soybeans	3	5		116
Split peas		55		113
Soaked for 2 hrs. previous to cooking				
Kidney beans	2	24	68	125
Navy beans	2	14	74	128
Yellow soybeans	2	22	62	122
Bansi soybeans	2	55	42	119
Split peas		43	40	115
Soaked for 2 hrs. in preboiled hot water				
Kidney beans	2	2	74	138
Navy beans	2		81	140
Yellow soybeans	2	5	69	134
Bansi soybeans	2	35	50	128
Split peas		30	60	120
Soaked overnight				
Kidney beans	1	10	125	156
Navy beans	1	4	127	158
Yellow soybeans	1	13	122	152
Bansi soybeans	1	35	124	141
Split peas		25	114	132
Soaked overnight and cooked with salt				
Kidney beans	1	20	120	153
Navy beans	1	13	166	155
Yellow soybeans	1	20	136	150
Bansi soybeans	1	42	124	139
Split peas		28	108	132

Table 1. (concl.).

Variations	Cooking time		Percentage increase in weight	
	hrs.	min.	During soaking	During soaking and cooking
Soaked for 2 hrs. with sodium-bicarbonate solution				
Kidney beans	2	4	70	127
Navy beans	2		76	131
Yellow soybeans	2	7	68	125
Bansi soybeans	2	45	58	123
Split peas		36	44	118
Cooked with sodium-bicarbonate				
Kidney beans		55		116
Navy beans		49		118
Yellow soybeans		58		109
Bansi soybeans	1	5		111
Split peas		20		106

Table 2. Average palatability scores for legumes prepared under various conditions.

Variations	Aroma (10)	Appearance (10)	Flavor (10)	Texture (10)	Total (40)
Cooked without soaking					
Kidney beans	5.5	6.2	5.0	5.5	22.2
Navy beans	6.0	6.1	5.5	5.9	23.5
Yellow soybeans	5.3	5.8	5.2	5.3	21.4
Bansi soybeans	5.7	5.9	5.4	5.3	22.3
Split peas	6.0	6.1	5.6	6.2	23.9
Soaked for 2 hrs. previous to cooking					
Kidney beans	5.8	6.7	5.4	5.8	23.7
Navy beans	6.3	6.4	5.9	6.0	24.6
Yellow soybeans	5.9	6.0	5.5	5.6	23.0
Bansi soybeans	6.1	6.2	5.7	5.8	23.8
Split peas	7.3	6.2	5.8	6.5	25.8
Soaked for 2 hrs. in preboiled water					
Kidney beans	6.3	7.1	6.0	6.3	25.7
Navy beans	6.7	6.9	6.4	6.3	26.3
Yellow soybeans	6.4	6.5	6.1	5.1	24.1
Bansi soybeans	6.8	6.7	6.0	6.2	25.7
Split peas	7.5	7.0	6.3	6.9	27.7
Soaked overnight					
Kidney beans	7.9	8.9	8.3	9.0	34.1
Navy beans	8.1	9.9	8.5	9.3	34.9
Yellow soybeans	8.3	8.9	9.4	8.1	34.7
Bansi soybeans	8.1	9.1	8.3	9.1	34.6
Split peas	7.9	8.0	8.7	8.9	33.5
Soaked overnight and cooked with salt					
Kidney beans	8.1	9.0	8.7	9.1	34.9
Navy beans	8.3	9.1	9.0	9.4	35.8
Yellow soybeans	8.4	9.1	8.6	9.5	35.6
Bansi soybeans	8.2	9.2	8.8	9.3	35.5
Split peas	8.1	8.5	9.1	9.0	34.7
Soaked for 2 hrs. in sodium-bicarbonate					
Kidney beans	5.9	7.1	5.9	6.2	25.1
Navy beans	6.5	7.0	6.1	6.3	25.9
Yellow soybeans	6.1	6.5	5.8	5.9	24.3
Bansi soybeans	6.6	6.6	5.9	6.1	25.2
Split peas	7.4	6.4	6.1	6.9	26.8

Table 2. (concl.).

Variations	Aroma (10)	Appearance (10)	Flavor (10)	Texture (10)	Total (40)
Cooked with sodium-bicarbonate					
Kidney beans	4.1	4.3	4.5	5.1	18.0
Navy beans	4.2	4.6	4.4	5.2	18.4
Yellow soybeans	5.1	4.8	4.6	5.0	19.7
Bansi soybeans	5.2	4.6	4.4	5.3	19.5
Split peas	4.0	4.1	4.1	4.9	17.1

Products Prepared from Kidney Beans and Soybeans. After the first part of the study was complete, four Indian students along with three American judges were asked to score the products. Cooked bean salad, soup, and curried beans were served. Average palatability scores for these products are given in Table 3.

Cooked bean salad was a new dish for the Indian students. Scores given in Table 3 show that there was little difference in the judges' rating of the soybean and the kidney bean salads. The soup was prepared with soybeans and red kidney beans. Both types of beans were soaked overnight and cooked until tender. The original recipe called for hard cooked eggs and lemon slices but the judges did not care for the appearance of this soup. Thus, tomatoes were used in the soup and eggs and lemon were eliminated. This improved the product. Soybeans when cooked tasted like nuts but unlike the other legumes these could not be pressed through a sieve and made into

a smooth paste. Small granules were formed which gave a grainy appearance to the soup. However, this was not objectionable and both kinds of soup were scored very desirable in every respect, except for the texture of soybean soup which was scored desirable.

Curried Beans. Red kidney beans and soybeans were curried and molasses and tomatoes were added. Some of the judges had never tasted curried beans. The judges preferred kidney beans to soybeans. Soybeans always retained a grainy texture which was different from other legumes. This might have been one of the reasons why the Indians did not find their texture and flavor very desirable. The addition of tomatoes and molasses rendered the product desirable.

Salted Beans. Soybeans were soaked overnight and excess moisture was removed by tossing the soybeans in a dish towel. They were browned in a skillet with a little butter. The browned beans tasted like nuts. Salt and a few drops of lemon juice improved the taste. The salted beans were scored very desirable.

Table 3. Average palatability scores for products prepared from legumes.[1]

Products	Aroma (10)	Appearance (10)	Flavor (10)	Texture (10)	Total (40)
Cooked soybean salad	9.2	9.0	8.9	8.8	35.9
Cooked red kidney bean salad	8.8	8.7	8.0	8.3	33.6
Curried soybeans	8.6	8.4	7.9	8.1	33.0
Curried kidney beans	9.0	9.0	8.8	8.6	35.4
Soybean soup	8.8	8.8	8.9	8.4	34.1
Kidney bean soup	9.1	8.9	8.9	8.8	35.7
Salted soybeans	9.1	9.0	9.0	8.7	35.8

[1] See Appendix for exact ingredients used. page 76.

Sprouted Beans

Flower Pot Method. Fifty gram samples of soybeans and red kidney beans were sprouted by this method. The method was repeated four times with each type of beans. The average weight of soybean sprouts obtained was 17 grams and that of red kidney bean sprouts was 19 grams. The length of sprouts for both kinds of beans ranged from one to four and one-half inches. This method was rejected for the following reasons:

1. It was hard to know whether the beans had sprouted or not unless the top layer of saw dust was removed.

2. The sprouts were not even in length. The sprouts in the top layer were from one to one-half inches long and those at the bottom had started roots on them and were about three to four inches long.

3. It was a tedious job to separate the beans and sprouts from the saw dust.

4. The beans were discolored and the color could not be completely removed even after washing the beans several times.

5. After every sprouting period, the saw dust had to be spread on a newspaper to dry so that it may not become moldy. It blew all over the floor. Therefore, it was decided that an average homemaker will not take the trouble to sprout the beans if this method were recommended.

Burlap Bag Method. This method was unsatisfactory when the directions of Everson et al. (1944) were followed. The experiment was carried on in the research laboratory so the beans could not be watered every four hours. Consequently the results were poor and the beans did not sprout properly. Using somewhat the same technique a modification of the method was developed, which gave more satisfactory results. The modification of this method is given in the experimental procedure.

The data given in Table 4 indicate that soaking decreased the percentage of sprouts obtained from a given weight of soybeans. However, this was not true for kidney beans. When the beans were soaked prior to sprouting, the percentage of long sprouts of red kidney beans, yellow soybeans and Bansi soybeans

Table 4. The percentage of sprouted beans obtained from soaked and nonsoaked dried kidney beans and two varieties of dried soybeans when sprouted by the burlap bag method.

Beans soaked before sprouting	Percentage of: Long sprouts (1½" to 2½")	Short sprouts (1" to ½")	Beans that did not sprout
Kidney beans	80	15	5
Yellow soybeans	60	20	20
Bansi soybeans	65	23	12
Beans not soaked before sprouting			
Kidney beans	64	24	12
Yellow soybeans	84.5	8.5	7
Bansi soybeans	94.5	3.7	1.8

was 80, 60, and 65, respectively, and the percentage for short sprouts was 15, 20, and 23. Twenty percent of yellow soybeans, 12 percent of Bansi soybeans, and five percent of red kidney beans did not sprout at all. When soaking was eliminated the percentage of long sprouts of the red kidney beans was reduced to 64. But the percentage of sprouts for yellow soybeans increased to 84.5, and that of the Bansi soybeans increased to 94.5. The percentage of short sprouts for these beans in the same order was 24, 8.5 and 3.9. The percentage of red kidney beans that did not sprout was increased to 12, but for yellow soybeans and Bansi soybeans was reduced to 7 and 1.6, respectively.

The Germinating Chamber Method. One cup or 180 grams of Bansi soybeans were soaked in four cups of water for 8 hours at 70° F. to 80° F. Then these beans were washed and put in the wooden germinating chamber which was covered with a cardboard. At first the beans were watered every 4 hours day and night for the first 36 hours. Later the beans were watered every 4 hours from 6 o'clock in the morning until 11 o'clock at night for the first 36 hours, then they were watered every 6 to 7 hours. On sprouting the beans increased in volume and weight and they were ready to use after 68 hours. The experiment was repeated five times. The data given in Table 5 show the percentage increase in weight and volume of the beans on sprouting. At the end of the sprouting period one cup of soybeans had increased 400 percent in volume and 208 percent in weight. After the skins of the beans were removed the beans had gained 157 percent of the original weight. The beans were clean and shining and the sprouts were straight.

This method is recommended for the larger families. The wooden chamber can be constructed easily and in summer an earthenware pot with small holes may be used for sprouting legumes.

Preparation of Sprouted Beans and Bean Sprouts. Americans have a way of serving raw vegetables with salad dressing which makes the vegetables palatable. Many vegetables which the Indians do not think of eating raw, become acceptable and even delicious when served with salad dressing. The recipes used

in this study for preparing salad dressing are given in the Appendix. Mayonnaise should be served while fresh. In the hot and warm climate of India and in the absence of refrigerators mayonnaise will not keep well. The recipe for mayonnaise can be reduced to half or doubled according to the size of the family and the group served. French dressing is made easily and is desirable if a simple dressing is needed. During the season when lemons are available, lemon juice, salt, and pepper may be used. The amount of red pepper may be increased in the recipe. In this study red pepper was served separately so that Indian students could add it to their salad whenever they desired.

Many different combinations of vegetables were used in this study so that people in India may be able to make salads throughout the year. The data given in Table 5 show that the judges found the flavor of raw red kidney bean and soybean sprouts desirable. There was not much difference in scores given for different combinations of vegetables or in the raw or cooked sprouted beans and sprouts. The sprouted beans and sprouts were served raw in some salads on one day and were cooked for 3 to 5 minutes and served in the same recipe on another day. The average score for flavor of raw and cooked beans did not differ much from day to day, but when cooked and raw sprouted beans were served at the same time there was a slight preference for the cooked sprouted beans and sprouts. Raw sprouted beans were served in gelatin salads. One of these

was scored the most desirable, average score for this was 38.2.

Sprouted soybeans fried in a skillet with a little butter until they were a golden brown were served with salt and sometimes a few drops of lemon juice. The data given in Table 6 show that these salted sprouts were desirable in flavor and texture and very desirable in aroma and appearance.

Soups are not served a great deal in India, but some families and institutions serve soups before dinner during the winter months. Soups are also served to invalids and convalescents. In this study sprouted beans and sprouts were used in meat and vegetable soups. The sprouts were separated from the beans and the beans were cooked for an hour with the stock. Ten minutes before the soup was served the sprouts were added to the soup. The sprouts added a new flavor, desirable appearance and texture. Both kinds of soups were scored very desirable in all factors.

Almost all foods consumed in India are highly seasoned. Vegetables and meats are curried for all main meals. In this study sprouted beans were cooked with meat, potato, and tomato curry. The meat curry was not tasted by two of the Indian boys. The palatability scores were slightly higher for the meat curry than they were for the other curries, but as in the other products prepared with sprouted beans and sprouts there was little difference in the scores for the three types of curries. All the seasonings used in India were not available

Table 5. Palatability scores for sprouted bean salads.[1]

Recipe	Types of sprouted beans and sprouts	Aroma (10)	Appearance (10)	Flavor (10)	Texture (10)	Total (40)
1	a. Soy sprouts	9.1	9.5	8.4	9.4	36.4
	b. Red kidney bean sprouts	9.3	9.2	8.9	9.1	36.5
	c. Sprouted soybeans and sprouts	9.5	9.2	8.8	9.2	36.7
2	a. Soy sprouts	8.6	8.9	8.8	9.3	35.6
	b. Red kidney bean sprouts	8.8	9.0	8.9	9.1	35.8
	c. Sprouted soybeans and sprouts	9.1	9.2	8.8	8.9	36.0
3	a. Raw sprouted beans	9.1	9.3	8.7	9.3	36.4
	b. Sprouted beans cooked 5 min.	9.6	9.6	9.3	9.5	38.0
4	Raw sprouted beans	9.6	9.0	8.7	9.2	36.5
5	Raw sprouted beans	9.2	9.3	9.1	9.4	38.0
6	a. Raw sprouted beans	9.1	9.0	9.2	9.4	36.7
	b. Sprouted soybeans cooked 3 min.	9.3	9.3	9.4	9.6	37.6
7	a. Yellow soybeans	9.0	9.1	8.9	9.0	36.0
	b. Bansi soybeans	9.3	9.2	9.3	9.4	37.2
8	a. Sprouted beans without soaking, raw	9.2	9.1	8.8	8.9	36.0
	b. Sprouted beans without soaking, cooked	9.3	9.4	9.3	9.2	37.2
	c. Navy bean sprouts	8.9	8.8	8.5	8.9	34.1
9	Gelatin salad with sprouted beans	9.3	9.5	9.3	9.6	37.7
10	Raw sprouted beans	9.1	9.5	9.2	9.2	37.0
11	Raw sprouted beans	9.3	9.2	9.2	9.1	36.8
12	Gelatin salad with sprouted beans	9.4	9.7	9.4	9.7	38.2

[1] See page 78 in Appendix for exact ingredients used.

Table 6. Palatability scores for other sprouted bean products.[1]

Product	Aroma (10)	Appearance (10)	Flavor (10)	Texture (10)	Total (40)
Salted sprouts	9.1	9.0	8.7	8.6	35.4
Potato and sprout curry	9.1	8.7	9.0	8.9	35.7
Meat and sprout curry	9.3	9.1	9.3	9.3	37.0
Tomatoes and sprout curry	9.3	9.0	8.6	9.0	35.9
Vegetable soup with sprouts	9.1	8.9	9.2	9.0	36.2
Meat soup with sprouts	9.3	9.1	9.3	9.1	36.8

[1] See page 76 in Appendix for exact ingredients used.

so some things had to be omitted and others were used to the best advantage.

Bread. There are three kinds of breads commonly used in India. Chappatti is called by different names in different parts of the country. In north India chappatties are made with whole wheat flour alone, but in other parts of the country where wheat is not easily available and is not as cheap, flours of other grains are mixed with whole wheat flour. This bread is used for almost all meals, is prepared fresh for every meal, and is usually served as soon as it is ready. It is prepared by kneading flour and salt (salt is optional) with water to the desired consistency. Some people prefer thin small chappatties, some thick and large chappatties. There

are many different methods used for cooking chappatties but only the two most commonly used by a homemaker are discussed here. Chappatties are cooked on iron tawa (a kind of a griddle with a slightly concaved bottom). The tawa may be heated over a wood, charcoal, or coal fire. After both sides of the chappatti are slightly cooked on the tawa, it is put directly on the charcoal and both sides are thoroughly broiled for one to two minutes. The chappatti puffs up like a ball. In the second method the chappatti is cooked on a tawa only. During cooking the chappatti is pressed gently with a cloth until the steam is distributed evenly throughout the chappatti. The chappatti again puffs up like a ball. The chappatties made by this method are usually not as soft and tender as those cooked directly on charcoal. For this study, since the chappatties could not be cooked on the gas flame, the cooking was done on a skillet.

The second kind of bread used in India is parathas. These are made like chappatties except that the dough is richer and instead of cooking them like a chappatti they are cooked in a skillet with a little fat to fry the outer layers. The parathas are usually served for breakfast and for special dinners. Purees are a third kind of bread still richer than parathas. As stated previously, these are fried in deep fat.

In India more than half of the meal consists of bread, and breakfast is usually bread only. It is very important that the protein, fat, vitamins and minerals of the bread be in-

creased. The nutritive value of soy flour has been discussed in the review of literature. For this study whole wheat flour and soy flour were mixed together in the proportions of 1:1, 2:1, and 4:1 parts of whole wheat and soy flour, respectively, for preparing chappatties. As the data in Table 7 indicate, more liquid was required for the doughs containing soy flour than for the dough containing all whole wheat flour, and still more liquid was required for the doughs containing higher proportions of soy flour. For 100 grams of whole wheat flour 60 milliliters of water were required. For 100 grams of the mixtures of whole wheat flour and soy flour in the proportions of 4:1, 2:1, 1:1, the amount of water required was 63, 68, and 73 milliliters, respectively. Bowman et al. (1945) and Childs et al. (1946) found that more water was required for low fat soy flour than for high fat soy flour.

When the same amount of salt was used for the various proportions of whole wheat and soy flour, the bread containing a higher percentage of soy flour tasted flat. Childs et al. (1946) recommended that seasoning or flavoring be increased when soy flour is used. The amount of salt used for whole wheat flour and for the blends of whole wheat flour and soy flour ranged from $\frac{1}{4}$ teaspoon to $\frac{1}{2}$ teaspoon.

When the chappatties were cooked on the skillet which was hot enough for the chappatti containing the lower portion of soy flour, it was found to be a little too hot for a

chappatti containing a higher percentage of soy flour. The data in Table 7 show that the cooking time was less for chappatties containing higher proportions of soy flour than it was for those containing four parts whole wheat flour to one part soy flour. This was also true for parathas and purees fried in deep fat. Childs et al. (1946) discovered that lower oven temperatures should be used for soy flour products than for wheat flour products as soy flour browns quickly.

The average scores of the palatability committee for the three kinds of Indian bread made with blends of whole wheat flour and soy flour are given in Table 8. Chappatties made with four parts of whole wheat flour to one part of soy flour were scored the same as those made with all whole wheat flour. Chappatties made from the other two ratios of whole wheat flour and soy flour were scored desirable by most of the judges, but at first were said to have a slightly bitter taste. One judge described the flavor of all the chappatties as "fishy". The Indian judges considered the flavor of soy flour similar to that of basen, a grain with which they are familiar.

In order to introduce soy flour into India it is advised that smaller proportions of the flour be mixed with whole wheat flour until the people get used to its taste. This study shows that whole wheat flour and soy flour may be used successfully in all ratios tried for three breads.

Table 7. Average amount of water and salt used in chappatties for 100 grams of blends of whole wheat flour and soy flour and the cooking time required for each product.

Proportions of whole wheat flour and soy flour	Amount of water for each 100 grams flour	Amount of salt for each 100 grams flour	Time for cooking on each side
Whole wheat flour	60 mil.	¼ tsp.	1 min. 55 sec.
4 part:1 part	63 mil.	¼ tsp.	1 min. 53 sec.
2 part:1 part	68 mil.		1 min. 44 sec.
1:1	73 mil.	½ tsp.	1 min. 37 sec.

Table 8. Average palatability scores for Indian breads.

Variations	Aroma (10)	Appearance (10)	Flavor (10)	Texture (10)	Total (40)
Chappatties					
Whole wheat	9.4	9.2	9.3	9.4	37.3
4:1	9.4	9.4	9.4	9.0	37.2
2:1	8.8	9.1	8.8	9.1	35.8
1:1	8.2	8.8	7.8	8.6	33.4
Parathas					
4:1	9.5	9.6	9.5	9.6	38.2
2:1	9.2	9.5	9.3	9.4	37.4
1:1	9.0	9.1	9.0	9.0	36.1
Purees					
2:1	9.5	9.6	9.5	9.4	38.0
1:1	9.5	9.5	9.3	9.4	37.7

SUMMARY

The work in this study was divided into three parts. The first part included the preparation of five kinds of dried legumes, navy beans, kidney beans, two varieties of soybeans, yellow and Bansi, and split peas. Kidney beans and soybeans were also served in salads, soups and curries. For the second part, the two varieties of soybeans and kidney beans were sprouted and served in various dishes. Whole wheat flour and soy flour blends were used for Indian breads in the proportions of 1:1, 2:1, and 4:1, respectively, for the third part.

The dried legumes were cooked or soaked and cooked until they became tender, and the duration of cooking time was recorded. Seven variations were used. The legumes were cooked without soaking. They were soaked in tap water and in hot water, which had been boiled for 30 minutes, for 2 hours previous to cooking. They were soaked overnight and cooked with and without salt. The legumes were soaked for 2 hours with sodium-bicarbonate, and were also cooked with sodium-bicarbonate. All the legumes required a longer cooking time when they were not soaked previous to cooking. When legumes were soaked for 2 hours the cooking time was reduced from 15 to 20 minutes and when they were soaked in hot preboiled water the cooking time was further reduced. Best results were obtained when legumes were soaked overnight. They were whole

and plump and the cooking time was reduced to about half the time required to cook legumes when they were not soaked. In general, split peas required the least amount of time to become tender and navy beans, kidney beans, yellow soybeans and Bansi soybeans followed in the order given. When sodium-bicarbonate was used for cooking, the beans became soft and were discolored.

The beans were served in cooked bean salad; these salads were scored from desirable to very desirable. When soups were made with kidney beans and soybeans the kidney beans were easily made into a smooth paste but the soybeans remained grainy. However, this was not objectionable. The judges scored the soups from desirable to very desirable. The beans were also curried and molasses and tomatoes were added to improve the color and flavor. The red kidney beans were scored slightly higher than soybeans which were scored desirable in every respect.

For the second part, two varieties of soybeans, yellow and Bansi, and red kidney beans were sprouted. The burlap bag method and germinating chamber method of sprouting were used. The kidney beans were always soaked prior to sprouting. Eighty percent of the beans had sprouts 1½ to 2½ inches long; 15 percent had shorter sprouts, and 5 percent of the beans did not sprout at all. Soaking was eliminated for the two varieties of soybeans because only 60 percent of yellow soybeans and 65 percent of Bansi soybeans had long sprouts and 20 and 23 percent short sprouts, respectively. When soaking was

eliminated the percentage of sprouted beans increased to 84.5 for long sprouts and decreased to 8.5 for short sprouts for yellow soybeans and 94.5 and 3.7, respectively for the Bansi soybeans.

The germinating chamber method was used with success and is recommended for large families and groups. The beans should be watered regularly to obtain satisfactory results. When this method was used the beans increased 400 percent in volume and 208 percent in weight, the sprouts were straight and beans were clean and shiny. The sprouted kidney beans and soybeans were served in salad with various vegetable combinations. The beans were served both raw and cooked. The judges scored all the salads from desirable to very desirable. Beans were cooked with meat, potato, and tomato curries. The scores for the meat curry were slightly higher than those for the other curries, but curries were scored desirable to very desirable.

Three kinds of Indian breads, chappatties, parathas and purees were prepared using whole wheat and soy flour blends in the proportions of 1:1, 2:1, and 4:1, respectively. When soy flour was used, salt and liquid were increased as the amounts of soy flour in the blend increased. The temperature of the skillet for chappatties and parathas and of the fat used for frying purees was a little lower than the temperature used for whole wheat flour alone. Chappatties were best when whole wheat flour and soybean flour were used in the proportions of

4:1, respectively. For parathas and purees the blend in the ratios of 2:1 and 1:1 were used successfully.

A panel of seven judges, four Indians and three Americans scored the products. Since these products were considered desirable by Indian judges, it is hoped that more beans can be consumed in India, especially dried soybeans, sprouted soybeans and soybean flour because these are the richest sources of nutrients among plant foods which can be used in India.

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REFERENCES

Ahmad, B.
The vitamin C value of some common Indian fruits, vegetables and pulses by the chemical method. Indian Jour. Med. Res. 22: 789-799. 1935.

Ascham, L., and J. A. LeClerc.
The availability of iron in various food. Jour. Nutr. 13: 425-436. 1938.

Aykroyd, W. F.
The nutritive value of Indian foods and the planning of satisfactory diets, 3rd ed. Health Bul. No. 23. Government of India Press. New Delhi, India. 1941.

Bailey, L. H., and J. A. LeClerc.
The composition and characteristics of soybeans, soybean flour and soybean bread. Cereal Chem. 12: 441-449. 1935.

Baily, W. M.
Structural and metabolic after-effects of soaking seeds of phaseolus. Bot. Gaz. 94: 688-713. 1933.

Baked beans a meat substitute? Consumers Research Bul. 16: 7-8, 1945.

Barnes, Richard H. and Jean E. Maack.
The Hormel Institute of the University of Minnesota. Review of literature on the nutritive value of soybeans. University of Minnesota. 1943.

Beeskaw, Herbert C.
Bean sprouts: Their preparation and properties. Mich. Agr. Expt. Sta. Tech. Bul. 184. June, 1943.

Beeskaw, Herbert C.
Bean sprout production in the home. Mich. Agr. Expt. Sta. Tech. Quart. Bul. 26: 346. 1944.

Berezeller, Laslo.
It began in Vienna. The soybean Digest. 4: 4, March, 1944.

Bowman, Ferne, Leta Maharg, Margaret Mangel, and Maxine McDivitt. Culinary preparation and use of soybeans and soybean flour. Miss. Agr. Expt. Sta. Bul. 485. 1945.

Burkholder, Paul R.
Vitamins in edible soybeans. Science. 98: 188, 1943.

Cahill, William M., Laurence J. Schroeder, and Arthur H. Smith. Digestibility and biological value of soybean protein in whole soybean flour and soybean milk. Jour. Nutr. 28: 207. 1944.

Cheldelin, Beron H., and Robert L. Lane.
B. vitamins in germinating seeds. Proceedings of the Society for Experimental Biology and Medicine. 54: 53. 1943.

Chick, H., and E. M. Delf.
The antiscorbutic value of dry and germinated seeds. Biochem. Jour. 13: 199-218. 1919.

Childs, Margaret M., Elizabeth Gruginskis Addition and Mabelle S. Ehlers. Soybeans and soybean products in quantity cookery. Mich. Agr. Expt. Sta. Cir. Bul. 204. 1946.

Delf, E. M.
Studies in experimental scurvy with special reference to the anti-scorbutic properties of some South African foodstuffs. Lancet. 1: 576-579. 1922.

Djou, Y. W.
Studies on the production of soybean and mung bean sprouts. Lingnan Science Jour. 16: 627-628. 1937.

Edwards, T. I.
Relations of germinating soybeans to temperatures and length of incubation time. Plant Physiology 9: 1-30. 1934.

Everson, G. J., H. Steenbock, D. C. Cederquist, and H. T. Parsons. Effect of germination, the stage of maturity, and the variety upon the nutritive value of soybean protein. Jour. Nutr. 27: 225. 1944.

Everson, G. J., and Ada Heckert.
Biological values of some leguminous sources of protein. Amer. Dietet. Assoc. Jour. 20: 81. 1944.

Eyster, H. C.
Conditioning seeds to tolerate submergence in water. Amer. Jour. Bot. 25: 33-36. 1938.

Eyster, H. C.
Cause of decreased germination of bean seeds soaked in water. Amer. Jour. Bot. 27: 652-659. 1940.

Frantz, Royene D., and Jean I. Simpson.
Effectiveness of fat in soy flour as a shortening agent. Food Res. 12(6). 1947.

French, Cyrus E., George H. Berryman, John T. Goosley, Harold A. Harper, Daniel M. Harkness, and Edward J. Shacker.
The production of vitamins in germinated peas, soybeans, and other beans. Jour. Nutr. 28: 63-70. 1944.

Gerolt, F. V.
Report of the Commissioner of Patents, Agriculture. 33 Congress, 1st Session, House of Representatives. Ex. Doc. No. 39, Part 2, 222. 1853.

Gloyer, W. D.
Sclerema and hard shell, two types of hardness of beans. Proc. Assoc. Offic. Seed Analysts of North America. 11-21. 1921.

Greenwood, Mary L.
Pinto beans, their preparation and palatability. New Mexico Agr. Expt. Sta. Bul. 231. May, 1935.

Grow fresh vegetables. Better Homes and Gardens, 28: 8. 1928.

Hafenrichter, A. L.
Respiration of the soybean. Bot. Gaz. 85: 271-298. 1928.

Hayward, J. W., and F. H. Hafner.
The supplementary effect of cystine and methionine upon the protein of raw and cooked soybeans as determined with chicks and rats. Poultry Sci. 20: 139. 1941.

Honeywell, E. M., and H. Steenbock.
The synthesis of vitamin C by germination. Amer. Jour. Physiol. 70: 322-332. 1924.

Horvath, A. A.
Soyflour as a rational food. Sci. Monthly. 33: 25-26. 1931.

Horvath, A. A.
Acceptance of soyflour depends on correct processing. Food Indus. 7: 15-16. 1935.

Johns, C. O., and A. J. Finks.
The nutritive value of soybean flour as a supplement to wheat flour. Amer. Jour. Physiol. 55: 455. 1921.

Johnston, L. M., H. T. Parsons, and H. Steenbock.
The effect of heat and solvents on the nutritive value of soybean protein. Jour. Nutr. 18: 423. 1939.

Johnston, G. H., L. Schaner, S. Rapaport, and H. J. Daniel, Jr.
The effect of cooking with and without sodium-bicarbonate on the thiamine, riboflavin, and ascorbic acid content of peas. Jour. Nutr. 26: 227-239. 1943.

Jones, D. Breese, and J. P. Divine.
The protein nutritional value of soybean, peanut and cottonseed flours and their value as supplements to wheat flour. Jour. Nutr. 28: 41-48. 1944.

Khan, S. N. M.
The finest Indian muslim cooking. London. George Routledge and Sons, Ltd. 1934.

Kidd, F. and C. West.
The influence of temperature on the soaking of seeds. New Phytol. 18: 35-39. 1919.

Kon, S. K., and Z. Markuze.
Biological values of the proteins of breads baked from rye and wheat flours alone or combined with yeast or soybean flour. Biochem. Jour. 25: 1476. 1931.

Lantz, Edith M.
Effect of different methods of cooking on the vitamin B_1 content of pinto beans. New Mexico Expt. Sta. Bul. 254. 1938.

Laughland, J., and D. H. Laughland.
Effect of age on the vitality of soybean seed. Sci. Agr. 20: 236-237. 1939.

Lee, Foo Hing.
Bean sprouts as sources of vitamin C. Unpublished Master's thesis. Kansas State College, Manhattan, Kansas. 1936.

Lowe, Belle.
Experimental cookery, 3rd ed. Chicago: John Wiley. 144-148. 1943.

Lonsbury, T. F.
Kitchen garden with soybeans. Ladies Home Journal. 21: 20-21. 1943.

McCay, O. M.
Sprouted soybeans, N. Y. S. Emergency Food Committee. Nutr. Serv. September, 1943.

Mendel, L. B., and M. S. Fine.
Studies in nutrition. IV. The utilization of the proteins of legumes. Jour. Biol. Chem. 10: 433. 1912.

Miller, C. D., and D. B. Hair.
The vitamin content of mung bean sprouts. Jour. Home Econ. 20: 263-271. 1928.

Harasinga, Ras., K. K. P. and Kanala Bhagnat.
Vitamin C in germinating grains. Ind. Jour. Med. Res. 30: 493-504. 1942.

Nauhauer, Maria.
Das vitamin C in der Pflanze Protoplasma. 33: 345-370. 1939.

Niyogi, S. P., N. Narayana, and B. G. Desai.
Studies in the nutritive value of Indian vegetable foodstuffs. Ind. Jour. Med. Res. 18: 1217-1229. 1931.

Osborne, T. B., and S. H. Clapp.
Hydrolysis of glycinin from the soybean. Amer. Jour. Physiol. 19: 468. 1907.

Osborne, T. B., and L. B. Mendel.
The use of soybean as food. Jour. Biol. Chem. 32: 32-369. 1917.

Reid, M. E.
Localization of ascorbic acid in the cow pea plant at different periods of development. Amer. Jour. Bot. 24: 445-447. 1937.

Salmon, W. D.
Soybeans for human food. Jour. Home Econ. 35: 4. 1943.

Santos, F. O.
Some plant sources of vitamin B and C. Amer. Jour. Physiol. 59: 310-334. 1922.

Sheets, O., and M. V. Ward.
Studies in nutritional anemia. Miss. Agr. Expt. Sta. Tech. Bul. 26. 1940.

Sherman, H. C.
Chemistry of food and nutrition, 7th ed. New York: Macmillan Co. 601-605. 1946.

Sherman, W. C., C. A. Elvehjem, and E. B. Hart.
Further studies on the availability of iron in biological material. Jour. Biol. Chem. 107: 383. 1934.

Sherman, W. C., and H. R. Albrecht.
Edible soybeans. Alabama Agr. Expt. Sta. Bul. 255. 1942.

Shrewsbury, C. L., and J. W. Bratzler.
Cystine deficiency of soybean protein at various levels in a purified ration and as a supplement to corn. Jour. Agr. Res. 47: 889. 1933.

Simonik, F.
Teneur en Vitamine C des graniesde legumieuses pendant la germination. Compt. rend. Soc. 199: 431-432. 1929.

Smith, M. C., and L. Otis.
Sex variations in the utilization of iron by anemic rats. Science. 85: 125. 1937.

Snyder, Edna B.
Some factors affecting the cooking quality of the pea and great northern types of dry beans. Nebr. Agr. Expt. Sta. Res. Bul. 85. 1936.

Sprague, P. E.
Edible soy flour. Soy Flour Association. Chicago: 22 p. 1940.

Swaminathan, M.
The relative value of the protein of certain foodstuffs in nutrition. The comparative biological values of the proteins of certain cereals, pulses and skim milk powder measured by the growth of young rats. Ind. Jour. Med. Res. 25: 57-79. 1937.

Tilford, P., C. F. Able, and R. P. Hibbard.
An injurious factor affecting the seeds of Phaseolus vulgaris soaked in water. Papers of Mich. Acad. Sco. Arts and Letters. 4: 345-356. 1924.

Vickeny, Hubert Bradford.
Symposium on substitutes for animal protein in nutrition. Introduction and discussion of the amino acid composition of plant seeds. Federation Proceedings. Vol. 3. 1944.

Vail, Gladys E.
Sprouted soybeans. Unpublished. Department of Foods and Nutrition. Kansas State College. 1945.

Voltz, E., R. M. Forbes, W. L. Nelson, and J. K. Loosli.
The effect of soy flour on the nutritive value of the protein of white bread. Jour. Nutr. 29: 269-275. 1945.

Wats, R. C., and W. J. Woodhouse.
Some sources of vitamin C in India. The antiscorbutic value of various kinds of sprouted mung (phaseolus mung) and their extracted juices. Ind. Jour. Med. Res. 21: 467-473. 1934.

Williams, Jo Eloise.
The effect of sprouting and subsequent dehydration of the vitamin content of the pinto bean. Unpublished Master's thesis. University of Texas. Austin, Texas. 1947.

Wiltshire, H. W.
A note of the value of germinated beans in the treatment of scurvy, and some points in prophylaxis. Lancet. 2: 812-813. 1918.

Woodruff, S., and H. Klaas.
A study of soybean varieties with reference to their use as food. Illinois Agr. Expt. Sta. Bul. 443. 1938.

Zahnley, J. W.
Home testing for germination of seed. State Board of Agriculture Report. 41: 5-8. 1932.

Zucker, Theodore F., and Lois Zucker.
Nutritive value of cotton, peanut and soy seeds. Indus. and Engin. Chem. 35: 868. 1943.

APPENDIX

Form 1

Score Card for Legumes

Product _____ Date _____

Samples _____ Judge _____

Key

Very Desirable	10-9
Desirable	8-7
Acceptable	6-5
Slightly Undesirable	4-3
Undesirable	2-1

Score	1	2	3	4
Aroma				
Appearance				
Whole				
Some Unbroken				
Broken				
Mushy				
Plump				
Wrinkled				
Flavor				
Desirable				
Too strong				
Starchy				
Texture				
Too soft				
Tender				
Slightly hard				
Hard				
Skin not noticeable				
Skin barely noticeable				
Skin noticeable				

Comments:

Note: Check (*) the word or words that indicate the reason for your decision.

Dried Bean Products

Cooked bean salad:

Beans	cooked	50 grams
Sweet pickles	chopped	15 grams
Onion	diced	10 grams
Celery	diced	10 grams
Eggs	hard cooked	2
Mayonnaise	to blend	2 tsp.

Combine soybeans, sweet pickles, onions, celery, and diced eggs. Add mayonnaise and mix lightly. Serve on lettuce or other salad greens.

Salted soybeans:

Soybeans	50 grams
Butter	½ tsp.
Salt	¼ tsp.
Lemon juice	a few drops

Soak soybeans overnight. Drain completely and remove excess of moisture by tossing the soybeans in a dish towel. Heat the butter and brown soybeans until golden brown in color. Add salt and lemon juice if desirable and serve while still hot.

Curried beans:

Beans	50 grams
Water	350 mil.
Tumeric	½ tsp.
Garlic	1 flake
Onion	½ small
Black pepper	a few grains
Paprika	¼ tsp.
Red pepper	a few grains
Salt	¼ tsp.
Tomatoes	2 small
Molasses	1 tablespoon
Fat	1 tablespoon

Pick, wash and soak beans overnight. Chop onion and garlic and mix all the ingredients with two tablespoons of water. Heat fat on low flame and cook the ingredients until golden brown. Add beans and cook until tender. Add diced tomato, salt and molasses and continue cooking for another ten minutes.

Bean soup:

Beans	50 grams
Water	400 mil.
Onion	½ small
Celery	1 stalk cut in pieces
Salt	¼ tsp.
Pepper	a few grains
Butter	1 tablespoon
Flour	1 tablespoon
Tomato	1

Pick, wash, and soak beans overnight. Drain and add fresh water. Melt half the butter and add the sliced onion. Fry onions for 5 minutes, add diced celery, and beans with water. Simmer for 1½ hours. Add sliced tomato and cook for another half hour. Rub through a sieve. Add seasoning and bind the soup with remaining butter and flour cooked together.

Sprouted Bean Products

Salads:

The following salads may be served with mayonnaise, French dressing or lemon juice, salt and pepper. It is very important to cut the vegetables shortly before serving the salads, and salad dressing should be added just before the salad is served.

1

Celery	diced	40 grams
Raisins		20 grams
Sprouts		30 grams

2

Cucumber	diced	50 grams
Sprouts or sprouted beans		30 grams
Onions	diced	10 grams

3

Lettuce	chopped	40 grams
Tomatoes	cut in small pieces	30 grams
Green pepper	cut in long thin slices	15 grams
Sprouted beans		30 grams

4

Carrots	grated	40 grams
Cabbage	shredded	30 grams
Celery	diced	20 grams
Onions	diced	10 grams
Sprouted soybeans		30 grams

5

Lettuce	cut in cubes	30 grams
Cauliflower	large flowerets split	30 grams
Tomatoes	cut in large wedges	25 grams
Cucumber	peeled, scored and sliced	30 grams
Radishes	cut and made in roses	3
Sprouted soybeans		30 grams

6

Carrots	grated	30 grams
Raisins		30 grams
Sprouted beans		20 grams

7

Lettuce	shredded	40 grams
Cabbage	shredded	30 grams
Celery	diced	15 grams
Carrots	chopped	15 grams
Onion	diced	10 grams
Green pepper	cut in round slices	10 grams
Sprouted beans		40 grams

8

Carrots	shredded	40 grams
Radishes	sliced	20 grams
Green pepper	chopped fine	10 grams
Sprouted beans		40 grams

9

Gelatin salad

Gelatin	lemon flavored	½ package
Water	hot	1 cup
Carrots	grated	20 grams
Cucumber	diced	20 grams
Celery	diced	10 grams
Radishes	round slices	10 grams
Green pepper	thin long pieces	5 grams
Salt		½ tsp.
Paprika		⅛ tsp.
Sprouted beans		40 grams

When the jello is about to set add the vegetables, place salad in well oiled individual ring molds and chill thoroughly. Turn it out on lettuce leaves.

10

Cucumber	diced	40 grams
Celery	diced	20 grams
Green pepper	chopped	10 grams
Tomatoes	diced large pieces	40 grams
Sprouted beans		40 grams

11

Cabbage	shredded	40 grams
Onions	diced	10 grams
Green pepper	cut in round slices	10 grams
Radishes	cut round	20 grams
Sprouted beans		50 grams

12

Gelatin salad:

Gelatin	lemon flavored	½ package
Carrots	grated	40 grams
Cabbage	shredded	40 grams
Sprouted beans		40 grams

Fried salted sprouted beans:

Sprouted beans	50 grams
Butter	½ tsp.
Salt	½ tsp.
Lemon juice	a few drops

Melt butter and fry sprouted beans until golden brown, add salt and lemon juice, and serve immediately.

Sprouted bean soups:

Meat soup

Brisket	1 pound
Water	2 quarts
Carrots	1
Sprouted beans	50 grams
Onion	1
Tomato	1
Salt	½ tsp.
Black pepper	a few grains

Cut brisket in small pieces. Add water and simmer for 1½ hours. Separate sprouts from the beans and add diced carrots, onions, tomato, and beans to the stock. Cook for another hour. Strain the soup. Cool and remove the fat layer from the top. Add salt and sprouts and cook for another 10 minutes.

Vegetable soup

Onion	1
Carrot	1
Celery	1 stalk
Tomato	1
Sprouted beans	50 grams
Water	350 mil.
Salt	¼ tsp.
Black pepper	a few grains

Cut onion, carrot, celery, and tomato into small pieces. Separate the sprouts from the beans. Cook the vegetables and beans with water for 1½ hours. Press vegetables through a sieve with a wooden spoon. Add seasonings and sprouts. Cook for another 10 minutes.

Sprouted bean curries:

Potato and sprouted bean curry

Sprouted beans	50 grams
Potato	1
Water	100 mil.
Tumeric	½ tsp.
Garlic	1 flake
Onion	½ small
Black pepper	a few grains
Paprika	¼ tsp.
Red pepper	a few grains
Salt	¼ tsp.

Cut potato in 3/4 inch cubes. Chop onion and garlic and mix the ingredients with two tablespoons of water. Heat fat on low flame and cook the ingredients until golden brown in color. Add potato, beans and water. Cook until tender. Add salt and tomatoes and continue cooking for another 10 minutes.

Meat and sprouted bean curry

Sprouted beans	50 grams
Shoulder lamb chop	1
Water	100 mil.

Onion	1 small
Garlic	2 flakes
Tumeric	1 tsp.
Corriander	1½ tsp.
Red pepper	a few grains
Green pepper	1/8
Black pepper	a few grains
Tomato	1
Salt	½ tsp.

Cut the lamb chop in small pieces separate the fat and melt it in a pan. Chop onion and garlic, mix all the ingredients with two tablespoons of water. Cook the ingredients until golden brown. Add the meat and cook until all the liquid is evaporated and the meat is golden brown in color. Add sprouted beans and water. Cook for 30 minutes then add salt and tomato and continue cooking for another 10 minutes.

Tomatoes and sprouted bean curry

Sprouted beans	50 grams
Water	100 mil.
Tumeric	½ tsp.
Onion	1/8
Black pepper	a few grains
Red pepper	a few grains
Salt	½ tsp.
Tomato	1
Fat	2 tsp.

Chop onion and mix all the ingredients with two tablespoons of water. Heat fat on low flame and cook the ingredients until golden brown. Add beans and cook until tender. Add diced tomato, salt and molasses and continue cooking for another 10 minutes.

Breads

Chappatti:

Whole wheat flour	100 grams
Water	60 milliliters
Salt	1/4 teaspoon

Sift the flour and salt once. Add about half the water and knead the dough. Continue kneading the dough with addition of a little water until the dough is smooth, soft and slightly spongy. Cover with a damp cloth and let stand for an hour. Knead the dough again with just enough water to dampen the hand. Divide the dough into small balls. Flatten the ball and roll into circular sheets 1/8 inch thick. Heat skillet and test the temperature by pouring some dry flour on the skillet; if the flour becomes brown within 20 seconds, the skillet is ready. Put the chappatti on the skillet, turn after one minute and cook for nearly 2 minutes. Turn again and press it lightly with a cloth to spread the steam evenly until the chappatti puffs up like a ball.

For blends of whole wheat flour and soy flour in different proportions the amount of liquid and seasonings are increased and cooking time for each side of the bread as the amount of soy flour increases is reduced.

Whole wheat flour	80 grams
Soy flour	20 grams
Water	63 milliliters
Salt	1/4 spoon plus a pinch

Whole wheat flour	66 grams
Soy flour	34 grams
Water	68 milliliters
Salt	1/8 teaspoon

Whole wheat flour	50 grams
Soy flour	50 grams
Water	73 milliliters
Salt	½ teaspoon

Parathas:

For parathas, follow instructions given for chappatties. After the chappatti is rolled, spread one teaspoon of melted butter on it evenly and divide its diameter into approximately three parts. Fold one end over the middle piece then fold the other on top of this. Spread about one-half teaspoon of butter on this rectangular piece and fold each end over the center part. Flatten the square and roll again until one-eighth inch thick.

Heat the skillet and test as for the chappatties. Cook the paratha for one minute on one side, spread butter, turn and spread butter on the other side and cook until both sides are golden brown in color.

Purees:

For purees add one tablespoon of butter to flour and salt and knead the dough as for the chappatties. Divide the dough for purees into smaller balls than for the chappatties. Flatten

the ball and roll into circular sheet until one-eighth inch thick.

Put one cup of hydrogenated fat in a deep pan and heat the fat. To test the temperature of the fat, place a small piece of dough in it. When the fat does not foam, it is ready; put in the puree and fry until golden brown in color.

Salad Dressing

Mayonnaise		
Egg yolk	1	18 grams
Vinegar	1 tblsp.	15 grams
Oil	½ cup	108 grams
Salt	½ tsp.	
Mustard	¼ tsp.	
Paprika	¼ tsp.	
Sugar	½ tsp.	

Put the egg yolk in a small bowl, add the seasonings and the vinegar, and beat with a rotary egg beater. It may be necessary to tilt the bowl or the egg beater first, in order that the egg beater blades may come in contact with the small amount of material. Add the oil in small quantities at first, about ½ teaspoon, then in larger quantities as the emulsion is formed.

French dressing

Salad oil	1 cup	216 grams
Vinegar	½ cup	
Paprika	1 tsp.	
Sugar	1 tsp.	

Put ingredients into a quart fruit jar or a large glass stoppered bottle. Shake vigorously just before using as this dressing separates after standing a few minutes. It requires shaking each time before it is used.