AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch #14

1. SUBJECT CLASSIFICATION

A. PRIMARY
Agriculture

AQ10-0336-0000

B. SECONDARY
Food processing--Oil crops--Soybean

2. TITLE AND SUBTITLE
Roasting of soybeans as a processing technique

3. AUTHOR(S)
Badenhop,A.F.; Wilkens,W.F.; Bourne,M.C.; Hackler,L.R.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1968	10p.	ARC 664.33.B134d

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Cornell

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*
(In Frontiers in Food Research Sym. Proc.,p.53-62)

9. ABSTRACT

10. CONTROL NUMBER
PN-RAA-659

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Roasting
Soybean

13. PROJECT NUMBER

14. CONTRACT NUMBER
CSD-1815 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

664.33
B134d

Proceedings of the Frontiers in Food Research Symp
June 11-12, 1968.

ROASTING OF SOYBEANS AS A PROCESSING TECHNIQUE

A. F. Badenhop, Post-doctorate Fellow, W. F. Wilkens, Assistant Professor,
M. C. Bourne, Associate Professor, and L. R. Hackler, Associate Professor
Food Science and Technology
New York State Agricultural Experiment Station
Cornell University
Geneva, N.Y.

The processing operation of roasting as applied to peanuts, tree-nuts, coffee, and other products includes a rapid dehydration followed by a partial pyrolysis. The process is carried out mainly for the desirable flavor changes which it produces in the product. In some cases the process also imparts other beneficial changes, such as improved texture and color. Also, as in the roasting of soybeans, the process may improve nutritional quality by destroying substances such as antitrypsin.

There are at least two types of roasting processes. The simplest and most direct form is often termed "dry roasting" and involves heating of the product in air and/or a mixture of gases from the heat source. Dry roasting is employed in the coffee and cocoa processing industries, to a considerable extent in the peanut processing industry, and to some extent in the tree-nut processing industry. The other type involves the heating of the product in an oil or fat and is often termed "oil roasting" or "deep-fat frying." Oil roasting is used extensively in the peanut and tree-nut processing industries, as well as in other industries such as the potato chip processing industry.

In the case of peanuts and other tree-nuts, a desirable texture can be achieved merely by roasting the shelled raw product without any pre-treatment other than perhaps a preliminary drying or curing operation or, in some cases, a blanching operation to loosen and remove skins or hulls. The roasting of soybeans without some pre-treatment results in a product with an extremely hard texture.

The roasting of soybeans is not a new process. Soybeans have been roasted for centuries in Japan for the production of kinako. Kinako was originally made in the home by roasting soybeans in an earthenware pan over an open flame. The resulting roasted beans were then ground into a powder which was used as a coating on or ingredient in other foods (1).

In this country, considerable attention was directed toward the soybean as a source of food during the early 1940's, when, due to the effects of World War II, various sources of high-protein food were quickly becoming limited. In this connection considerable work was done on the production of a roasted soy nut which could be salted and consumed as is, like other nutmeats, or utilized in candy products in place of peanuts. The Borden Soy Processing Company used a procedure which involved soaking the beans followed by a dry roasting process in order to produce a soy nut with a desirable tender texture (2). Another product was made by deep-fat frying soybeans which had been subjected to a previous soaking step (3,4).

The present investigations were undertaken in order to evaluate the ef-

fects of roasting on the texture, nutritional quality, and acceptability of soybeans. Both dry and oil roasting methods have been investigated.

DRY ROASTING STUDIES

Sample Preparation

The design of the dry roasting study is shown in Figure 1. Certified

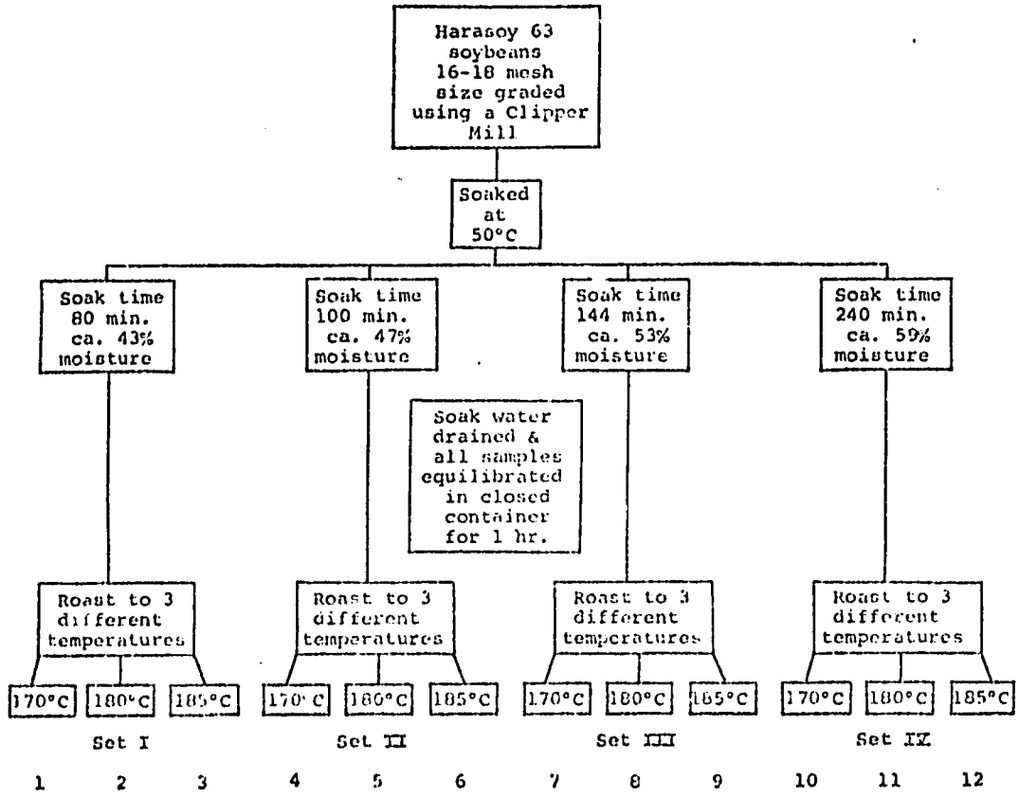


Fig. 1.--Design of dry roasting studies.

seed soybeans of the variety (Harasoy-63) were size graded using a Clipper Mill (Model M-2B), manufactured by the A.T. Farrell and Company, Saginaw, Michigan. This operation was done not only to obtain beans of uniform size, but also as a means of partially cleaning the beans. Only beans which would pass a number 18, but not a number 16, sieve were used. These sieves contain round holes of 18/64 and 16/64 inch diameter, respectively.

The preliminary soaking step was done at 50°C in order to realize a relatively rapid hydration of the beans without any pre-cooking taking place prior to roasting. The moisture content of the beans was raised to four different levels as indicated, and the equilibration step was included to allow for a uniform moisture level within the beans. Two small, gas-fired, coffee sample roasters, manufactured by the Jabez Burns Company (now part of the Blaw-Knox Corporation), were used for roasting. The temperature of the roaster prior to charging was approximately 400°C.

The end points of the roasting operation were determined by means of a

glass thermometer held in the product during the final minutes of roasting. Thermocouples were also positioned in the roasters so that they were constantly surrounded by the tumbling product. These thermocouples were connected to a recorder in order to give an indication of the time-temperature relationship throughout the roasting operation. An examination of a set of the thermocouple traces for six batches of sample No. 4, shown in Figure 2, from 90°C to the end point of the roast shows that a nearly straight line relationship appears to exist to approximately 134°C, at which point the rise in temperature becomes more and more rapid with time. A possible explanation for this is that below this break point the amount of water evaporating from the product is sufficient to keep the rate of temperature rise constant, while above this point the product has lost sufficient moisture so that the rate of temperature rise is no longer linear.

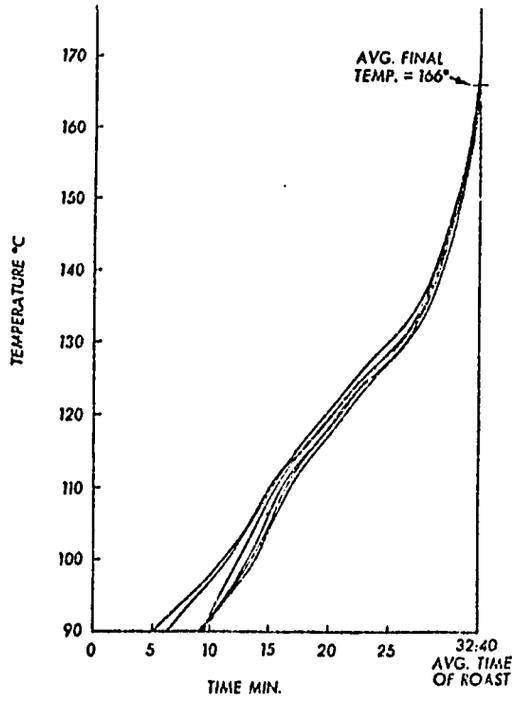


Fig. 2.--Time-temperature curves of six batches of sample #4 (170°C roast from an ingoing moisture level of 47.9%).

In order to preserve a relatively constant time-temperature product for all of the sample sets with different ingoing moisture levels, the size of the batches was adjusted to give a relatively constant weight of ingoing moisture in each batch. In this manner the times of roast for the four sets of samples were approximately equalized. Table 1 shows the comparison of the samples from the four different moisture levels which were roasted to identical final temperatures.

As can be seen, samples (1, 2, and 3) from the lowest moisture level contained the smallest weight of moisture per batch and also required the least amount of roasting time. The product temperature for the samples was determined by dumping batches from the samples containing the highest and lowest

Table 1.

Sample No.	Final Temperature	Wt of Sample Batch g	% Ingoing Moisture (as is basis)	Wt of Moisture per Batch	Roasting Time Min.	Sec.	Product Temperature
1	170	1163	43.5	505.9	30	23	159
4	170	1117	47.9	535.0	31	53	--
7	170	1019	53.1	541.2	31	33	--
10	170	918	59.1	542.5	31	58	160
2	180	1163	43.5	505.9	31	10	167
5	180	1117	47.9	535.0	31	34	--
8	180	1019	53.1	541.2	32	40	--
11	180	918	59.1	542.5	32	13	168
3	185	1163	43.5	505.9	31	40	174
6	185	1117	47.9	535.0	32	53	--
9	185	1019	53.1	541.2	32	18	--
12	185	918	59.1	542.5	32	40	175

per cent ingoing moisture into a Dewar flask and recording the highest temperature attained. From the table it is apparent that the final temperature, i.e., the temperature reading used to determine the end point of the roast was higher in each case than the temperature measured in the Dewar flask. Also, it is evident that, although the final temperatures show a 10-degree difference between the low and middle roast and a 5-degree difference between the middle and high roast, the product temperatures for these samples show a range of 8 degrees between low and middle and 7 degrees between the middle and high roasts.

Color Measurement

Figure 3 shows the color of the 12 samples expressed as the Hunter L value of the whole beans. As expected, the color of the samples within a set shows a darkening with increasing degree of roast. The interesting thing to note, however, is that the samples from the longest soak time (10, 11, and 12) are considerably darker than the other three sets. This may be due to a movement of the soluble carbohydrates to the surface of the bean where considerable caramelization and browning takes place during the roasting operation.

Texture Measurements

Texture measurements were made on the roasted samples using an Instron texture measuring device. The test consisted of measuring the amount of force required to puncture the product using a flat-faced, round punch with a diameter of 1/8 inch. Although little or no difference was observed between samples of a particular set, considerable difference was evident between the samples from the four different sets. Figure 4 shows the distribution of samples from the four different moisture levels with regard to the amount of force required to puncture the beans over the scale from 0 to 5 kg. The figure also lists the per cent of the sample which required more than 5 kg of puncture force. The figure shows rather clearly that the distribution curve is more compressed as the soak time is increased. The amount of the sample requiring more than 5 kg of puncture force also decreases with increasing soak time.

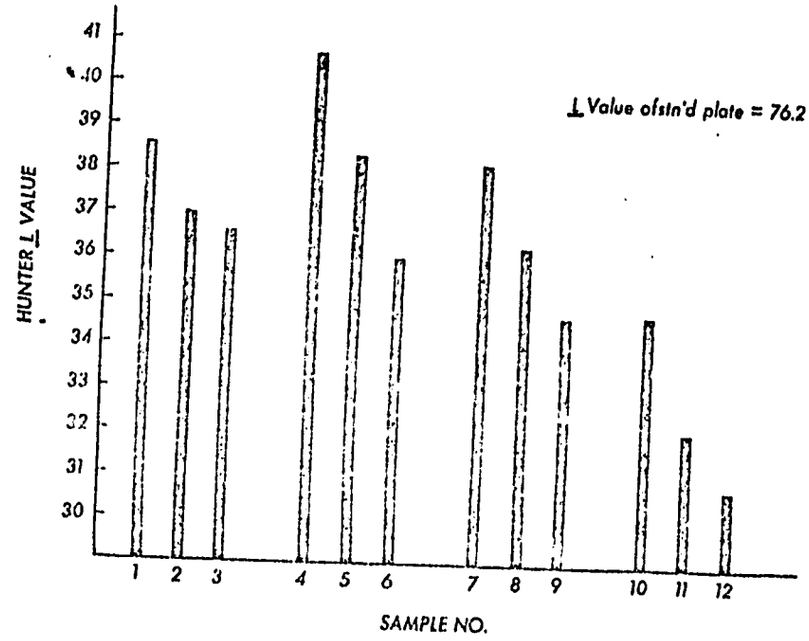
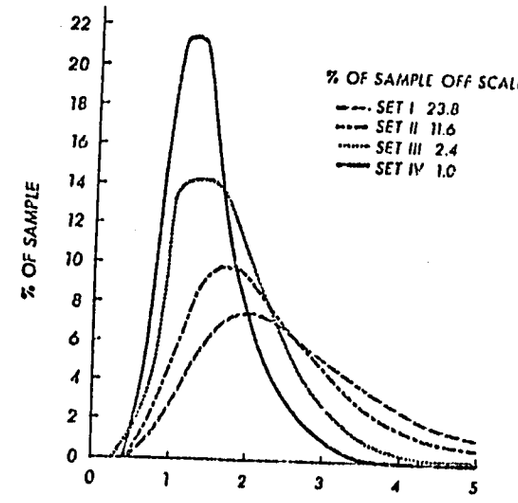


Fig. 3.--Hunter L values for 12 samples of dry roasted soybeans.

Fig. 4.--Graphic comparison of puncture force measurements for dry roasted soybeans.



Bulk Density Measurements

Another indication of the effects of the soaking pre-treatment on the final product may be seen in Figure 5 which shows the bulk density of the samples from the four sets compared with the raw product. Bulk density measurements were conducted by pouring an aliquot from each sample into a container which had a diameter of 4¾ inches, a depth of 2½ inches, and a volume of 538 ml. The samples were poured in until the container over-flowed. The excess was struck-off using a wooden straight edge. Five replications were made for each sample.

An examination of the data from the 12 samples indicated that very little

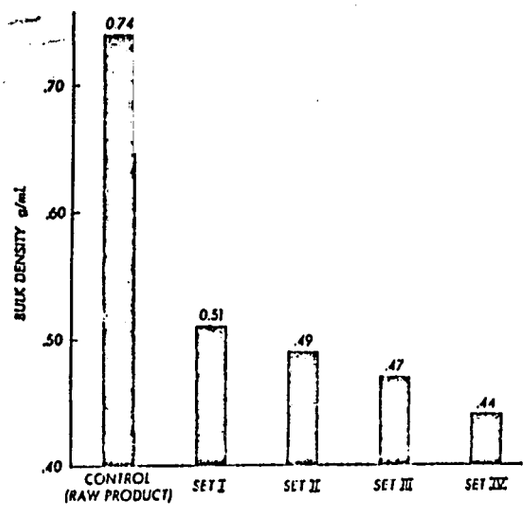


Fig. 5.--Bulk density measurements for dry roasted soybeans.

difference existed among the 3 samples within a particular sample set. Differences were apparent among the four sets of sample. However, examination of the data presented in Figure 5 shows that by increasing the ingoing per cent moisture the bulk density of the final roasted product is decreased. These data compare well with the texture data, since, generally with increasing ingoing moisture level, larger beans were produced which required less puncture force, or, in subjective terms, were more chewable.

Taste Paneling

The 12 samples of dry roasted beans were presented to a taste panel of 15 members which was asked to rank the samples in order of increasing flavor preference and to rate the samples on a scale of 1 to 10. The samples were presented in four sets of three samples each corresponding to the three degrees of roast from each ingoing moisture level. Although none of the four panels showed significant differences at the 5 per cent level, the trend in all of these panels was the same, in that a preference was indicated for the middle degree of roast (180°C).

The four samples which were roasted to 180°C were then presented to the panelists with instructions to again rank them in order of increasing preference and to rate them on a scale of 1 to 10. The results of this panel indicated that sample No. 8 (180°C roast from an ingoing moisture level of 53.1%) was significantly better than the other 180°C samples at the 1 per cent level.

Panelists were next asked to judge the texture of the two best flavored samples. This panel was of triangular design, and the results showed that sample 8 was significantly preferred for texture at the 1 per cent level.

Economics of Production

A determination of the amount of gas required to roast soybeans in the small sample roasters from the highest ingoing moisture level was conducted. A wet test gas meter was connected between the gas source and the burner, and batches equivalent to sample 11 (180°C roast from 59.1% moisture) were roasted. The amount of gas consumed was found to be 3.76 cu. ft. per batch with an average yield of 375.5 gm of roasted beans per batch. Using these figures, the calculated amount of gas required to produce 1 lb. of roasted beans would be approximately 4.55 cu. ft. using the small sample roasters.

OIL ROASTING STUDIES

Sample Preparation

For the oil roasting work a preliminary survey of different soak times and temperatures was conducted in order to find the proper pre-treatment required to produce a desirable product. Soak temperatures of 100, 90, 70, and 50°C were used initially. After soaking, the beans were dehulled by passing them through a Quaker City Mill (Model F No. 4) which had the grinding plates spaced far enough apart to effect a loosening of the hulls from the beans while producing a minimum of damage to the cotyledons. In the oil roasting work, dehulling was desirable in order to avoid the deposition of oil between the hull and the cotyledons. After the hulls were loosened from the cotyledons, they were separated by a water flotation procedure. The cotyledons were then deep-fat fried in corn oil at 190°C. A small deep-fat fryer (Sunbeam, Model TC F-6) was used for the initial work, and a Hotpoint, Model HK-3, deep-fat fryer was used for the preparation of the larger samples.

Texture Data from the Initial Samples

Figure 6 shows the results of texture measurements on the samples of beans which were soaked at the various temperatures for increasing periods of time. All samples were roasted for 3 minutes at 190°C. The test was conducted using an Instron texture measuring device employing a round, flat-faced punch 1/16-inch in diameter to puncture individual cotyledons. The points on the graphs correspond to the average force required to puncture 30 cotyledons from each soak treatment. The graphs show that the higher soak temperatures produce a softening effect on the roasted product in much less time than do the lower temperatures. From the graphs it would appear that a short soak at 100 or 90°C would be the ideal pre-treatment. Such pre-treatments were found to cause considerable difficulty in dehulling, and the texture of the finished product, although soft, was found to become mealy when chewed, causing it to be quite objectionable to a screening panel of four people who sampled the product from the various pre-treatments. Based on the results of the screen-

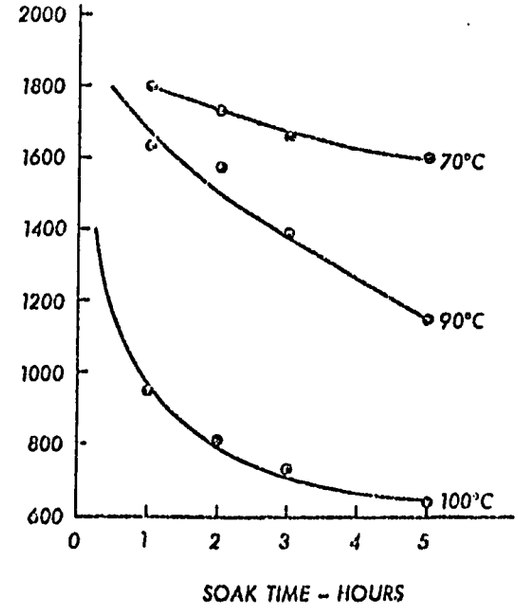


Fig. 6.--Puncture force measurements for oil roasted soybeans.

ing panel, a soak time of 2 hours at 70°C was used in the subsequent experimentation. Such a soaking treatment produced a hydration ratio of approximately 2.30 or a moisture content of approximately 60 per cent. This pretreatment produced a significant decrease in the bulk density from approximately 0.7 for the raw product to approximately 0.4 for the finished product.

Effect of Oil Roast Time on Color and Acceptability

An experiment was next conducted using roasting times of 2, 3, 4, and 5 minutes. A sample of soaked beans was also freeze-dried to be used as a control. Figure 7 shows the effect of roasting time on the resulting color of the whole cotyledons expressed as the Hunter L value. The curve shows the increase in darkness of the beans subjected to longer frying times. The sample roasted for 4 minutes was judged to be superior in flavor by the screening panel.

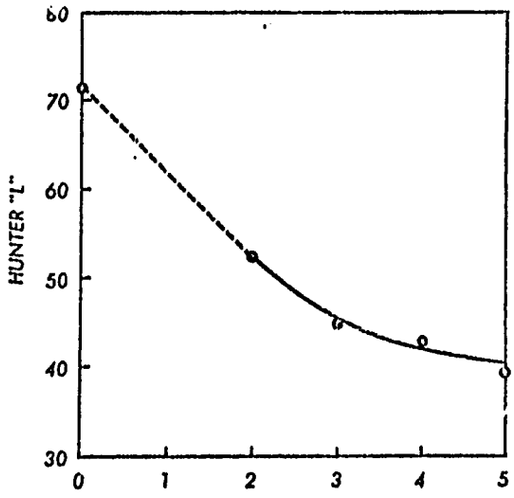


Fig. 7.--Hunter L values for oil roasted soybeans.

Effects of Oil Roasting and Economics of Production

In the process of oil roasting the raw product is subjected to changes other than dehydration and partial pyrolysis due to the nature of the roasting medium. Figure 8 shows the change in per cent lipid with frying time using the unroasted freeze-dried sample for comparison. This graph shows that the amount of lipid contained in the roasted product increases with frying time due to absorption of the corn oil in which the beans were roasted. Figure 9 shows the yield in grams which was obtained for each increasing roasting time. Each point on the graph represents the yield of product resulting from a starting weight of 2 kg of beans. The yield for the unroasted sample indicates the loss in weight due mainly to the removal of the hulls prior to roasting and the initial moisture content of the beans. The total loss in weight was approximately 28 per cent of the original starting material. Approximately 44 per cent of the original weight loss is regained due to the oil which is absorbed during the roasting process.

As in the dry roasting process, the most expensive factor involved would seem to be the removal of the water taken up during the soaking pre-treatment. In each case, the amount of water which is removed to produce 1 lb. of the

finished product amounts to approximately 1.5 lb.

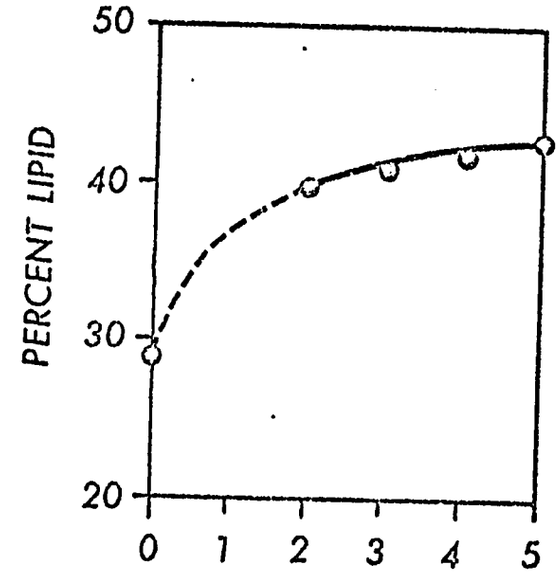


Fig. 8.--Lipid content of oil roasted soybeans.

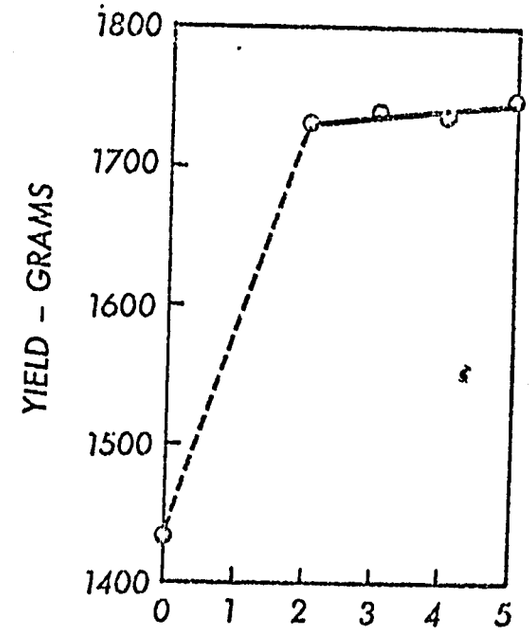


Fig. 9.--Yield of oil roasted soybeans from 2 kg of raw product.

CONCLUSION

The production of a roasted soy nut product by either the dry roasting process or the oil roasting process would seem to be rather expensive in terms of the energy expenditures required. In each case a considerable amount of water must be evaporated during the roasting procedure. In the case of the

oil roasted product, additional energy must be expended in the dehulling operation.

The cost of processing is partially offset, however, by the relatively low cost of the raw product which is between ¼ and ½ the cost of shelled and cleaned peanuts (5).

From a nutritional standpoint, perhaps most important, is the fact that the protein content of soy nuts is approximately 1½ times that of peanuts (6). Studies are presently under way to determine the nutritional value of soy nuts, both in terms of the quantities of the essential amino acids which they contain and the quality of the protein as determined by rat feeding experiments. Studies are also planned for investigation of the volatile components contributing to the flavors formed during the roasting process. These areas of research will be reported later.

REFERENCES

1. Fukushima, D. 1968. Personal communication.
2. Soy Products in the Candy Industry. January 1948. Bordens Soy Processing Co. Soybean Digest.
3. Hale, J.K. 1941. "Soybeans in the Diet." Circular No. 74, The University of Tennessee Agricultural Experiment Station.
4. Blumenthal, S. 1947. "Food Products." Chemical Publishing Co., Inc., p. 335.
5. "Agricultural Statistics." 1966. U. S. Government Printing Office, Washington, D. C. 20402, pp. 132 and 140.
6. Woodroof, J.G. 1966. "Peanuts; Production, Processing, Products." Avi Publishing Co., Westport, Conn.