

SWEET POTATOES AND MUNG BEAN FLOUR AS INGREDIENTS  
IN YEAST BREAD,

by

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## INTRODUCTION

Bread has been man's food for at least 6000 years. It was probably the first processed convenient food ever produced and remains widely acceptable. Today, bread in one form or another is used in almost all the countries of this world. Bread consumption is believed to be increasing at a rate greater than 8 percent per year throughout Africa and at an even faster rate in certain countries of Asia (25). The problem of protein malnutrition, so prevalent in many parts of the world, makes the development of acceptable economical protein rich foods imperative. Because of the unique structural properties of hydrated wheat protein, bread is capable of greatly variable composition and can be fortified with a wide variety of protein, vitamin, and mineral supplements. Therefore, nutrient supplementation of bread would be a convenient means of increasing the nutritional status of some populations.

The sweet potato is a popular food crop in tropical areas and in warm places of the United States (15). It contains a high proportion of carbohydrates and carotenes (1, 15, 18). The sweet potato is a good source of carotene and could help to solve some vitamin A deficiency problems around the world. Some studies have shown that good quality bread could be made by replacement of some of the wheat flour with sweet potato flour (19, 20). However, only a little sweet potato flour has been used by the baking industry, because sweet potato flour has not been a popular product.

Mung beans in various forms are a popular food crop in many Asian countries and they are good protein sources (20 to 27 percent dry basis

content) (17, 45). Mung bean protein is rich in the amino acid lysine (8, 16, 45), one of the amino acid low in wheat products. Studies have shown that bread could be enriched with mung bean flour to increase the protein content of the bread but there were some adverse effects on bread quality (45, 46).

The hypotheses of this study are that a combination of mung bean flour and mashed sweet potato pulp could be substituted for part of the wheat flour in a bread dough to produce higher nutritional value and a good quality bread. The experiment was designed to determine: (1) acceptability of bread made by substituting mashed sweet potato pulp and mung bean flour for part of the wheat flour in a bread dough, (2) which factor (mashed sweet potato pulp or mung bean flour) had a greater effect on the acceptability of different characteristics of the bread, and (3) the percent crude nitrogen, percent crude fat, and moisture content of the baked experimental products.

## REVIEW OF LITERATURE

Significant populations of parts of the world (throughout the Middle East, parts of Africa, Latin America, and Southeast Asia) suffer from a lack of vitamin A (7) and a protein deficiency malnutrition (8, 37). Some food scientists continue trying to improve the nutritional value of a variety of foods by nutrification with added vitamin A, produced by chemical synthesis, in an effort to alleviate this vitamin A deficiency problem among parts of the world population (7). Sweet potatoes have been cited as a good source of vitamin A (1, 12, 18). Food scientists have also worked on fortifying basic food stuffs with protein rich foods or purified amino acids to alleviate protein malnutrition around the world (5, 8, 10, 24, 25, 36).

### Enriched Bread-making

Several researchers have used legumes or oilseeds, untreated and treated, as a replacement of part of the wheat flour in yeast breads in order to increase the protein content. Bacigalupo et al. used cottonseed flour (Protol) (5) and cottonseed protein concentrate (6) and reported that the protein efficiency ratio (PER) was increased from 0.96 to 1.05 with 5 percent Protol to 1.12 with 10 percent Protol, and 1.32 with 15 percent Protol. Harden and Yang (24) liquid cyclone processed cottonseed flour, Yousseff et al. (48) parboiled chickpea flour, Chastain et al. (10) coconut flour, Thompson et al. (45) dehulled mung bean flour, Thompson (46) mung bean protein isolate, Satterlee (42) et al. great northern bean protein isolate, Luh et al. (20) lima bean

protein concentrate and precooked lima bean powder, Khan et al. (26) aqueous processed peanut protein concentrates and Pomeranze et al. (39) germinated soybean flour to improve protein content of breads. Good volume, texture of crumb and of crust, and better shelf life of breads enriched with 5 to 10 percent cottonseed flour (Protol) were reported (5). Overall the acceptable breads could be produced by replacing wheat flour with 10 to 20 percent legume flours or oilseed flours which have higher protein content. Although the increase of loaf volume was reported for bread supplementation with parboiled chickpea flour up to 10 percent, the supplements of liquid cyclone processed cottonseed flour (24), coconut flour (10), dehulled mung bean flour (45), mung bean protein concentrate (46), germinated soybean flour (39), great northern bean protein isolate (41), lima bean protein concentrate and precooked lima bean powder (29), untreated and treated oilseed flours, aqueous processed peanut protein concentrates yielded reduced loaf volume and bread of lower eating quality in general.

D'Appolonia (14) observed that as the legume flour level of the bread dough was increased, dough developing time, stability and bread volume decreased. Matthews et al. (32) suggested that changes in the time and speed of mixing, consistency of dough, fermentation time and proofing time, and levels of some ingredients could improve the quality of breads made with high levels of oilseed flours. Marnett et al. (31) developed several methods for producing good quality soy-fortified bread.

Most of the bread enrichment studies were trying to develop products with a low cost and higher nutritional quality, especially high

in protein content. From these studies, it may be concluded that the supplementation of bread with other nutrient rich foodstuffs could produce a product with higher nutritional value but the quality of bread was often decreased as the supplementation level was increased more than 15 to 20 percent of the weight of wheat flour.

### Sweet Potato

The sweet potato is a perennial plant belonging to the Convolvulace family, that can grow throughout the whole year in the tropics. The sweet potatoes can resist dry weather and can grow on poor and barren land, and produce a considerable yield under such unfavorable conditions (47). The sweet potato is rich in carbohydrates and vitamins, especially carotenes and vitamin C (1, 15, 18), and has a good amino acid pattern, but is limited in the sulfur amino acids (18). In Taiwan, the sweet potato is next to rice in importance as a field crop. It can be grown all the year round and is distributed widely on the main island and the offshore islands. Due to continuous cultural varietal improvement, the yield per hectare of sweet potatoes in Taiwan has been steadily increased since the retrocession of Taiwan in 1945. But 63 percent of the sweet potato harvest is used as feed for animals, 30 percent used as food for people and 7 percent for other purposes (11).

Sweet potatoes contain the essential minerals---potassium, magnesium and phosphorous which stimulate yeast growth and fermentation (12, 18). Less volatile substances produced during the fermentation remain in the final product and contribute to its flavor and aroma (30). Gore (20) found that breads made with 1.5 percent sweet potato flour produced

the best quality bread. Volume of these breads were bigger than that of a control, and the texture, color, and flavor of these breads remained fully up to the standard. Fuente (19) made breads with 5, 10, and 15 percent sweet potato flour and found that 10 percent sweet potato flour gave the best quality. Plaut and Zelzbuch (36) studied the properties of sweet potato flour prepared by different processes and the effect of these flours in bread making. They found that bread made with 6 percent replacement of wheat flour with sweet potato flour was similar in taste, quality, inner and outer appearance to regular white bread, and the volume of the bread made with sweet potato flour was, on the average, 15 percent greater than that of regular bread. They also noticed that the porosity and the water content of the breads made with sweet potato flour were higher than that of regular bread but the protein content was slightly decreased.

Sweet potato flours prepared by different methods from two varieties of sweet potatoes were analyzed by Hamed et al. (22). They analyzed the chemical composition of dehydrated sweet potato flour and compared this to wheat flour. Results indicated that the protein content of the sweet potato flour was lower than that of wheat flour, range from 2.3 to 3.0 percent (N X 5.7) in sweet potato flour; the total amount of carbohydrates, reducing sugars and non-reducing sugars, ash and fiber of sweet potato flour were higher than that of wheat flour. These workers also studied the physical properties of dough mixed with sweet potato flour and wheat flour and found that the addition of sweet potato flour increased moisture absorption, weakened the dough, and decreased dough development and dough stability (23).

Mung Bean

Mung bean or green gram (Phaseolus aureus) is a legume commonly grown in many Asian countries (8, 45). It has 20 to 27 percent protein content (17, 45), and an amino acid pattern comparable to that of soy and kidney beans (16) and of lima beans (29) but has methionine as the first limiting amino acid (17, 45).

Thompson et al. (45) prepared mung bean flour by milling the beans after they were dehulled and conditioned in a Palyi dehulling system. These workers found this mung bean flour as a protein supplement in a wheat flour bread mixture, was acceptable when the level of mung bean flour did not exceed 15 percent. The food value of the flour with respect to both protein content and sensory characteristics was improved by removing the hull before milling. Replacing 15 percent of the wheat flour by mung bean flour resulted in an approximate 10 percent increase in protein content of the bread, and an average of 71 to 72 percent increase in lysine content. D'Appolonia (14) observed the rheological and baking properties of blends which contained 5, 10, and 20 percent of legume flours with a hard spring wheat flour. He found that as the level of legume flour was increased, farinograph dough developing time and stability decreased. He also pointed out that loaf volume of bread decreased as the level of legume added was increased. His study also showed that at the 10 percent level the wheat-mung bean bread was judged by a taste panel as the most satisfactory of the tested legume-wheat breads.

### Sensory Evaluation

Parks et al. (34) used 6 trained judges who scored (a) external characteristics---including lightness, shape, and crust; (b) internal characteristics---including texture, grain, color and flavor for a bread with increased nutritive value. The acceptability of all the breads were considered good (numerical score 79 to 100) by the panel of judges. Chastain et al. (10) used six panelists who were selected by pretesting through triangle and ranking tests to determine the acceptability of enriched coconut breads. The breads were scored for color, grain, texture, flavor and general acceptability by the panel. A 7-point scale was used to score the breads, in which a score of "7" was given to an "excellent" product and "1" to a "very poor" product. A control sample bread was used to compare with the other samples. Each level of coconut bread was judged at least twice.

Okaka et al. (33) used a mixed panel (six Nigerians, two Asians, and four Americans) to score bread enriched with cowpea powder. The breads were evaluated one hour and 24 hours (after baking). A nine point hedonic scale was used to score crust color, crumb color, loaf appearance, flavor, texture and overall acceptance of enriched breads. The results were analyzed statistically and comparisons were made between the mean scores of the Nigerian panelists and all panelists. Collins et al. (13) utilized 10 male panelists from West Africa who were familiar with yam foods to evaluate the dough samples of yam flour enriched with soy flour. A preference test consisting of a 6-point hedonic scale was used to evaluate the samples for an

appearance-kinesthetic quality and then for eating quality. Tests were conducted between 3:00 and 4:00 P.M. in a room designed for sensory testing. Illumination was by cool white fluorescent light at each testing session, three samples were evaluated.

Khan et al. (26) used a six member taste panel to score texture, crumb color, taste and flavor of breads baked with 100 percent wheat flour and that prepared by substituting 20 percent of an oilseed flour for the wheat flour. The flavor and taste detections were made before and after toasting. A hedonic score of 1 to 5 was used; 1 was equal to poor and 5 was equal to excellent. Flavor, texture, color and overall acceptability of breads made with dehulled mung bean flour were tested separately by a ten member taste panel, using a nine-point hedonic scale (45).

These reports indicated that the most popular method for measuring food acceptance was the hedonic scale. Amerine et al. (3) gave a definition of a hedonic scale as a calibrated continuum upon which degree of like and dislike is recorded. The most popular hedonic scale is the nine point scale developed at the Quartermaster Food and Container Institute.

The major advantages of the hedonic scale method are (35):

1. Its simplicity which makes it suitable for use with a wide range of populations.
2. Even the subjects without previous experience can use this method and get meaningful results.
3. The data can be analyzed statistically.
4. Within broad limits the results are meaningful for indicating general levels of preference.

Schutz (43) found that a nine-point quality judgment successive category rating scale (from extremely poor to excellent) gave reliable estimates of food quality using experienced judges on the panel. Some hunger studies indicated that the best test time is three to four hours after meals (3).

## PROCEDURE AND MATERIALS

### Procurement and Storage of Ingredients

Twenty pounds of sweet potatoes were bought from two local grocery stores in Blacksburg, Virginia. One lot was purchased in January; the other in February, 1977. Sweet potatoes were selected from the vegetable counter in the grocery stores. After purchase, they were stored in a dark cupboard at ambient temperature until cooked.

Mung beans (Phaseolus aureus) were bought from a local natural food store in Blacksburg. The whole beans (hull intact) were ground into flour with a Wiley Food Mill and sifted through a 40-mesh screen. The flour was stored in a glass jar at ambient temperature.

Enriched all purpose flour (Gold Medal), non-fat dry milk (Carnation Instant), iodized salt (Morton), shortening (Crisco), granulated sugar (Richfood) and active dry yeast (Fleischmann) were bought from a local supermarket in Blacksburg. The yeast and shortening were stored in their original containers in a refrigerator except when removed for measuring. The sugar was stored in a screw top jar at ambient temperature. The salt and non-fat dry milk were left in their original containers and stored in a dark cupboard at ambient temperature.

### Pretreatment of Ingredients

The sweet potatoes were prepared as follows:

1. They were washed and put into a large sauce pan, then covered with water.
2. They were brought to a boil, then cooked over low heat for about two hours until they were very tender.

3. Next the cooked sweet potatoes were drained and cooled until the skin could be peeled off by hand.
4. The peeled sweet potatoes were mashed with a fork, put into a plastic storage box and stored in a freezer until used in making bread.

### Measuring Ingredients

The mashed sweet potato pulp was thawed before weighing. All the ingredients except the shortening were weighed on a Mettler P1000 balance to the closest 0.1 gram the day before making the bread. The weighed portion of flour was put in a loaf pan (17.5 X 8.0 X 5.5 cm) and covered with a plastic wrap. The non-fat dry milk was put in a measuring cup and covered with a plastic wrap. The other ingredients were wrapped with waxed paper. After weighing, the mashed sweet potato pulp and yeast were wrapped separately with waxed paper and stored in the refrigerator until the next day. The shortening was weighed just before making the bread to avoid oxidation and sticking to the waxed paper. The water used in the bread formula was measured in a graduated cylinder just before making the bread.

### Bread Formula

The formula used for the control (standard) and variations are shown in Table 1. Non-fat dry milk solids were used instead of fresh milk to eliminate possible variation. The proportion of sugar, salt, and liquid used in this study was adjusted to less than usual in a white bread recipe because pilot study work indicated these changes were desirable. Each formula was prepared four times.

Table 1. Bread formula for standard and variations.

Ingredients	Standard	4% Mung bean flour			8% Mung bean flour			16% mung bean flour		
		Sweet potato pulp			Sweet potato pulp			Sweet potato pulp		
		10%	20%	30%	10%	20%	30%	10%	20%	30%
Flour (g)	350	301	266	231	287	252	217	259	224	189
SP <sup>a</sup> (g)	0	35	70	105	35	70	105	35	70	105
MB <sup>b</sup> (g)	0	14	14	14	28	28	28	56	56	56
NFDM <sup>c</sup> (b)	25	25	25	25	25	25	25	25	25	25
Sugar (g)	15	15	15	15	15	15	15	15	15	15
Fat (g)	6	6	6	6	6	6	6	6	6	6
Salt (g)	5	5	5	5	5	5	5	5	5	5
Yeast (g)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Water (ml)	200	180	150	120	180	150	120	180	150	120

<sup>a</sup>Mashed sweet potato pulp

<sup>b</sup>Mung bean flour

<sup>c</sup>Non-fat dry milk

### Mixing Method

1. Each batch of dough was mixed using a K5A Kitchenaid mixer fitted with a dough hook and linked to the power source through a timer. Half of the flour, all of the sugar, salt, yeast, mashed sweet potato pulp, and mung bean flour were put into the mixing bowl. These ingredients were mixed on speed 1 for one minute.
2. The water was heated in a small sauce pan to 87°C to 90°C; then the heat was turned off, and the non-fat dry milk and shortening were added to the hot water and stirred to melt the shortening and dissolve the milk solids.
3. The sauce pan with the milk and shortening was placed in cold water and cooled to 37°C to 40°C.
4. The milk and shortening mixture was added to the dry ingredients in the mixing bowl and mixed at speed 2 for three minutes while most of the remaining flour was slowly added with a spoon.
5. The control was turned to speed 3 and the dough was again kneaded for three minutes, and the last of the flour was slowly added to the mixture with a spoon.

### Fermentation

1. The dough was shaped into a ball, and placed in a large glass bowl which was greased with one gram of shortening. The dough was rolled around the bowl once to grease the entire dough surface, and then the bowl was covered with a wet towel and the dough allowed to rise for half an hour in a warm oven pre-heated to about 35°C.
2. After the half hour fermentation, the dough was kneaded by hands for one minute, the bowl recovered with the wet towel and let rise for another one hour in the warm oven.
3. The dough was kneaded for another one minute, then divided into two equal pieces by weight (Mettler P1000).

### Panning

1. The dough was flattened with a rolling pin into a sheet about 1 cm thick. One end was folded to the center, the other end

folded to overlap and the edges sealed.

2. The shaped dough was placed into a greased loaf pan (17.5 X 8.0 X 5.5 cm), brushed with the remaining shortening in the loaf pan, covered with waxed paper and a wet towel.

### Proofing

The shaped loaf was placed in the still warm oven and let rise about one and a half hours until the loaf volume was doubled.

### Baking

The bread loaf was baked at 400°F for thirty minutes, a piece of heavy duty aluminum foil was used as a cover for the loaf during the last fifteen minutes of baking to protect the crust of the bread.

### Cooling

After the bread was baked, it was removed from the pan immediately and placed on a wire rack to cool to room temperature for further analysis.

## Analysis of The Bread

### Volume

The bread loaf volume was determined by the rapeseed displacement method, using a volumeter. Each loaf was measured separately and the volumes were averaged for each replication.

One loaf of the bread was cut according to the diagram in Figure 1, so that all the judges would have similar pieces of bread to taste

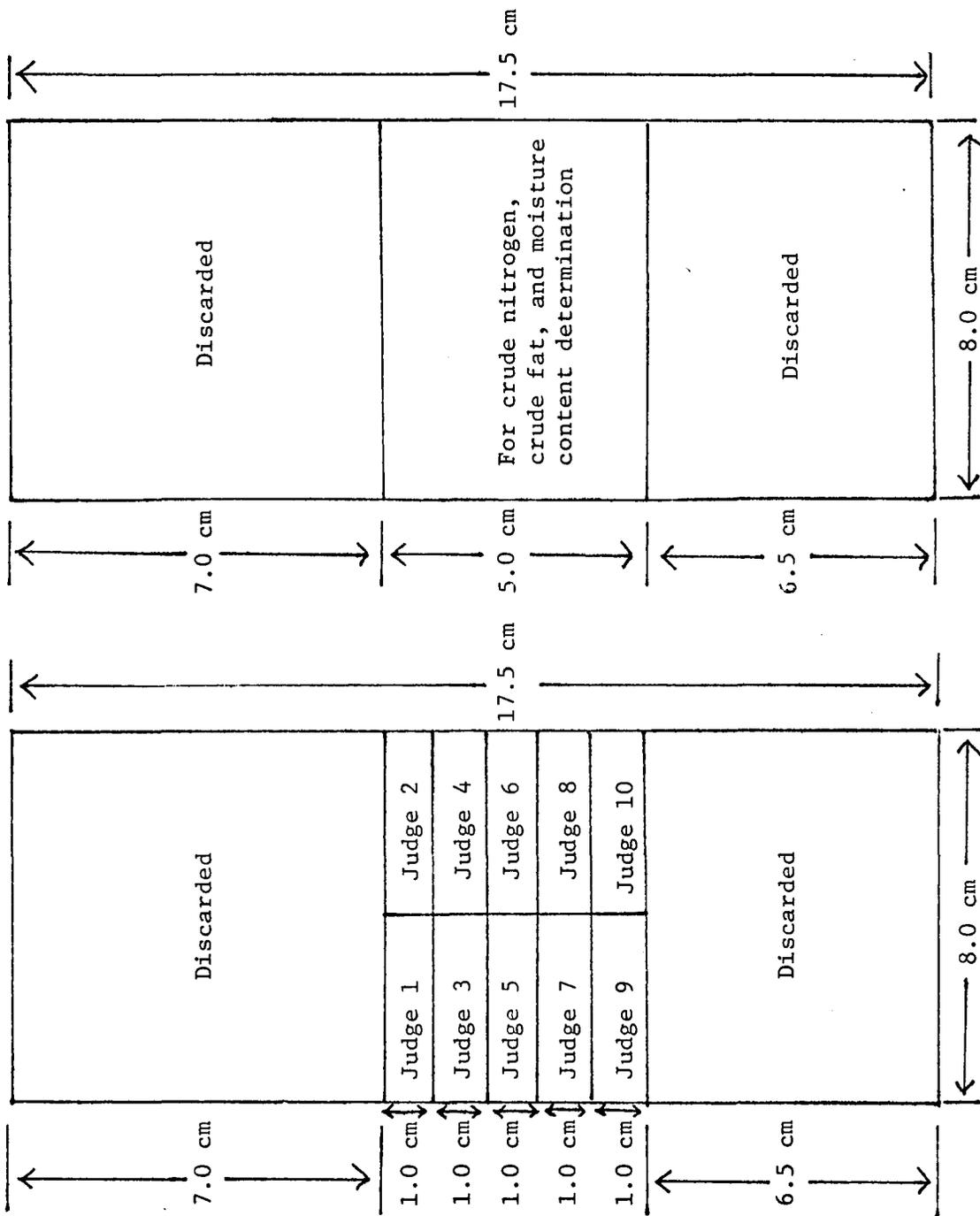


Figure 1. Schematic portioning of bread loaf for subjective and objective measurements.

each time. The same central portion of the other loaf of bread was wrapped in plastic wrap and placed in a plastic storage bag (Ziploc), then placed in a freezer for subsequent fat, moisture and crude nitrogen analysis.

### Sensory Evaluation

The sensory evaluation of this study was designed to determine the acceptability of the breads and the factors involved in this acceptability. Therefore, there were six different sequences of bread combinations as follows:

- Sequence 1: 4% mung bean flour with 10%, 20%, and 30% mashed sweet potato pulp.
- Sequence 2: 8% mung bean flour with 10%, 20%, and 30% mashed sweet potato pulp.
- Sequence 3: 16% mung bean flour with 10%, 20%, and 30% mashed sweet potato pulp.
- Sequence 4: 10% mashed sweet potato pulp with 4%, 8%, and 16% mung bean flour.
- Sequence 5: 20% mashed sweet potato pulp with 4%, 8%, and 16% mung bean flour.
- Sequence 6: 30% mashed sweet potato pulp with 4%, 8%, and 16% mung bean flour.

Each sequence was presented twice to the judges, on different days.

### Taste Panel

A taste panel was formed with ten judges. This taste panel included nine females and one male chosen from the graduate students, and staff of the Department of Human Nutrition and Foods. Most of them had not had previous sensory evaluation experience. An instruction sheet

as developed by Stahl and Einstein (43) was given to each taster with the samples at the first session. In addition, an oral explanation was given to each individual to explain what was expected and how to get the best results.

The taste panel was held between 2:30 and 3:30 P.M. on Tuesday and Thursday afternoons, in a special room designed for sensory evaluation in Wallace Hall at Virginia Polytechnic Institute and State University. A three digit (from 0 to 9) random number was given to each sample. Numerically coded samples were placed on a white plastic plate and presented to the panelists through a specially designed port without disturbing the panelists. A cup of water at room temperature was supplied with the samples to each taster in order to help them clear the mouth between samples. The samples were placed under a cool white fluorescent light.

The panelists used a score sheet based on a nine-point hedonic scale with 1 equal to "dislike extremely" and 9 equal to "like extremely" (see Appendix A). The panelists were asked to score the following characteristics:

External characteristics: color, shape and crust

Flavor: taste and odor

Internal characteristics: texture, lightness, moisture and color

The data was analyzed by using the method of analysis of variance.

## Procedures of Objective Measurements

### Moisture Content

The moisture content of the mashed sweet potato pulp and of the baked bread was determined with a Brabender Moisture Tester. Ten grams of mashed sweet potato pulp or chopped bread were placed in a tared pan; the sample was put into a Brabender Moisture Tester set at 110°C for one and a half hours.

### Objective Measurements of Bread

The breads were chopped with a knife, then a blender before any further objective analysis. The chopped bread pieces (crumbs) were stored in a plastic storage bag (Ziploc) and placed in the freezer. One day before the objective analysis, the chopped samples were taken from the freezer and thawed for twenty four hours in the refrigerator.

### Analysis For Crude Nitrogen Content

The method used for determining crude nitrogen content was a modified Boric Acid Crude Nitrogen Kjeldahl Method (2).

### Digestion

1. Approximately 2 grams of finely ground bread were weighed with a Mettler P1000 balance (to the nearest 0.1 gram), and placed in a 500 ml Kjeldahl flask.
2. One spoon of sodium sulfate-copper sulfate catalyst (about 6 to 7 grams) was added to each flask.
3. 30 ml of concentrated H<sub>2</sub>SO<sub>4</sub> was then added to the contents of the flask, with 5 to 8 pieces of Selenized granules (boiling

chips).

4. The flasks were placed on digestion racks, and heated over low heat until the carbon residue disappeared, then over high heat until the sample became a clear blue color. During digestion, the flasks were rotated once every fifteen minutes to dislodge any particles on the side.
5. When digestion was completed, the heaters were turned off and the flasks were left on the racks to cool.
6. After the samples cooled to room temperature, 250 ml of distilled water was added to each flask.
7. The mixture was then cooled to room temperature.

#### Distillation of Digested Samples

1. A 500 ml Erlenmeyer flask was used to collect the distillate.
2. 25 ml of distilled water plus 25 ml of 4 percent boric acid and 3 drops of methyl red indicator were added to each Erlenmeyer flask.
3. The Erlenmeyer flasks were placed under the distillation apparatus so that the end of the condenser tube was below the surface of the solution. The cooling water in the distillation apparatus and the heater of the distillation racks were turned on.
4. 70 ml of 50% NaOH was slowly poured down the side of the flask so that a layer of the base could form on the bottom.
5. Approximately 1 gram of granular zinc was added to the contents of the Kjeldahl flask.
6. Immediately the Kjeldahl flask was set on the distillation rack and connected to the condenser. Each flask was swirled to mix the two layers.
7. The mixture was distilled until the flask jumped up and down on the rack.
8. The heater was turned off before the condensation tube was taken out of the Erlenmeyer flask. The condenser tube was washed with distilled water.

Tritration

The distillate was titrated with 0.1005N HCl to a faint whitish pink end point. During titration and the distillate was stirred with a Corning PC-353 Stirrer. The percent of crude nitrogen was calculated using the following equation (4):

$$\% \text{ crude nitrogen} = \frac{\text{ml HCl} \times \text{N of HCl} \times 1.4008}{\text{Weight of sample}} \times 100\%$$

Moisture Content Determination

1. The temperature of the Brabender Moisture Tester was set at 110°C, the machine was allowed to run two hours to reach a temperature equilibrium.
2. Two samples 10 grams each were weighed in a marked tared pan.
3. All the samples in the tared pan were placed in the tester. Every ten minutes the percent loss was read until a plateau was reached.
4. For these experimental bread samples, they took about one and a half hours to reach a plateau.
5. The dried bread samples were removed from the tared pan and were placed in an aluminum pan (40 mm X 15 mm). The dried bread samples in the aluminum pan were placed in a dessicator overnight for crude fat determination.

Fat Extraction With Diethyl Ether (  $(C_2H_5)_2O$  )

1. Fat extraction beakers were washed with dishwashing detergent (Dawn) then rinsed thoroughly before using. The washed beakers were put into a drying oven for one hour.
2. Plastic gloves were used to avoid touching the fat extraction beakers because any oil from the hands would be deposited on the beakers.
3. The dried fat extraction beakers were placed in a dessicator and cooled for one hour; then the beakers were weighed with

Mettler H 33 (to the nearest 0.0001 gram).

4. After weighing, the beakers were placed in a drying oven for another one hour, then cooled in a dessicator for one hour. This procedure was repeated until the beakers attained a constant weight.
5. About 3.5 grams of dried bread was weighed with a Mettler H 33 balance to the nearest 0.0001 gram and wrapped with #541 Whatman filter paper.
6. The samples with the filter paper were placed in a fat extraction thimble.
7. The thimble was placed in a glass holder and then attached to a Goldfish Fat Extraction Apparatus.
8. The water cooling system was turned on.
9. Approximately 25 ml of diethyl ether was added to each fat extraction beaker and the beakers were attached to the apparatus.
10. The burners were turned to high and positioned under the beakers. The ether was allowed to boil for thirty minutes.
11. After the ether was boiled for thirty minutes, the heaters were turned off and another 25 ml of diethyl ether was added to each beaker.
12. After the second addition of the ether, the burners were again turned to high and the ether was allowed to boil for three and a half hours to extract all remaining fat from the bread.
13. The burners were turned off and the thimble and holder were replaced with a reclamation tube.
14. Heat was applied until the ether was completely collected.
15. Beakers were placed in the holder and rotated to ensure complete evaporation of the ether.
16. The beakers were then placed in a drying oven for one hour until dry.
17. The beakers were cooled in a dessicator for one hour, then weighed. The percent of crude fat was calculated using the following equation:

$$\% \text{ crude fat, dry basis} = \frac{\text{Amount of crude fat in sample}}{\text{Weight of dried sample}} \times 100\%$$

## RESULTS AND DISCUSSION

### Dough Quality

Mashed sweet potato pulp used in this study contained about 75 percent moisture; therefore, the quantity of water used was adjusted accordingly and thus the total batch weight of the doughs decreased with increased amounts of added mashed sweet potato pulp (Table 2). The total amount of available water was kept constant, because mashed sweet potato pulp had a water content up to 75 percent.

The doughs prepared with the higher amounts (8 and 16 percent) of mung bean flour were sticky and less elastic, probably because the total amount of water used to make these doughs was not adjusted with the addition of mung bean flour. These findings are similar to the results of D'Appolonia (14) who found that the farinograph absorption during blends decreased as the percentage of mung bean flour in the blends was increased. Yousseff et al. (48) also reported that the substitution of chickpea flour for wheat flour resulted in decreased water absorption despite the elevated protein content. In the doughs made with the highest amount (16 percent) of mung bean flour, the bubbles were big and irregularly formed during fermentation. Doughs made with the lowest (4 percent) amount of mung bean flour were more elastic than doughs made with 16 percent mung bean flour which were more sticky and less elastic. These observations were similar to those of Matthews (34) who found that the elasticity of dough decreased with an increased level of oilseed flour replacement. In addition, the doughs made with the highest amount of mashed sweet potato pulp (30 percent) were less elastic than those

Table 2. The mean value<sup>a</sup> of dough weight, bread weight, and baking loss<sup>b</sup> of sweet potato mung bean bread.

	4% Mung bean flour			8% Mung bean flour			16% Mung bean flour		
	Sweet potato pulp			Sweet potato pulp			Sweet potato pulp		
	10%	20%	30%	10%	20%	30%	10%	20%	30%
Dough weight (g)	279.53	265.19	250.35	288.19	226.56	251.06	280.21	265.51	249.00
Bread weight (g)	255.90	239.76	225.44	258.01	241.93	229.25	257.17	243.60	226.84
Baking loss (g)	23.63	25.43	24.91	23.18	24.63	21.81	23.04	21.91	22.16

<sup>a</sup>Mean value of sixteen observations (eight duplicated samples).

<sup>b</sup>Weight loss during baking (dough weight of bread minus bread weight).

made with the lower amounts of mashed sweet potato pulp but they were more elastic than those made with the higher amounts of mung bean flour.

#### Loaf Volume and Baking Loss

The weight loss during baking (dough weight minus baked bread weight) was not significantly different for any of the loaves of bread at any level of added mung bean flour or of added mashed sweet potato pulp. The volume of the breads was decreased with the addition of mung bean flour and with the addition of mashed sweet potato pulp (Figure 2). These decreased volumes were as expected because the added mung bean flour and mashed sweet potato pulp replaced part of the wheat flour. The water insoluble protein of wheat flour hydrates to form gluten during dough mixing (38). Gluten is very important to bread quality and volume because it is the framework of a wheat flour dough and is responsible for gas retention and expansion of the dough (21). The addition of the sweet potato pulp and mung bean flour to the doughs caused further undesirable changes in that the crumb texture was firmer and more compact.

Results in this study were similar to those found by Hamed et al. (23) who showed that the addition of sweet potato flour resulted in a gradually but significant decrease in the loaf volume. However, these coworkers, using only sweet potato flour as a replacement ingredient found that the volume decrease was not great until the amount of sweet potato flour exceeded 15 percent. Hamed et al. (23) also pointed out that the sweet potato flour had no gluten and the starch content was lower than that of wheat flour. In contrast, Gore (20) reported that

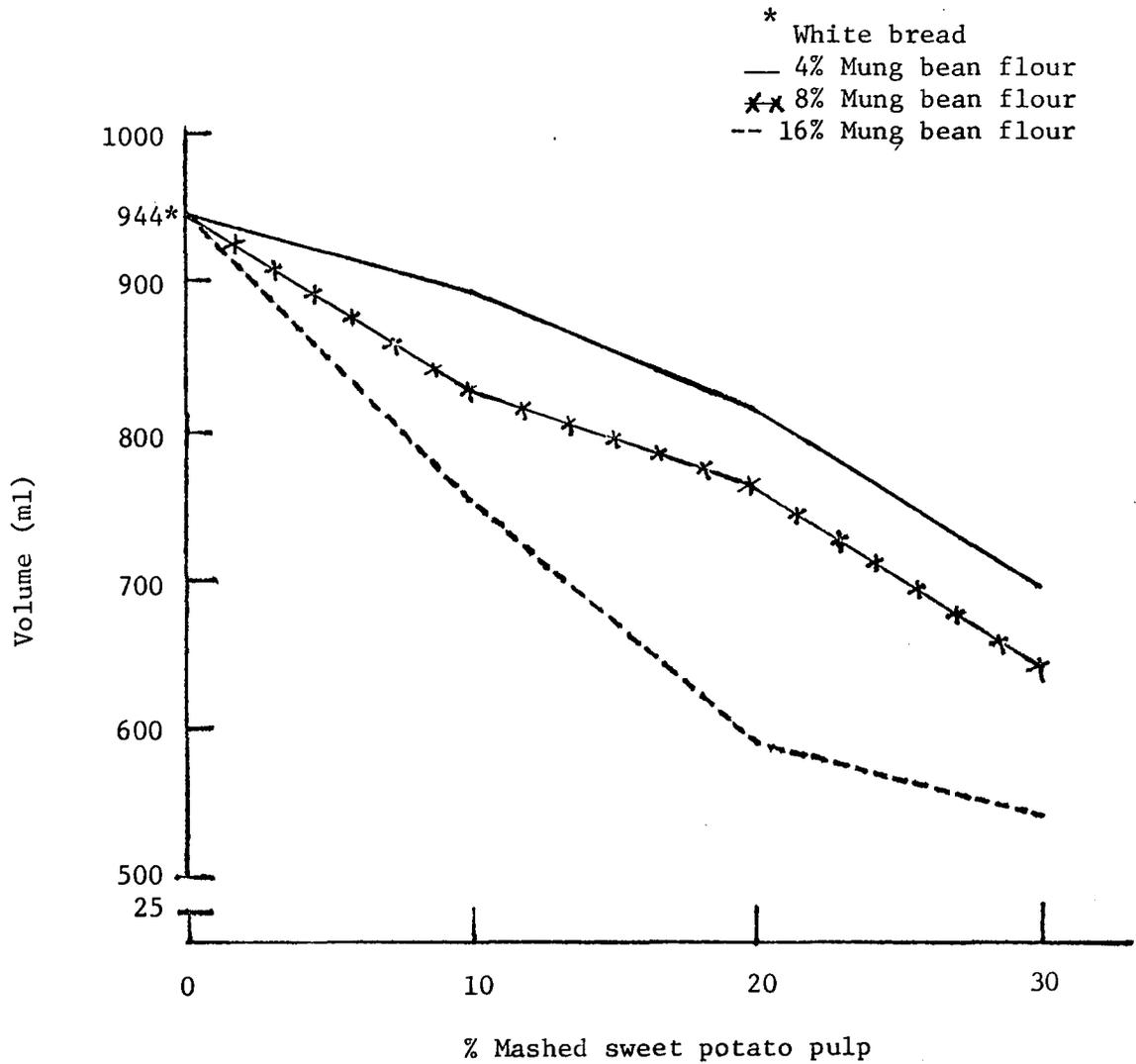


Figure 2: Volume of bread loaves made with mashed sweet potato pulp and mung bean flour (mean value of eight observations).

bread loaf volume was increased with only 1.5 percent sweet potato flour. Plaut et al. (36) also found that the addition of 5 percent sweet potato flour yielded the best quality of bread. But the data from their study showed that gas retention of dough made with a sweet potato flour-wheat flour blend decreased a little bit. The finding of the bread volume decreased with an increased amount of mung bean flour, these findings agreed with the reports by Thompson (45) and D'Appolonia (14).

Since mashed sweet potato pulp does not have gluten and the protein composition of mung bean flour is different from that of wheat flour, addition of the mashed sweet potato pulp and mung bean flour diluted the gluten content of the bread doughs. Low gluten content of the bread doughs made with sweet potato pulp-mung bean flour did not form a framework to hold enough gas during fermentation, proofing, and baking. Therefore, the volume of the breads decreased with the increased amounts of mung bean flour and mashed sweet potato pulp.

### Sensory Evaluation

#### Texture of Baked Loaves

In this part of the discussion the results of sensory evaluation by the panel of tasters is reported. All the sensory evaluation data used here was from seven panelists who completed the total twelve taste sessions. The numerical scores from these seven judges who participated in this taste panel were significantly different ( $p < 0.05$ ) from each other and the internal consistency of the judges in evaluating bread

characteristics varied from day to day except for crust and internal color (Table 3). The internal inconsistency on the part of judges may have been due in part to comparison of any one sample with the other samples presented at each session.

Each taste session, three samples of bread made with consistent amount of mashed sweet potato pulp and varied amount of mung bean flour, or consistent amount of mung bean flour and varied amount of mashed sweet potato pulp were presented to the tasters. The panelists were consistent in evaluating internal color of bread from day to day probably because the internal color of bread for each variation was about the same from replication to replication.

#### External Characteristics

External color The external color of the breads was darker with increased amounts of mung bean flour or with increased amounts of mashed sweet potato pulp. The change was probably due to the increased total carbohydrate content of the dough and an increase in the browning reaction during baking. Studies have shown that mung beans are rich in the amino acid lysine (8, 9, 16); therefore, more free amino groups from this amino acid were available for reaction with the reducing sugars present in the sweet potatoes.

The crust of the breads made with the highest amount of mung bean flour appeared dry and brittle. Some comments such as "hard crust", "cracker crust", and "good browning of crust" were given by the panelists. Judges in this study awarded lower scores for the darker color of the crust of bread made with higher amounts of mashed sweet potato

Table 3. Values of the F ratio from ANOVA of scores from sensory evaluation for the consistency of tasters from day to day.

	External Characteristics			Flavor			Internal Characteristics		
	Color	Shape	Crust	Taste	Odor	Texture	Lightness	Moisture	Color
Taster	4.07**	2.48*	1.83	3.48*	4.53**	2.90*	4.59**	5.11**	1.56
Sweet potato	0.19	1.17	0.68	0.07	0.77	0.34	0.71	0.73	0.28
Mung bean	0.04	0.91	1.33	1.37	0.22	1.21	1.85	1.15	0.03
Sweet Potato X Mung bean	0.86	2.07	1.69	0.68	0.90	1.45	1.54	0.20	0.08

\*\* Significantly different  $p < 0.01$

\* Significantly different  $p < 0.05$

pulp or higher amounts of mung bean flour. Although the addition of mashed sweet potato pulp affected the acceptability of external color of bread (Table 4); the addition of mung bean flour seemed to have a stronger effect on the external color (Table 4).

Shape The author observed that breads made with higher amounts of mashed sweet potato pulp had a good shape, but those breads made with higher amounts of mung bean flour tended to have a flat and compact shape. "Short shape" and "not appealing shape" were comments given by the judges for the breads made with 16 percent mung bean flour. In addition, statistical analysis indicated that mung bean flour was a factor having effect on the acceptability of bread shape (Table 4 and 5). The mean score for bread shape decreased with increase in the amount of mung bean flour (Table 6).

Crust Statistical analysis of sensory evaluation data (Table 4) indicated that mung bean flour affected the crust quality in sequence 4 to 6 (consistent amounts of mashed sweet potato pulp and varied amounts of mung bean flour). Overall the crust (Table 5) did not significantly affect the acceptability of bread, because some of the judges liked the cracker type crust.

### Flavor

Taste and Odor The taste of bread with lowest amount of mashed sweet potato pulp (10 percent of the weight of flour) and of mung bean flour (4 percent of the weight of flour) was not noticeably different from the white bread. That is why some of the panelists complained about the bland taste of the bread, Breads made with higher amounts of

Table 4. Values of the F ratio from ANOVA of scores from sensory evaluation for two replications of each bread formula.

External characteristics	Sweet potato pulp varied mung bean flour constant		Mung bean flour varied sweet potato pulp constant	
	Sweet potato	Mung bean	Sweet potato	Mung bean
Color	3.36*	0.21	2.23	0.12
Shape	5.27*	0.40	0.40	1.87
Crust	1.74	0.91	1.36	0.44
<hr/>				
Flavor				
Taste	0.26	0.45	1.40	0.23
Odor	1.07	1.38	0.54	1.70
<hr/>				
Internal characteristics				
Texture	3.44*	0.83	1.90	0.28
Lightness	1.35	1.49	1.32	0.82
Moisture	0.49	1.49	1.36	1.32
Color	1.15	0.19	1.22	0.19

\*\* Significantly different p<0.01

\* Significantly different p<0.05

Table 5. Values of the F ratio from ANOVA of scores from sensory evaluation of overall sequences combined average over day 1 and day 2.

	External Characteristics			Flavor		Internal Characteristics			
	Color	Shape	Crust	Taste	Odor	Texture	Lightness	Moisture	Color
	Sweet potato	2.11	4.32*	1.31	0.12	0.05	0.42	1.03	0.07
Mung bean	7.63**	4.66*	0.42	7.21**	8.81**	6.54**	9.56**	7.40**	3.62*
Sweet potato X Mung bean	1.28	1.09	0.62	0.70	0.93	0.34	0.19	1.37	0.53

\*\* Significantly different  $p < 0.01$

\* Significantly different  $p < 0.05$



sweet potato pulp and lower amounts of mung bean flour, were described as, "a little bit sweet with a good smell". Most of the judges liked this taste but some of them complained about a strong flavor. In contrast, breads made with higher proportion of mung bean flour and lower amounts of mashed sweet potato pulp had a bitter taste and a beany smell. As shown by the low score given by the judges for taste and the judges comments of "beany taste", "grim taste", "strong flavor", and "bitter taste". The mean score for bread taste and odor decreased with the addition of mung bean flour (Table 6). Statistical analysis of sensory evaluation results indicated that mung bean flour was the major factor that affected bread flavor (Tables 4, 5, 7, and 8). The mean score for odor and taste of bread made with 30 percent mashed sweet potato pulp and 16 percent mung bean flour was higher than that of bread made with 16 percent mung bean flour and 10 or 20 percent mashed sweet potato pulp. It is possible that the sweet taste of sweet potato pulp overcame some of the bitter taste of mung bean flour and formed a unique aroma.

#### Internal Characteristics

Texture The texture of breads made with 4 percent mung bean flour and the three levels of mashed sweet potato pulp was good. Texture of breads became more compressed and coarse with increasing the amount of mung bean flour. Kim and Ruiter (27, 28) pointed out that breads made with pure starch or other cereals which structure was more rigid and cell structure was irregular. The results in this study agreed with their findings. The results of the taste panel indicated that most of

Table 7. Values of the F ratio from ANOVA of scores from sensory evaluation for three categories of bread loaf quality.

	Sweet potato pulp varied mung bean flour constant		Mung bean flour varied sweet potato pulp constant	
	Sweet potato bean	Mung bean Sweet potato X Mung bean	Sweet potato bean	Mung bean Sweet potato X Mung bean
External characteristics	4.71*	0.18	1.45	1.45
Flavor	0.63	0.85	0.84	0.84
Internal characteristics	1.36	0.71	1.64	1.64
			0.30	17.84**
			0.41	15.44**
			0.37	12.33**
				0.60
				0.95
				0.62

\*\* Significantly different  $p < 0.01$

\* Significantly different  $p < 0.05$

Table 8. Values of the F ratio from ANOVA of scores from sensory evaluation for overall categories of bread loaf quality combined average over day 1 and day 2.

	External Characteristics		Internal Characteristics	
		Flavor		
Sweet potato	2.94	0.08	0.73	
Mung bean	4.96*	9.77**	8.63**	
Sweet potato X Mung bean	0.71	0.62	0.50	

\*\*Significantly different  $p < 0.01$

\*Significantly different  $p < 0.05$

the judges did not like the texture of bread made with the higher proportions of mung bean flour. The low score (Table 6) given to the bread was due to uneven texture and coarseness. Again, mung bean flour was a major factor that affected the acceptability of the texture of the bread (Table 4, and 5). Hamed et al. (23) pointed out that higher proportions of sweet potato flour affected bread quality. The results of the statistical analysis indicated that in sequence 1 to 3 (consistent of amounts of mung bean flour and varied amounts of mashed sweet potato pulp) mashed sweet potato pulp was a major factor significant effect on the bread texture acceptability. In general, bread texture with the higher amounts of mashed sweet potato pulp was slightly coarse compared to bread made with the lowest amount (10 percent) of mashed sweet potato pulp.

Lightness The lightness texture of bread was affected by the amount of mung bean flour and of mashed sweet potato pulp. Lightness was decreased with the addition of mashed sweet potato pulp or mung bean flour, especially with mung bean flour. There was not too much difference in lightness of bread between lower and higher amount of mashed sweet potato pulp. Scores for the lightness of bread decreased significantly with increase in the amount of mung bean flour. The panelists comments on breads made with higher amounts of mung bean flour were "heavy", or "heavy consistency". The statistical analysis of sensory evaluation scores indicated that mung bean flour significantly affected bread acceptability judged by lightness (Table 4 and 5).

Moistness The scores for sensory perception of moistness of

bread were decreased with the addition of mung bean flour, and the panelists commented that the bread made with the higher proportions of mung bean flour was rather dry. Judges perception of moistness for breads made with different levels of mashed sweet potato pulp indicated little difference but the bread made with the highest amount of mashed sweet potato pulp was dryer compared with the bread made with the lowest amount of mashed sweet potato pulp. The addition of mung bean flour significantly affected the acceptability of perceived bread moistness (Table 4 and 5).

Internal Color The internal color was varied with the amount of mung bean flour or mashed sweet potato pulp in the breads. The internal color was more yellow with increase in the amount of mashed sweet potato pulp, and was darker with increase in the amount of mung bean flour. The mean score for internal color was lower ("like slightly" to "like moderately") than for other bread characteristics. The internal color of bread made with the lowest proportion of mung bean flour and of mashed sweet potato pulp resembled a white bread, and some panelists thought the color of the bread was too pale. Some of them did not like the yellowish color which was from the large amount of mashed sweet potato pulp. The judges also indicated that there were dark spots and a dark color for bread made with higher amounts of mung bean flour. The black spots were from the hull of the mung beans; therefore, the increase in the amount of mung bean flour increased the black spots. Most of the judges did not like the black spots in bread crumb, and the scores for the internal color decreased with increased amounts of mung bean flour (Table 6). The acceptability of bread in internal color was

affected by mung bean flour significantly (Table 4 and 5).

In general, the sensory evaluation results indicated that mung bean flour is a major effect factor on the acceptability in different bread categories (Table 7 and 8).

### Objective Measurements

#### Percent Crude Nitrogen

In this investigation, there was not a suitable protein conversion factor for breads made with mashed sweet potato pulp and mung bean flour; therefore, a percent crude nitrogen content was reported as an index to crude protein content. The results of percent crude nitrogen for the experimental products are shown in Table 9. The percent crude nitrogen content of bread made with sweet potato pulp and mung bean flour was higher than that of control (white bread) except for the bread made with 4 percent mung bean flour and 30 percent mashed sweet potato pulp. The percent crude nitrogen content increased with the addition of mung bean flour and decreased with the addition of mashed sweet potato pulp (Figure 3). The addition of mashed sweet potato pulp (about 75 percent moisture content) added more moisture than dry solids. In addition to this fact, Hamed et al. (22) found that the protein content of sweet potato was markedly lower than that of wheat, ranging from 2.3 to 3.0 percent ( $N \times 5.7$ ) in sweet potato flour. Plaut and Zelebuch (36) found that the protein content of breads made with a 6 percent sweet potato flour was slightly decreased from 8.9 to 8.6 percent.

Table 9. The mean composition of sweet potato - mung bean bread.

	4% Mung bean flour			8% Mung bean flour			16% Mung bean flour		
	Sweet potato pulp			Sweet potato pulp			Sweet potato pulp		
	10%	20%	30%	10%	20%	30%	10%	20%	30%
% Crude nitrogen <sup>a</sup>	1.534	1.512	1.475	1.554	1.580	1.551	1.719	1.686	1.656
% Crude fat <sup>a</sup>	1.24	1.34	1.24	1.16	1.31	1.41	1.25	0.96	1.20
Moisture <sup>b</sup>	31.64	32.04	34.11	34.68	33.29	33.37	32.05	34.63	35.30

<sup>a</sup>Mean value of eight observations (four duplicated samples).

<sup>b</sup>Mean value of sixteen observations (eight duplicated samples).

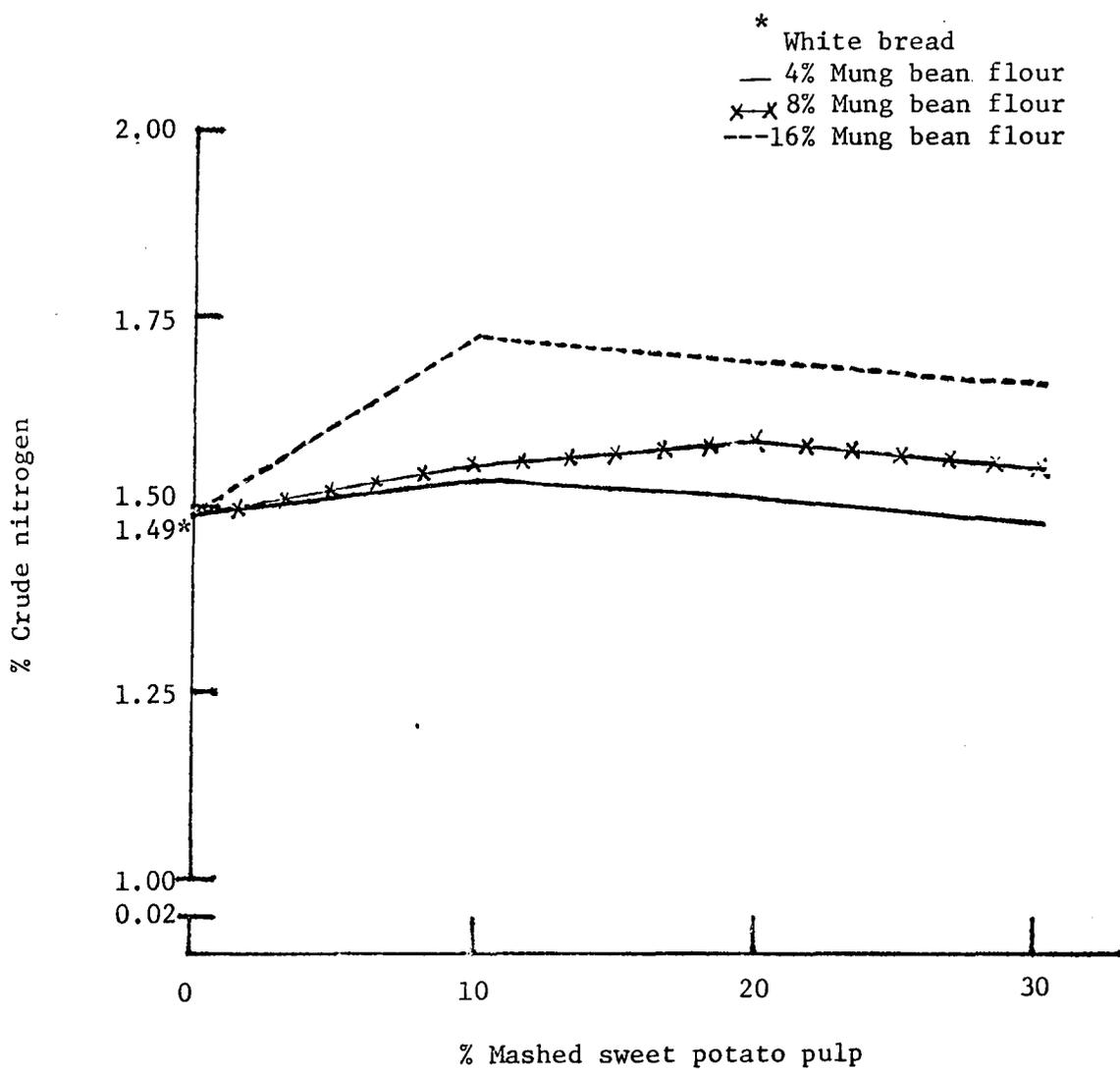


Figure 3. Percent crude nitrogen content of bread loaves made with mashed sweet potato pulp and mung bean flour (mean value of eight observations).

The percent crude nitrogen of the breads increased with the higher percent of mung bean flour by total weight of flour. The protein content of mung bean flour was higher than that of wheat flour (16, 17, 45). Therefore, the more mung bean flour added the more protein added to the bread. Thompson et al. (45) found that a 15 percent replacement of strong wheat flour with mung bean flour could increase the protein content approximately 10 percent in the breads. In this experiment, percent crude nitrogen in the bread made with 16 percent mung bean flour increased about 16.7 percent over (breads made with 16 percent mung bean flour and 10 percent mashed sweet potato pulp) that of control white bread.

#### Percent Ether Extractable Crude Fat

The ether extractable crude fat of the experimental breads was very low (range from 1.16 to 1.45 percent by dry weight) (Table 9). The low fat content is attributed to the fact that only 10 grams of shortening was used in making each batch of bread (6 grams in the formula and 4 grams in greasing the bowl, dough, loaf, and the loaf pan). The ether extractable crude fat from the different combinations of mashed sweet potato pulp and mung bean flour was irregular (Figure 4).

The irregularity of ether extractable crude fat may have been due to:

1. The sampling procedure. The bread samples were blended before drying and were not sifted through a 20 mesh sifter as suggested by the AOAC method (3). According to the method used in this experiment, the surface of the bread would have more fat content (from the surface of loaf pan and loaf surface). Therefore, if the bread sample for crude fat determination contained more crust the extraction would yield a higher

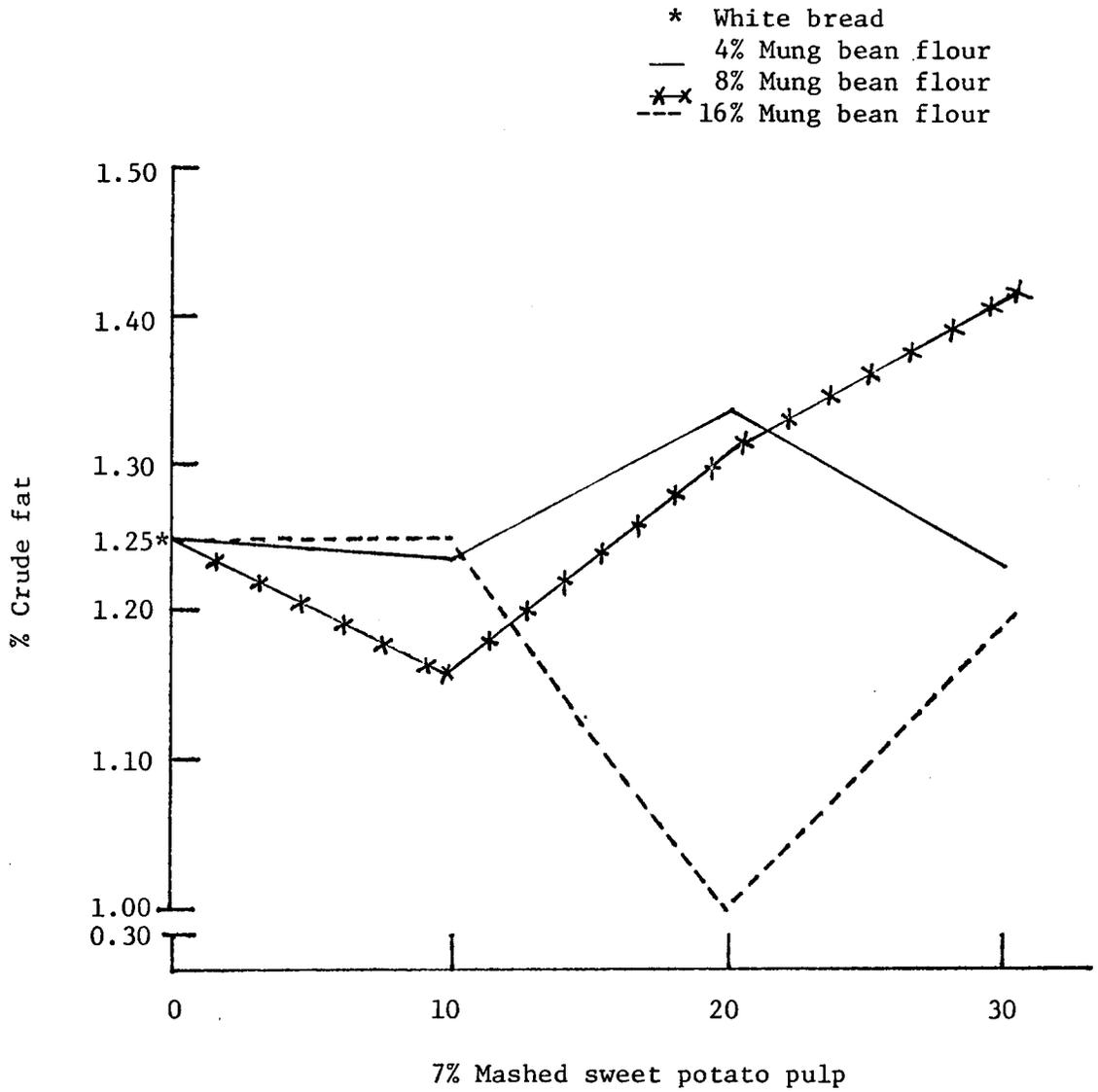


Figure 4. Percent ether extractable crude fat content of bread loaves made with mashed sweet potato pulp and mung bean flour (mean value of eight observations).

percent crude fat content.

2. There were likely other lipid or fat soluble substances in the crude fat extract, including carotenes from the mashed sweet potato pulp. If the sample of bread contained more sweet potato solid, there would be more fat soluble material in the extract (e.g. carotene), and the results of ether extractable crude fat would be higher.

### Moisture Content

The total amount of water used in all levels of mashed sweet potato pulp and mung bean flour combinations was almost the same. The moisture content of baked breads indicated that moisture increased with the addition of mashed sweet potato pulp and mung bean flour except for the bread made with 8 percent mung bean flour with the 3 levels of mashed sweet potato pulp. Plaut and Zcelzbuch (35) reported that the bread containing sweet potato flour had higher water content and porosity. D'Appolonia (14) showed the water retention capacity of mung bean-wheat flour blend increased with the addition of mung bean flour. Luh et al. (29) found that bread enriched with precooked and frozen dried lima bean powder had a progressive increase in total moisture content with increasing the amount of lima bean powder. In this study, the results agreed with the former observations.

From the drying curves (Figures 5, 6, 7), the water loss was almost constant after drying in the Brabender Moisture Tester at 110°C for about seventy minutes. Irregular change of moisture content of breads made with 8 percent mung bean flour and 10, 20, and 30 percent mashed sweet potato pulp, may be due to undesirable frozen storage or defrosting processes. Bread samples were ground and stored in a family

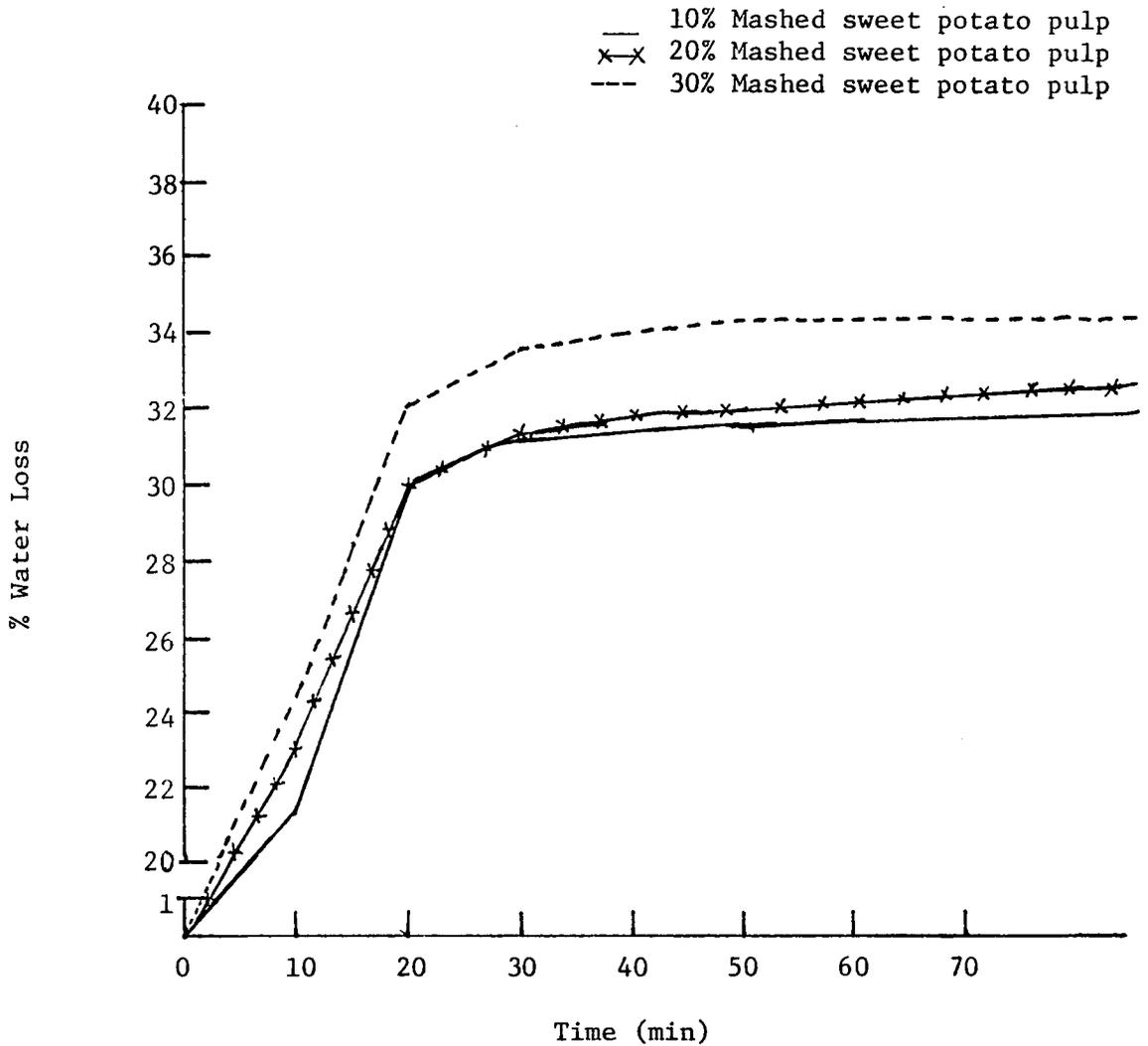


Figure 5. Moisture loss of bread loaves made with 4% mung bean flour and varied percent of mashed sweet potato pulp (mean value of eight observations).

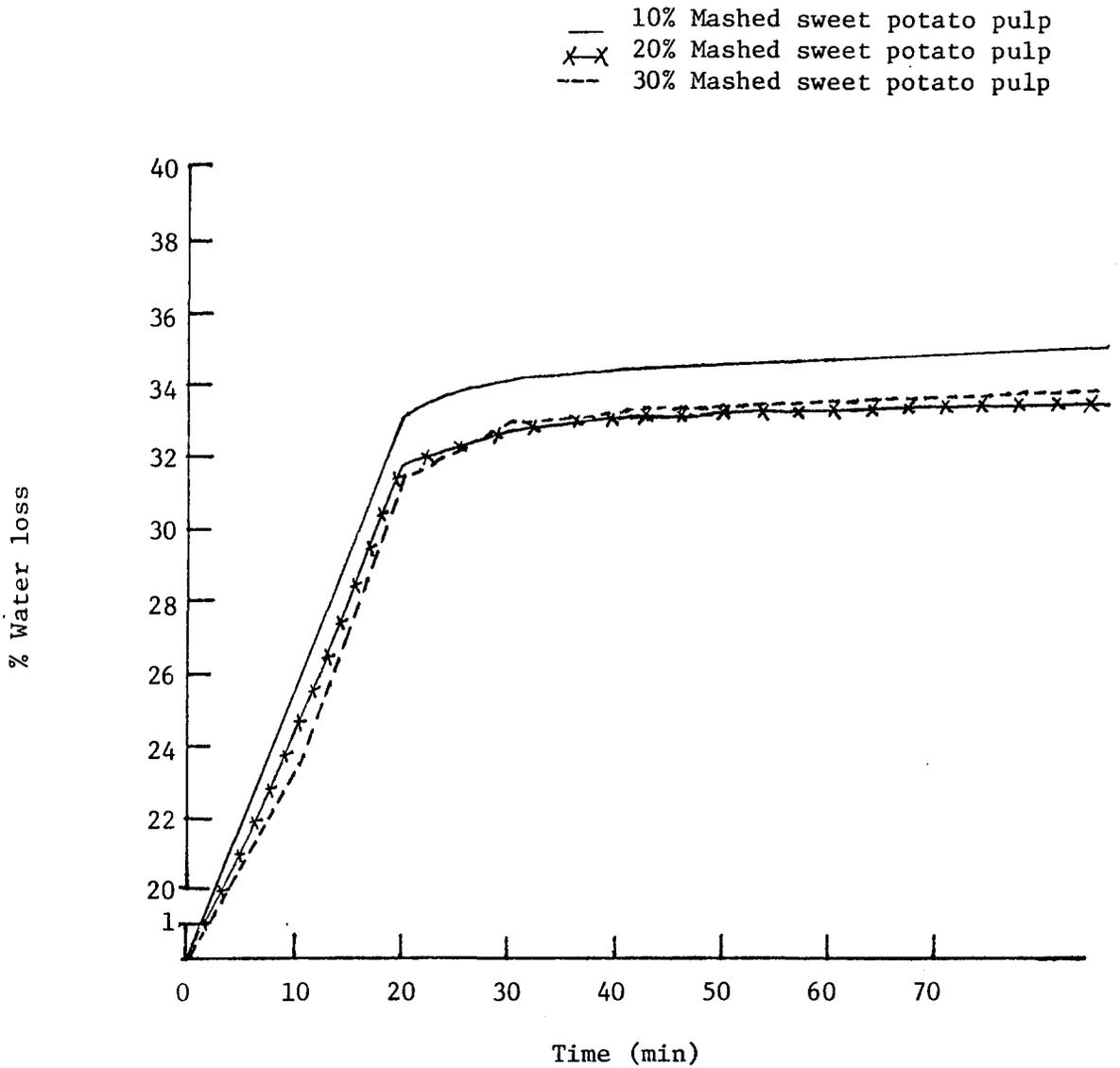


Figure 6. Moisture loss of bread loaves made with 8% mung bean flour and varied percent of mashed sweet potato pulp (mean value of eight observations).

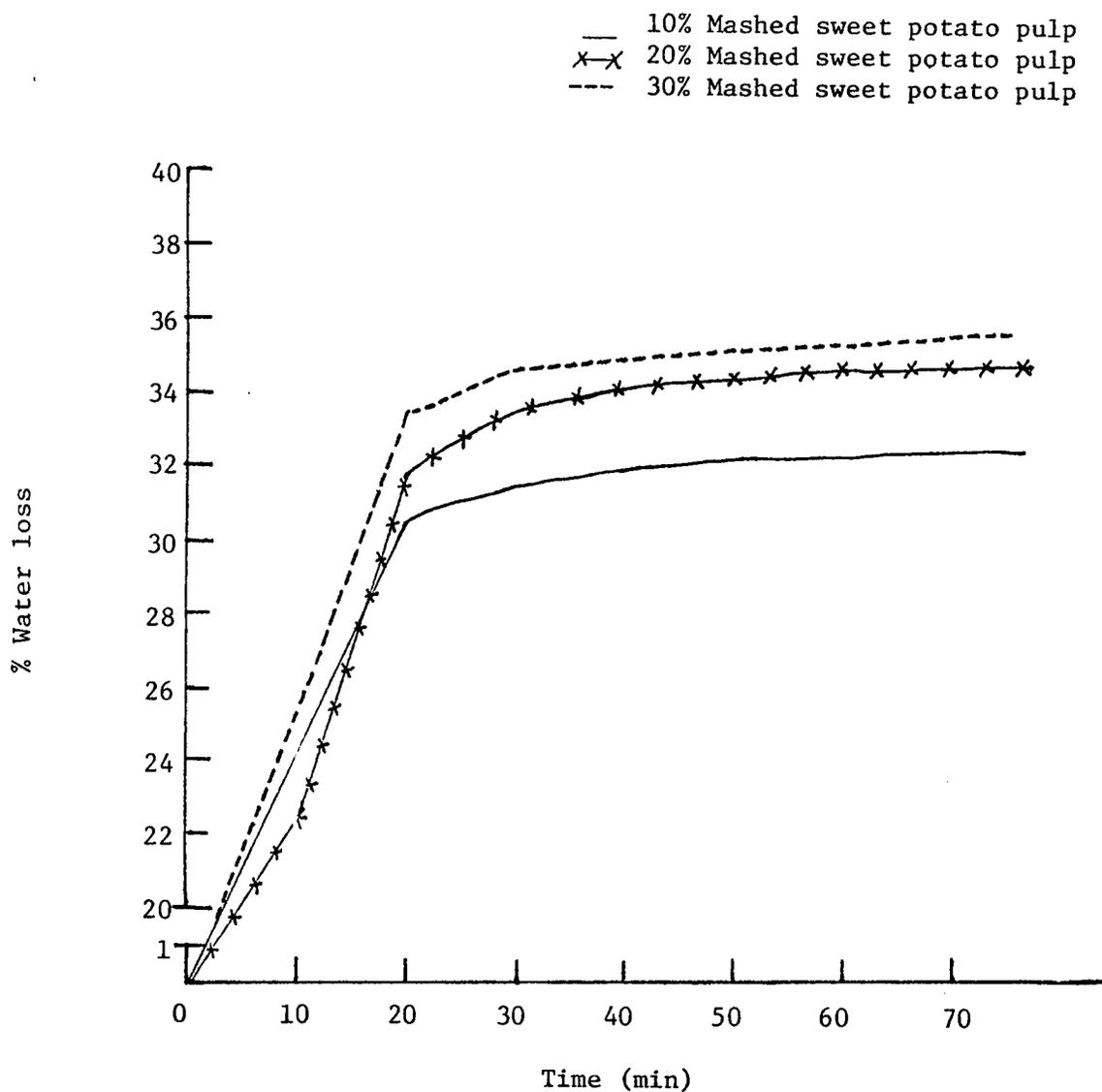


Figure 7. Moisture loss of bread loaves made with 16% mung bean flour and varied percent of mashed sweet potato pulp (mean value of eight observations).

type freezer until one day before further objective analysis took place. Then the samples were placed in a refrigerator and thawed for twenty four hours. During the thawing period, sample may have been moistened by the melted ice crystals. This is probably why the high moisture content was found for bread made with 8 percent mung bean flour and 10 percent mashed sweet potato pulp compared with breads made with 4 and 16 percent mung bean flour with 10 percent mashed sweet potato pulp.

#### Recommendation

From the experimental finding of this study, further studies are needed in order to develop a high quality bread with high nutrient value. The following recommendations are suggested.

1. Mung bean should be soaked for two to three days to remove the hull and bitter taste, then dried and ground.
2. Convert the weight of mashed sweet potato pulp to the weight of total solid content then substitute for flour accordingly.
3. Use a farinograph and an extensograph to study dough properties.
4. Analyze the nutrient content of the products, such as amino acid pattern, vitamin content especially vitamins A and C, and fiber, to study changes occurring within various mixtures.
5. Bioassay the nutritional value of these experimental products to understand the utilization of various nutrients in these products.

## SUMMARY AND CONCLUSIONS

This experiment was designed to determine: (1) if an acceptable bread could be made by substituting mashed sweet potato pulp and mung bean flour for part of the all purpose wheat flour in yeast bread, (2) the factor (mashed sweet potato pulp or mung bean flour) which had a greater effect on the acceptability of different characteristics of the breads, (3) the percent crude nitrogen, ether extractable crude fat and moisture of the experimental products.

There were three variations in the amount of mashed sweet potato pulp (10, 20, and 30 percent) and three variations in the amount of mung bean flour (4, 8, and 16 percent) of the total amount of wheat flour. These variations were combined to form nine variations of bread.

Breads were evaluated by a ten member taste panel for the following characteristics:

External characteristics: color, shape, and crust

Flavor: odor, taste

Internal characteristics: texture, lightness, moisture and  
color

An analysis of variance was used to analyze sensory evaluation data and the results of significant difference of treatment indicated the factor which affected the acceptability of different characteristics.

Objective measurements were used to determine the volume, percent crude nitrogen, percent ether extractable crude fat, and moisture content of the breads.

All the breads produced in this experiment were acceptable (scored

"like slightly" to "like moderately") to the panel of judges. The quality of bread decreased significantly with each increase in the amount of mung bean flour; and mashed sweet potato pulp affected bread quality only at the highest (30 percent) level. The major factor that affected the bread acceptability was mung bean flour, which caused: the external color to be darker, decrease volume, uneven shape, a more brittle crust, a beany smell, a bitter taste, a coarse texture with irregular cell structure, a significantly heavier texture, and a dry, dark, unpleasant crumb. In general, the most acceptable bread was that bread made with 4 percent mung bean flour and 20 percent mashed sweet potato pulp, with near acceptability for the bread made with 8 percent mung bean flour and 20 percent mashed sweet potato pulp.

The objective measurements indicated that bread volume decreased significantly with the addition of mung bean flour and of mashed sweet potato pulp. The percent crude nitrogen increased with the addition of mung bean flour and decreased with the addition of mashed sweet potato pulp. Percent crude nitrogen of bread made with 16 percent mung bean flour and 10 percent mashed sweet potato pulp increased about 16.7 percent compared with the control (plain white bread). Percent ether extractable crude fat of all experimental products was very low (ranging from 1.16 to 1.45 percent). The moisture content of the breads was not significantly different.

#### Conclusion

Acceptable breads could be made by replacing wheat flour with mashed sweet potato pulp and mung bean flour. All the nine variations

were acceptable (ranging from like slightly to like moderately). The significant major factor which affected the acceptability of bread was mung bean flour because the substitution of mung bean flour for wheat flour induced adverse effects on bread quality. The protein content of these experimental breads was higher than that of white bread except bread made with 4 percent mung bean flour and 30 percent mashed sweet potato pulp. Sweet potato has a higher content of carotenes; therefore, a higher carotene content of the experimental breads could be predicted. Percent ether extractable crude fat content was very low in all experimental products. Moisture content of the breads was not significantly different from that of white bread.

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APPENDIX A

Rating score:

- |                             |                    |
|-----------------------------|--------------------|
| 1. Dislike extremely        | 6. Like slightly   |
| 2. Dislike very much        | 7. Like moderately |
| 3. Dislike moderately       | 8. Like very much  |
| 4. Dislike slightly         | 9. Like extremely  |
| 5. Neither like nor dislike |                    |

Factor	Code No.		
<b>External characteristics</b>  1. color  2. shape  3. crust			
<b>Flavor</b>  1. taste  2. odor			
<b>Internal characteristics</b>  1. texture  2. lightness  3. moisture  4. color			

Comments:

1. Do you like the products or not? Why?
2. The samples, which one you like extremely? Which one you dislike extremely? Please give the reason.

Date:

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SWEET POTATOES AND MUNG BEAN FLOUR AS INGREDIENTS  
IN YEAST BREAD

by

Shuh-ling Kuo

(ABSTRACT)

Yeast breads were prepared with three levels of mashed sweet potato pulp and of mung bean flour. Nine combinations of mashed sweet potato pulp (10, 20, 30 percent), and of mung bean flour (4, 8, 16 percent) substitutions for wheat flour were used to determine the acceptability of these enriched breads. Added liquid was adjusted for moisture in sweet potato pulp.

Sensory evaluation data was analyzed by analysis of variance to determine the major effective factor on the acceptability of bread. Objective measurements were used to determine bread volume, percent crude nitrogen, percent ether extractable crude fat, and moisture content of the breads.

The sensory evaluation results indicated that the bread quality decreased with increase in the amount of mung bean flour; mashed sweet potato pulp did not affect the bread quality except that the highest level (30 percent) has a slight adverse effect on bread texture. The characteristics of all breads made with mashed sweet potato pulp and mung bean flour varied with the amount of substitute ingredient. In general, mung bean flour affected the acceptability of bread and bread quality. Breads made with 20 percent mashed sweet potato pulp and 4 or

8 percent mung bean flour were judged to have more desirable eating quality.

Volume of bread was decreased with increase in the amount of mung bean flour and of mashed sweet potato pulp. The percent crude nitrogen increased with the addition of mung bean flour and decreased with the addition of mashed sweet potato pulp. Bread enriched with 16 percent mung bean flour and 10 percent mashed sweet potato pulp increased in the amount of percent crude nitrogen approximately 16.7 percent compared with the control. Percent ether extractable crude fat content of all breads was low and was varied, Moisture content increased with addition of mung bean flour and mashed sweet potato pulp.