SOY SAUCE PRODUCTION UTILIZING ROOT CROP FLOUR AS SUBSTITUTE FOR WHEAT FLOUR (100% SUBSTITUTION)

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ABSTRACT

Soy sauce yield was not affected by the substitution of wheat flour with root crop flour as carbohydrate source for the fermentation microorganisms. The titratable acidity, pH and NaCl content were not significantly affected by flour substitution while the protein content and amino nitrogen of root crop-based soy sauce were lower than that of sauce produced from wheat flour.

Sensory evaluation showed that when soy sauce was used in preparing beef steak or as dip for broiled fish, root crop-based soy sauce was comparable to one commercial brand based on general acceptability scores. Cooked sweet potato-based soy sauce was comparable to two commercial brands when served as pure soy sauce based on color, aroma, consistency and flavor.

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KEY WORDS: Soy sauce. Wheat substitution. Root crop flour. Soybean. Fermentation. *Aspergillus oryzae. Aspergillus sojae.*

INTRODUCTION

Soy sauce is a popular condiment used in daily meals of Asians. It is a salty, dark brown liquid which is used mainly as a flavoring ingredient in various culinary recipes.

Traditionally, soy sauce is prepared from a mixture of soybeans and wheat which is fermented through the action of microorganisms particularly *Aspergillus oryzae*. Soybean can be grown in many parts of the Philippines whereas wheat is imported from other countries. Millions of dollars are spent by the Philippine government yearly for wheat flour. It is therefore necessary to find alternative materials that can substitute wheat flour. These materials should be cheap, locally available and could be produced in large quantities to meet the demand.

Possible substitutes are flour from root crops, especially cassava and sweet potato. These crops grow very well under Philippine conditions and their supply appears not to be a problem considering the reported dramatic increase in their total production in the country (Villanueva, 1982).

This study was undertaken to determine the suitability of sweet potato and cassava flour for soy sauce production based on chemical constituents, acceptability and soy sauce yield.

MATERIALS AND METHODS

Preparation of Root Crop Flour

Sweet potato (BNAS-51) and cassava (Golden Yellow) were the root crops utilized in this study. Flour was prepared in two ways, i.e. the roots were either washed, peeled, chipped and dried under the sun; or cooked after washing, peeled, chipped and dried under the sun. The dried chips produced in either way were ground into flour.

Preparation of the Starter

Two hundred grams of rice was soaked in water for 5 hours, drained and sterilized at 15 pounds for 15 minutes using a pressure cooker. It was cooled down to room temperature and seeded with spores of *Aspergillus oryzae* or *A. sojae*. Incubation was done at room temperature for 4-6 days or until greenish spores were formed.

Manufacture of Soy Sauce

Soy sauce production follows several operations as shown in Figure 1. One kilogram of soybeans was soaked in water overnight. The excess water was drained off and the beans were steam-cooked for 3 hours. After cooking, the beans were spread out on trays, cooled and mixed with one kilogram roasted flour. The starter prepared previously was thoroughly mixed with the flour-coated beans, and incubated for 4-5 days at room temperature (Frazier, 1967) with daily stirring to permit proper circulation of air throughout the mixture. During incubation, heavy growth of *A. oryzae* or *A. sojae* developed on the mixture as indicated by the formation of yellowish green spores. This mixture (starter and flour-coated soybeans) is termed *koji*. The *koji* was transferred to a plastic pail, then 0.925 kilogram of salt and 3.55 liters of water were added. This was incubated at room temperature for 3 months or until the pH was 5.05-5.5. The mash was stirred daily for one week and for three times per week after one month. After 2 months, stirring was done twice per month until fully mature.

After 3 months of fermentation, the mash was pressed and strained to get the sauce liquor. Sediments were allowed to settle overnight after which the sauce was decanted.

A second sauce was extracted by adding 1000 ml water with 10% salt to the pressed cake. This was mixed thoroughly and pressed again. The resulting liquor was allowed to settle

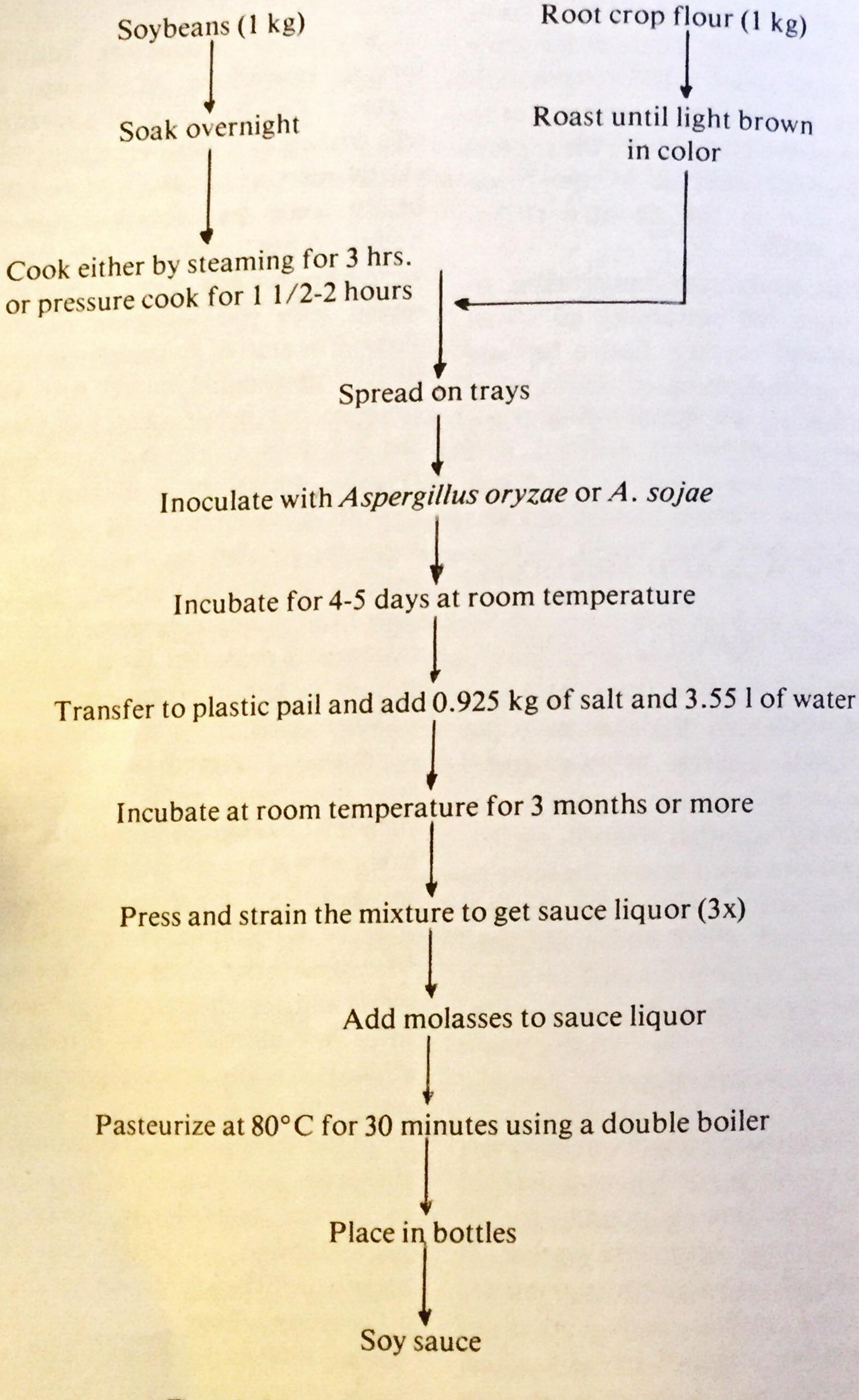

Figure 1. Schematic diagram of soy sauce production.

overnight after which the sauce was decanted. A third sauce was extracted by adding 2000 ml of water with 10% salt to the pressed cake. Extraction was similar to the second extraction.

The sauce from the three extractions were mixed and molasses was added to the mixture to give a darker color and viscosity. The mixture was then pasteurized at 80°C for 30 minutes.

Two types of pressers were tested in extracting sauce liquor for comparison with hand extraction. In the hand extraction, the mash was placed in muslin cloth, allowed to drip for a day and squeezed by hand. In the vent vise (screw type presser), the mash inside a nylon cloth was placed in the vent vise and the sauce was pressed out (Fig. 2). The lever type presser was also tried in extracting the sauce from the mash (Fig. 3).

Chemical Analyses

Soy sauce samples were analyzed for pH using a Horiba H-7LC pH meter. Total titratable acidity, amino nitrogen and crude protein content were analyzed using the glass electrode method, Sorensen method and Microkjeldahl x 6.25 determination, respectively (AOAC, 1980). Salt determination was done using the volumetric method of sodium chloride analysis with modification (AOAC, 1980).

Evaluation of Soy Sauce

The soy sauce produced was compared with a locally available commercial brand (Brand A) in terms of color, flavor, aroma, consistency and general acceptability. Brand A was chosen for comparison because it is readily available and preferred by most consumers. Brand B was also used for comparison because of its light color and taste which approximates that of the root crop-based soy sauce.

Soy sauce was served as dip sauce for broiled fish and marinade for beef steak as commonly practiced by consumers. Coded test samples were placed in a tray and served. Evaluation by 20-30 panelists was done using the 9-point Hedonic scale. Some researchers and laborers of the Philippine Root Crop Research and Training Center (PRCTRC) served as panelists.

In pure soy sauce testing, each test sample was placed in individual petri dishes and served one at a time. For the broiled fish dip, each test sample was placed in individual petri dishes. Taste panelists were instructed to get a portion of broiled fish and dip this into each test soy sauce sample before tasting. For the marinade test, beef was marinated in individual test soy sauce for a period of approximately 15 hours, then cooked and served for tasting.

RESULTS AND DISCUSSION

Koji Making and Fermentation Process

During the *koji* making, healthiest growth of mold spores

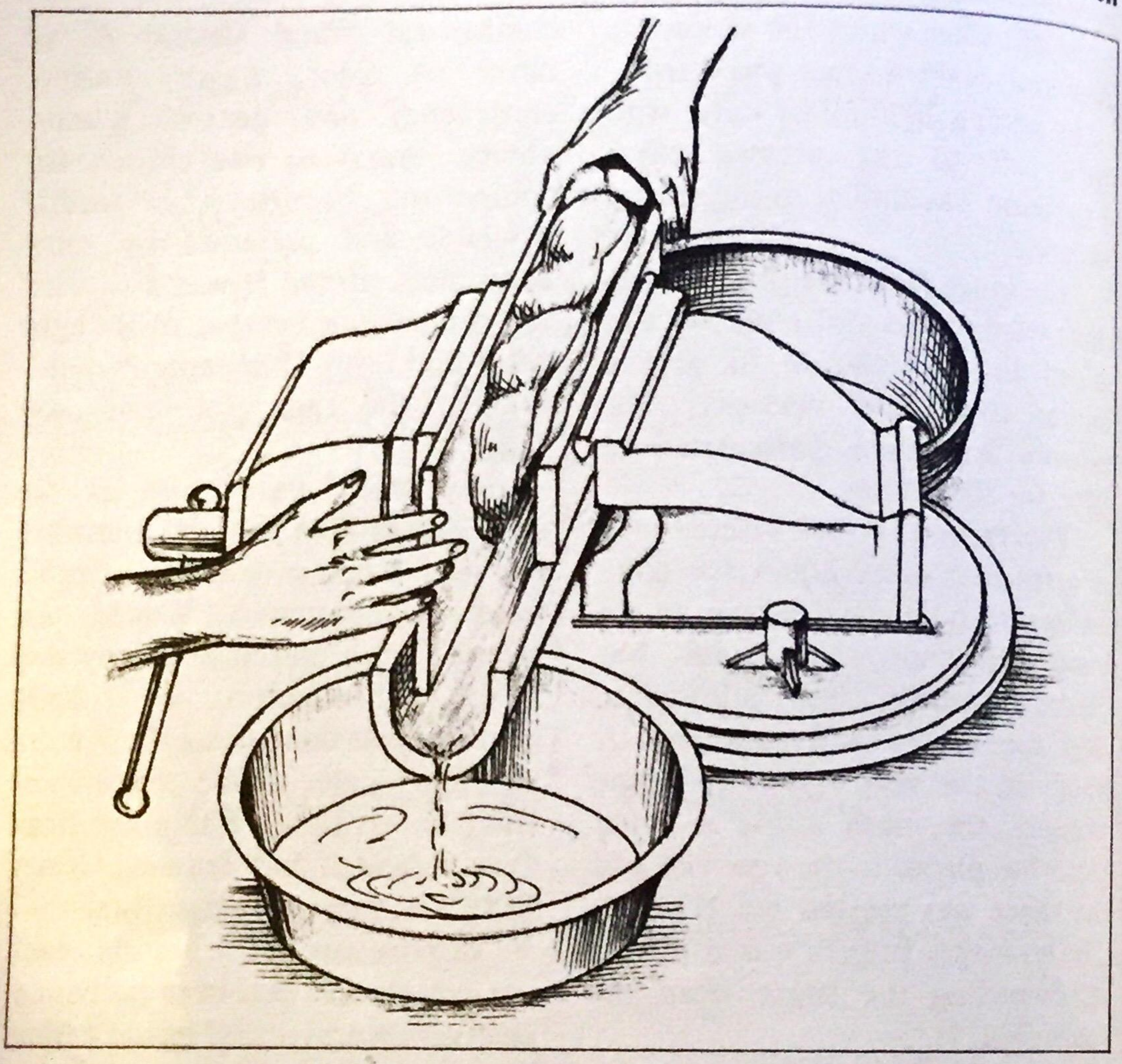

Figure 2. Screw type presser used in the extraction of soy sauce.

was observed on the substrate containing cooked sweet potato flour followed by wheat flour. Spores on uncooked cassava flour were not abundant.

Table 1 shows the percent soy sauce yield as influenced by kind of flour and presser used. In trial I, the highest yield was obtained from cooked sweet potato flour followed by the uncooked sweet potato and wheat flour. Cassava flour produced the lowest soy sauce yield especially when uncooked. Differences in soy sauce yield could have been due more to variation in the pressure exerted by the person squeezing the mash which could have diminished with time. Moreover, soy sauce yield is presumed to depend largely on the growth of molds on the mash. Molds were able to grow abundantly on the medium with cooked sweet potato flour thereby hastening the degradation of materials that form the important components of soy sauce.

It appears that slightly higher yield of soy sauce was produced when flour was prepared from cooked roots. Cooking gelatinized the starch present in the root, hence making it more available and easier for the microorganisms to act on.

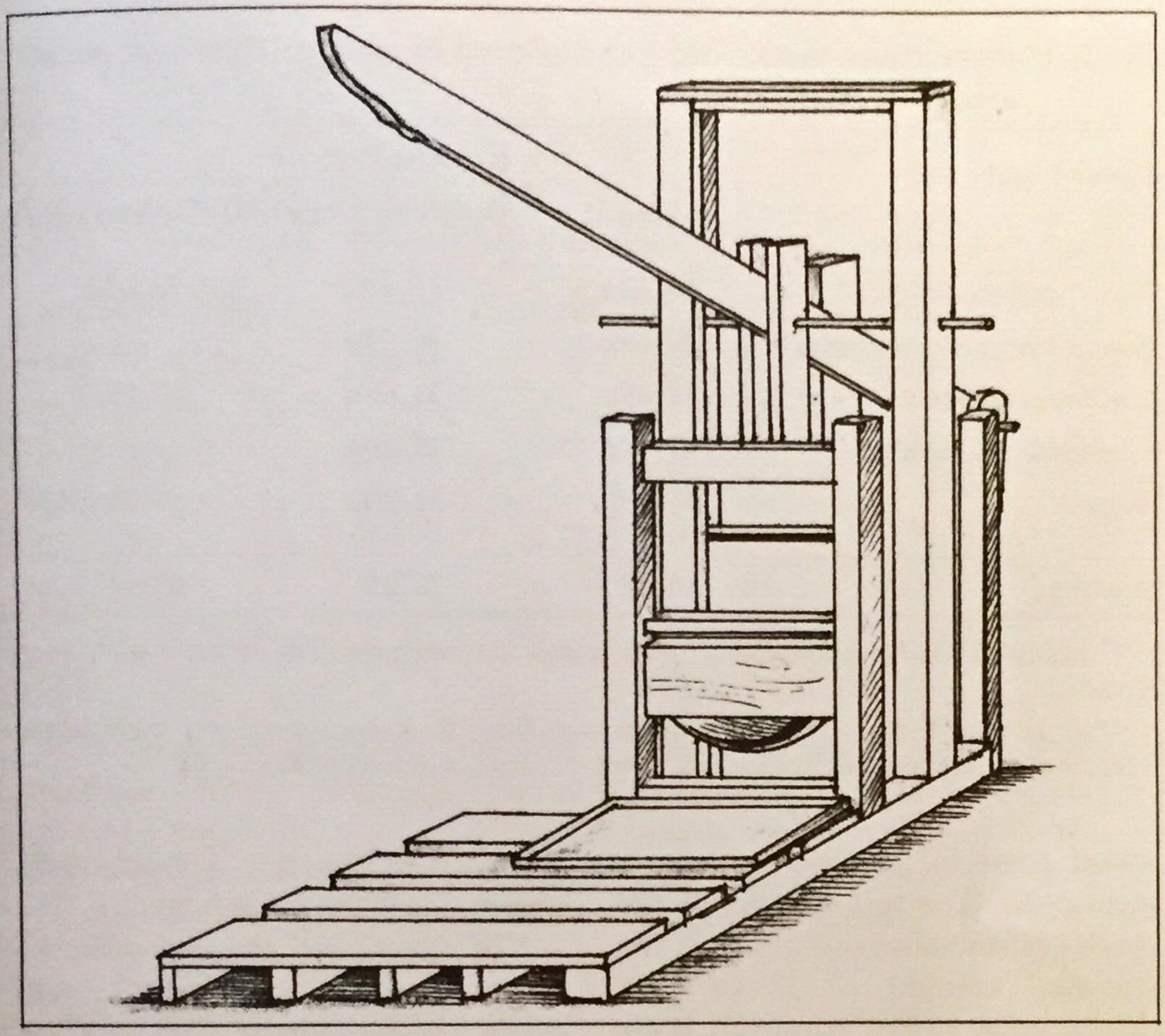

Figure 3. Lever type presser used in the extraction of soy sauce.

The higher yield of soy sauce from sweet potato-based substrate could also be attributed to the amount of digestible material which is 88% for sweet potato and only 76% for cassava (del Rosario et al., 1978).

In the second and third trials, the amounts of soy sauce produced using different kinds of flour were not significantly different. Differences in yield of the different flour treatments between trials I and II could be due to the difference in the method of extraction/type of presser used (Table 1). The lower soy sauce yield from mechanical extraction when compared with manual extraction suggests the need for the development of a more efficient presser for use even in small-scale soy sauce production.

Chemical Analyses

Table 2 shows the chemical analyses of the soy sauce produced from different raw materials during the second trial. The titratable acidity, pH and amount of NaCl were not significantly affected by flour substitution while the protein content and amino nitrogen of root crop soy sauce were lower than that of sauce produced from wheat flour except for cooked sweet potato flour which gave results comparable to

Table 1. Percent soy sauce yield as influenced by kind of flour and presser used.[1]

Flour Used	Kind of Presser		
	I (Hand)	II (Screw Type)	III (Lever Type)[2]
Sweet potato/cooked	54.13a	35.10a	36.62a
Sweet potato/uncooked	49.49b	30.27a	—
Cassava/cooked	41.89c	31.63a	50.28a
Cassava/uncooked	31.11d	31.60a	—
Wheat	47.89b	31.30a	35.92a
Average	44.90	31.98	40.94

[1]Means in a column followed by a common letter are not significantly different at 5% level, DMRT.

[2]In the third trial, yields of treatments with flour from uncooked roots were deleted because of the previous observation that molds do not grow rapidly on this media.

wheat flour in the two proporties mentioned. The salt content of the produced soy sauce did not meet the standard amount of 17 to 20% (Yokotsuka, 1960). However, these salt concentrations can be adjusted accordingly. Considering all the qualities studied, it can be said that soy sauce from cooked sweet potato was comparable to that from wheat flour.

Sensory Evaluation

The mean acceptability scores of the root crop-based soy sauce and the commercial brand (Brand A) served in different ways are presented in Table 3. When used in preparing beef steak or as soy sauce dip for broiled fish, all test samples were comparable to Brand A. As pure sauce, the samples prepared from uncooked cassava and cooked sweet potato were as good as Brand A. In general, all the test samples were acceptable to the taste panel.

To determine the influence of color, aroma, consistency and flavor on consumers' choice of soy sauce; cooked cassava-based and cooked sweet potato-based soy sauce were compared with Brands A and B. Brand B is considered the best, most popular but quite expensive brand available with a color which approximates that of the test sample.

Sweet potato soy sauce was rated as good in all sensory qualities as the expensive Brand B and the more common Brand A. Similarly, cassava soy sauce was as good as Brand B but both were rated inferior to Brand A in terms of color, aroma and consistency (Table 4). It is not known why Brand B was rated as good as Brand A when offered together with sweet potato soy sauce

Table 2. Chemical properties of soy sauce extracted by screw type presser during the second trial.

Flour Used	Chemical Properties[1]				
	% Amino Nitrogen	% Protein	% TTA	pH	NaCl
Cassava/uncooked	0.23b	4.68b	1.63a	5.02a	13.77a
Cassava/cooked	0.26b	5.22b	1.29a	5.21a	13.28a
Sweet potato/ uncooked	0.30b	4.57b	1.30a	5.07a	14.00a
Sweet potato/ cooked	0.58a	5.83ab	1.60a	5.07a	12.75a
Wheat	0.57a	6.95a	1.69a	5.19a	13.92a

[1] Means in a column followed by a common letter are not significantly different at 5% level, DMRT.

but inferior to Brand A in some qualities when evaluated with cassava soy sauce.

Based on the sensory evaluation, it can be concluded that root crop-based soy sauce was generally comparable to the two commercial brands since the lower ratings in some aspects were still within the acceptable range.

Table 3. Mean acceptability scores of the soy sauce samples served in different ways.[1]

Soy Sauce Source	Mean Scores[2]		
	Pure Soy Sauce	Broiled Fish Sauce Dip	Beef Steak Marinated in Soy Sauce
Brand A	6.93a	7.20a	7.40a
Cassava/uncooked	6.40ab	6.33a	7.60a
Cassava/cooked	5.27c	6.27a	7.05a
Sweet potato/uncooked	5.20c	6.73a	7.25a
Sweet potato/cooked	6.00abc	6.87a	7.55a
Wheat flour (control)	5.07c	6.47a	7.05a

[1] Soy sauce samples were evaluated using the 9-point Hedonic scale with 9 as extremely acceptable and 1 as extremely unacceptable.

[2] Means in a column followed by a common letter are not significantly different at 5% level, DMRT.

Table 4. Comparison of sensory qualities of root crop-based soy sauce with two leading commercial brands offered as pure sauce.[1]

Treatment	Mean Scores[2]				
	Color	Aroma	Consistency	Flavor	General Acceptability
Sweet potato/cooked	7.17a	6.50a	6.94a	7.22a	7.06a
Brand A	6.94a	6.78a	7.28a	7.06a	7.11a
Brand B	6.28a	6.89a	7.33a	7.56a	7.44a
Cassava/cooked	7.10b	6.44b	7.00b	7.00a	6.94b
Brand A	7.75a	7.94a	7.74a	7.45a	7.60a
Brand B	7.30b	7.00b	6.97b	7.62a	7.45ab

[1] Three soy sauce samples as indicated under treatment were served at the same time to the same evaluators.

[2] Higher score means higher acceptability of the sample. Values within a column followed by a common letter are not significantly different at 5% level, DMRT.

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