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Development and Proximate Properties of Acceptable Taro-Soybean Flour

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Abstract— ***A sample of trained panelists was used to evaluate a food product formulation called "Taro-Soy", a taro based soy bean edible composite flour. The proximate properties of the most acceptable formulation were determined. Different formulations of taro and soy bean flour were prepared in varying proportions of Taro: Soy as 90:10, 80:20, 70:30, and 60: 40, each named F1, F2, F3 and F4 respectively. Formulation F3 was the most acceptable and its proximate properties were 05.23% moisture, 03.53% ash, 10.93% crude fiber, 16.64% proteins, 05.18%fat and 53.55% total carbohydrates, making it resourceful in solving food security challenges and reducing prevalence of protein energy malnutrition (PEM).***

Keywords— ***Colocasia esculenta, Taro blends, Soy blends,*** *PEM*, ***Proximate analysis***

I. INTRODUCTION

Greater emphasis has been put on the reduction of the prevalence of protein energy and micronutrient malnutrition, which prevails in lesser developed countries and is the gravest threat to the world's public health and the biggest contributor to child illness and mortality [1]. With this emphasis comes the need for strategic use of inexpensive high protein resources that complement the amino acid profile of the staple diets in order to enhance their nutritive value. Newer protein sources are being explored as protein complements of which oilseeds occupy a prominent place [2], [3], [4]. Addition of legume and beans to cereal and root based products could be a good option for increasing the intake of legumes and beans. In addition, legume proteins are rich in lysine and deficient in sulphur containing amino acids, whereas cereal proteins are deficient in lysine, but have adequate amounts of sulphur amino acids [5], [6].

Taro is native to south-central Asia, perhaps India, but introduced to other parts of the world where it is primarily grown as a root vegetable for its edible starchy corm, and as a leaf vegetable [7], [8], [9]. The bulbous corms are cylindrical and vary in size, normally 30-40 cm long. A corm is a short upright underground stem encircled with rings from where leaves have arisen. These appear as dark, scaly or papery sheaths. The flesh may be purple, white, yellow or pinkish, depending on the variety, with a cheesy or slimy consistency compared to the potato. It is known by many local names such as; "Elephant ears", Dalo, Taro turu, Gabi, Keladi, Talas, Yutou, Mayuni in different regions [10]. It is a staple food in Africa, Oceanic and South India cultures [11]. The plant belongs to the genus *Colocasia*, within the sub-family *Colocasioideae* of monocotyledonous family *Araceae* [7].

The fresh corm of taro has about two-thirds water and 13-29% carbohydrate. The predominant carbohydrate is starch [12]. Taro is an excellent source of potassium, which is an essential mineral for many bodily functions. Phosphorus, iron and some calcium, vitamin C, vitamin E and B vitamins, as well as magnesium, manganese and copper are also present. Taro contains 7% protein on dry basis but its leaves have 23% protein content [13]. The concentration of histidine, lysine, tryptophan, and methionine is very low but that of other essential amino acid is relatively higher.

Soy bean (*lysine max*) is probably the most important legume in the world [14]. The unripe seeds are cooked and eaten as a vegetable. The dried seeds may be eaten in different forms. They may be eaten sprouted, fermented, boiled whole or milled into flour or may be used to make soy milk and soy cheese [15]. Soy beans are high in protein, containing all the essential amino acids and rich in oil and good substitute for animal products unlike other beans, yet they are rarely eaten in Africa [16]. The plant is an annual plant sometimes referred to as greater bean. They are also considered by many agencies to be a source of complete protein [17].This therefore makes it an important legume in the supplementation of various food products.

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Taro is the world's 14th largest staple food crop [18]. The world produces 11,949,300 metric tons of taros, of which 42,472 metric tons are from Taiwan, 2039175 from Asia and 9506170 metric tons are from Africa. East African region produces about 80,110 metric tons of taros [19]. Despite its high yields and bio availability, taro remains underutilized due to factors like; bulkiness, inconvenience, and perishability, which make their transportation, storage and distribution difficult [20]. This therefore calls for the need to process taro into flour which has an extended shelf life, easily transported and stored due to the reduced bulk, coupled with easy preparation into porridge or paste. Due to the greatly limited protein content, taro flour needs to be blended with other foods such as soy-flour for protein supplementation. This is because soy bean is an outstanding source of protein due to its high content of about 50% from its flour that is needed to protein supplement the taro flour to come up with enriched porridge, hence reducing the prevalence of Protein Energy Malnutrition (PEM). This study was therefore aimed at developing instant taro based-soy composite flour that shall be more convenient, having improved shelf stability, highly digestible, and suitable for consumption by all age groups, thus enhancing taro utilization.

II. MATERIALS AND METHODS

CHEMICALS

Boric acid, hydrochloric acid, Diethyl ether, Sulphuric acid, Sodium hydroxide. All chemicals and solvents used in this study were of analytical grade.

FOOD MATERIALS

Fresh taro corms (*Colocasia esculenta*) and soy beans were purchased from a farmer in Uganda. This taro species was chosen due to its abundance and lower utilization. The type of soy beans that was used was the yellow variety locally cultivated in Uganda.

FLOUR PREPARATION

1. *Taro Flour.*

Raw taro was washed in clean water to remove soil, cooked till ready, cooled and peeled to remove the outer skin, grated and then sun dried for about three consecutive days. The dried grits were milled into flour and sifted to attain uniform flour particles.

2. *Soy Bean Flour*

Soy beans were cleaned to remove damaged and discolored soy beans and other extraneous materials. The soaked beans were then washed in clean water and soaked overnight to reduce on the level of water soluble anti-nutrients, sun dried, roasted for 25 minutes, allowed to cool, milled into flour, and sifted for uniformity.

PREPARATION OF DIFFERENT FORMULATIONS

Taro and soy bean flour were blended in various proportions to come up with different formulations of Taro: Soy as 90:10, 80:20, 70:30, and 60: 40. This was done for complementation purposes between the two flours. The different blends were named F_1, F_2, F_3, and F_4 respectively.

SENSORY EVALUATION OF THE DIFFERENT DEVELOPED FORMULATIONS

1. Preparation of Porridge

Porridge was prepared from each of the developed formulations for sensory evaluation. About 200g of flour were mixed with 250ml cold water to form slurry .The formed slurry was added to about 750mls of boiling water while stirring using a wooden spoon. Cooking was done for 5 minutes and porridge was served in labeled plastic cups for sensory evaluation.

2. *Sensory Evaluation Tests*

The already prepared porridge at about 40ºC was subjected to sensory evaluation by using questionnaire of nine-point Hedonic scale ranging from 9- extremely like to 1- extremely dislike. A panel of thirty untrained panelists was selected from volunteers among the students of Islamic University in Uganda (Mbale campus) to assess the overall acceptability, appearance, aroma, taste and mouth feel of the products. Before the study, all panelists were briefed about the procedure and each had to verbally consent to participation. All the participants were nonsmokers, fluent in English, self-reported to have normal taste and smell sensitivity. Panelists

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were requested to refrain from eating or drinking for at least 1 hour before the scheduled time for tasting. Each panelist was provided with a sensory evaluation form coded with samples F_1, F_2, F_3, and F_4. Water was also provided to each panelist for rinsing the mouth before and between successive tests. There was no any information provided to the panelists about the ingredients and quantity used to avoid bias in them.

PROXIMATE ANALYSIS OF THE FLOUR FROM THE MOST ACCEPTABLE FORMULATION

The most acceptable composite flour formulation (F_3) was subjected to proximate analysis. The proximate analysis of the flour blend for crude protein, crude fibre and fat contents were determined using the methods described by Pearson [21]. Crude protein determination was done using Kjedhal's method as described by Kirk et al. [22], while crude fibre determination was done using Wende's method. Fat content was determined using continuous solvent extraction method [23]. Total ash content was determined by furnace 'incineration using the method of James [24]. The determination of moisture content was based on moisture evaporation as suggested by Nwodo and Nwinyi [25] and carbohydrate contents were determined using the methods described by AOAC [26].

STATISTICAL ANALYSIS

All determinations were conducted in triplicate and the data generated was analyzed using SPSS version 16. Data from sensory evaluation was subjected to Analysis of Variance (ANOVA) to establish whether there was a significant difference in different formulation at $p \leq 0.05$.

III. RESULTS AND DISCUSSION

SENSORY EVALUATION RESULTS

Results of the sensory evaluation for different formulations of the developed flour are indicated in table 1. Generally the overall acceptability of F_3 was significantly different from that of other formulations.

TABLE I

MEAN SCORE FOR SENSORY EVALUATION OF THE PRODUCT

FORMULATION	APPEARANCE	FLAVOR	TASTE	MOUTH FEEL	OVERALL
F_1	5.20 ± 207^a	5.27 ± 1.95^a	5.07 ± 1.91^a	5.10 ± 2.43^a	5.70 ± 1.88^a
F_2	6.80 ± 1.19^b	6.73 ± 1.37^b	6.00 ± 1.68^a	5.90 ± 1.84^a	6.47 ± 1.45^a
F_3	6.70 ± 1.90^b	6.73 ± 1.34^b	6.37 ± 1.96^a	6.63 ± 1.87^b	7.03 ± 1.83^b
F_4	6.50 ± 2.05^b	6.57 ± 1.98^{ab}	6.03 ± 1.92^a	5.53 ± 2.03^{ab}	6.40 ± 1.98^a

Values with the same letters in the same column are not significantly different at $p \leq 0.05$ while those with different letters are significantly different at $p \leq 0.05$.

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APPEARANCE

Appearance is a visual perceptual property corresponding in humans to the categories called red, blue, brown, green and others [27]. It is derived from the spectrum of light interacting in the eye with the spectral sensitivities of the light receptors [28]. Results in Table 1 indicate that there was no significant difference in the appearance between formulation F1 and F4 *($p \leq 0.05$)*. But there was a significant difference between formulations F_1, F_2 & F_3. The appearance of F_2 was the most liked, followed by that of F_3. The appearance of F_4 was fairly liked while that of F_1 was the least liked of all. The Appearance of F_2 was most preferred to that of the rest of the formulations; this was attributed to the moderate quantity of roasted soy bean flour that provided a cream-like-brown color to the porridge. The cream-like-brown color provided by the soy bean flour was as a result of the Millard reaction due to roasting.

FLAVOR

Flavor is a sensation caused by properties of any substance taken into the mouth which stimulates one or both of the senses of taste and smell and/or also the general pain, tactical and temperature receptors in the mouth. Results indicated that there was no significant difference in the flavor between formulation F_1 and F_4 *($p \leq 0.05$)*. But there was a significant difference in the flavor between formulations F_1, F_2 & F_3. Results further indicated that the flavors for formulations F_2 and F_3 were the most preferred followed by that of F_4, the least one being that for F_1. The high preference for F_2 and F_3 may be attributed to the considerable amount of roasted soy bean flour that was adequate to mask the oxalate smell of the taro [29]. Soy beans contain flavor compounds majorly pyrazine, allypyrazine and acetoxy pyrazine, that give rise to roasted, toasted and caramel smell [30]. These therefore helped to improve the flavors of the two formulations. The flavor of F1 was the least liked and this may be due to the less amount of soy bean flour, whose flavor was not intense enough to out mask the oxalate smell of the taro.

TASTE

Taste as a sensory attribute is defined as a sense that distinguishes the sweet, sour, salty, and bitter qualities of dissolved substances in contact with the taste buds on the tongue. Results in the table indicate that there was no significant difference between formulations F_1, F_2 & F_3 and F_4 *($P \leq 0.05$.)*. The taste preference for formulation F_3 was the highest followed by , and F_1, F_2 that of F_1 being the least F_4 was most preferred and this may be due to the high soy bean flour levels that gave an equal taste blend. This could be attributed to the inherent sugars and amino acids present in the soy beans that provided a nutty and toasted taste [31].

BODY/MOUTH FEEL

The term body describes the physical properties like; heaviness, thinness, oiliness, graininess, or wateriness of the fluid as it settles on your tongue. Body involves identifying its tactile impression, consistency and weight as perceived in the mouth at the back of the tongue when porridge is eaten and swallowed. Results in this study showed that there was no significant difference in the body between formulations F_1, F_2 and F_4. The same applies to F_3 and F_4 at *($P \leq 0.05$)*. But there was a significant difference between formulations F_3 when compared with F_1 and F_2. There was a high preference for the body of formulation F_3 followed by F_2, F_4 while F_1 mouth feel was the least liked. It was also observed that the higher the percentage of soy bean flour, the lighter the porridge body. This might be attributed to the fact that soy flour has lower starch content than taro and thus a lower degree of gelatinization/ lower water holding capacity, making the porridge appear more watery when compared to the other formulations that had less soy bean flour and more taro flour [31].

OVERALL ACCEPTABILITY

There was no significant difference in the overall acceptability between formulations F_1, F_2 and F_4 *($p \leq 0.05$)* but there was a significant difference between formulations F_3 and the rest of the formulations ($P \leq 0.05$). The preference for formulation F_3 was highest followed by F_2, F_4, and that of F_1 was the least The high acceptability scores of F_3 could be attributed to the substantial amount of soy bean flour in relation to taro flour that contributed to its better taste, flavor appearance and body.

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1. *PROXIMATE COMPOSTION OF MOST ACCEPTABLE FORMULATION*

TABLE II

PROXIMATE ANALYSIS RESULTS FOR THE MOST ACCEPTABLE FORMULATION

Constituent	**Mean Values***
Moisture Content	5.2312±0.329
Ash Content	3.529±0.409
Crude Fibre	10.9261±2.579
Crude Proteins	16.635±0.296
Fat Content	5.1803±0.0435
Carbohydrates**	53.549

* Values in the table are means of triplicate determination ± standard deviation

**Values obtained by difference.

MOISTURE

This provides a measure of water content of the flour and also indicates its storability. The most acceptable flour formulation contained 5.2312% moisture on dry basis (Table 11). This low moisture content of the flour was probably attributed to the pre-drying of the taro grits and roasting of the soy beans before milling into flour. This moisture content, below 11%, gives the flour a better shelf life. This biochemical parameter is important in the storage of flour [32].

ASH CONTENT

This is an indirect indicator of the mineral level in the food product. The most acceptable flour formulation contained 3.529% ash on dry matter basis. Results revealed that the product had a higher ash content compared to pure taro flour values (0.60-1.3%) reported by Onwueme [33] and wheat (1.59 %), but significantly lower than 6.1% of the soy bean flour alone [34]. This observed difference may be attributed to the variety and geographical location of the crops.

CRUDE FIBER

This indicates the bulk of roughages in food [32]. The most acceptable flour contained 10.93%.This is a very high value compared to 1.4% crude fiber content of taro flour alone [33], but slightly higher than 9.3%, contained in soy bean flour alone [35]. The bigger difference in crude fiber composition between the composite flour and taro flour alone may be attributed to the blending of taro flour with soy bean flour that contains high crude fiber content. The high crude fiber content is important in the maintenance of a healthy gastral intestinal tract through facilitating bowel emptying.

PROTEIN CONTENT

The crude protein content obtained is higher than 1.4-3% protein content of taro flour alone [33], though very low if compared to that of soy bean flour alone which is 36.49% [35]. The significant difference in the crude protein content between taro flour alone and the most liked formulation was attributed to the addition of soy bean flour which has a very high protein value. The high value of proteins attained is essential in the synthesis of new cells and body maintenance, thus promoting growth. This therefore makes it a good food for infants, adults, and elderly.

FAT CONTENT

This high content of fat is attributed to the added soy bean flour that is considerably rich in fat (19.5%). The fat content is important in the synthesis of energy that facilitates normal body functioning.

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CARBOHYDRATE CONTENT

The most acceptable flour blend contained 53.549% total carbohydrates. This was attributed to the fact that the biggest portion of taro is highly starchy in nature [33]. This also explains why the porridge had a heavy consistence. The high carbohydrate content is important in the production of energy that enables proper body functioning.

IV. CONCLUSION

The study showed that the development of an acceptable taro based edible composite flour was possible.
The developed product had high nutrient content especially carbohydrates, proteins, en fat which makes it useful in addressing cases of malnutrition and food security. The locally available resources can be used to develop more shelf life stable products that can help eradicate hunger, poverty, malnutrition and improve social status as well. The developed flour therefore, being rich in proteins and carbohydrate stands the ability of solving the problem of Protein Energy Malnutrition (PEM).

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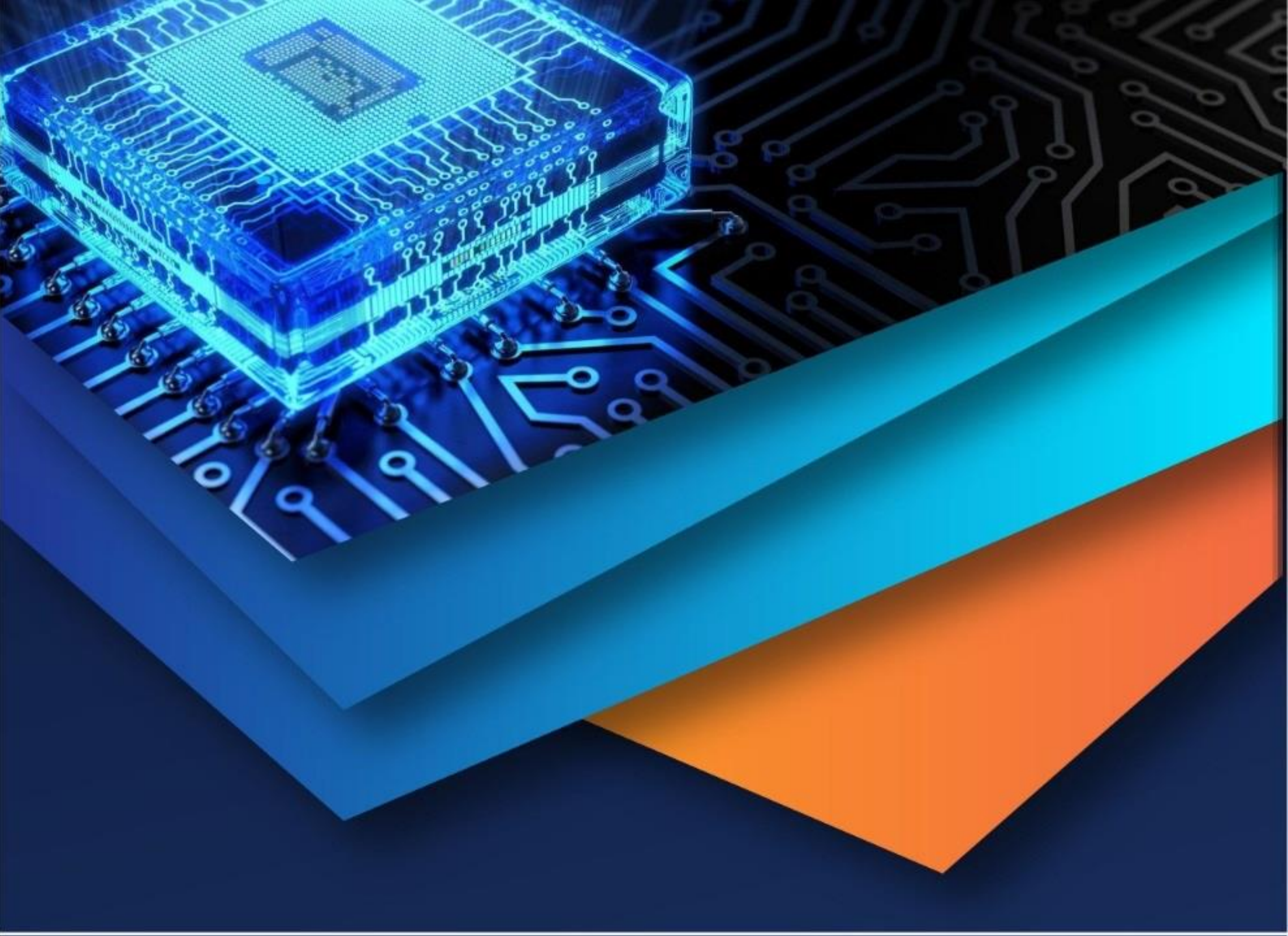

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