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Physico-Chemical and Sensory Evaluation of Cookies from Arrowroot Starch Enriched With Malted Soybean Flour

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ABSTRACT

Exploring Prospects for industrial utilization of arrowroot (*Tacca involucrata*) starch and desire to increase its nutritional content prompted this research. Cookies was produced from Arrowroot starch enriched with malted Soybean flour at different proportions of 100:0, 90:10, 80:20, 70:30, 60:40. 100% wheat flour was used as the control. Functional properties of the wheat and flour blends, proximate composition, mineral, vitamin content, physical properties, and sensory evaluation of the cookies were determined. Respectively, the functional properties of flour samples indicated Bulk density, dispersibility, oil and water adsorption capacity, swelling index, swelling capacity ranged 0.41-1.73g/ml, 79.09-99.26 %, 55.27-95.15 (g/Cm^3), 64.72-80.15, 0.10-0.54 ml/g, and 147.53-204.27 %. Proximate composition of cookies showed moisture, ash, fibre, fat, protein, carbohydrate, energy ranged 3.24-4.82 %, 2.65-4.50 %, 1.75-3.08 %, 1.74-3.04 %, 9.66-23.46 %, 66.90-80.46 %, and 357.14-376.97 Kcal/100g. Mineral content (mg/100g) of cookies revealed sodium, potassium, calcium, magnesium, zinc, and iron ranged 69.30-91.30, 98.56-117.04, 46.78-57.46, 58.19-77.51, 4.85-7.05, 69 and 1.43-2.45. Vitamin content (mg/100g) of cookies specified vitamins A,C, D,E and K ranged 988-1658, 0.002-O.007, 0.06-0.13, 1.85-5.34, and 13.46-22.36. Physical properties of cookies presented width, thickness, weight, fragility, diameter, spread ratio, and spread factor ranged 30.27-32.20 cm, 2.60-4.77 cm, 9.33-11.00 g, 283.33-616.67, 5.04-5.36 cm, 1.07-1.94, and 68.51-116. Based on sensory properties, the samples competed favorably with the control. There were significant differences ($p<0.05$) in all the values. Cookies from flour blend level 90:10 had highest overall acceptability. However, cookies from the flour blends of 70: 30 and 60:40 are recommended as best based on protein recommended dietary allowance (RDA) of adults (10%-35%). The lack of gluten in arrowroot starch makes it ideal as a replacement for wheat flour in baking, hence can be exploited for its potential use industrially as a snack food.

Keywords: Arrowroot, Cookies, Malted, *Tacca involucrata*, enriched.

INTRODUCTION

Cookies are popular examples of quick, ready-to-eat snack bakery product that possess numerous attractive features including wide consumption, carrying convenience, long shelf-life, tasty to eat, reasonably cheap and can serve as vehicles for important nutrient if made readily available to people [1], [2]. According to Uthumporn *et al.* [3], cookies with high nutritional value are greatly needed for proper functioning of body systems and potential health benefits. The main ingredients of cookies are wheat flour, fat (margarine) and sugar. They can also be enriched or fortified with other ingredients in order to meet specific Nutritional or therapeutic needs of consumers [1].

Roots and tubers refer to any growing plant that stores edible material in subterranean root, corm and tuber [4] and could substitute wheat in cookies production. African *Arrowroot (Tacca involucrata)* is a tuber found in the family of Taccaceae of the genus it is popular for its natural starch with almost zero fat [5]. It is widely distributed in most parts of the forest and Savannah region of Nigeria has also remained underutilized [6]. But,

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neglected and underutilized crops could play prominent roles in improving nutritional status and sustaining the impoverished rural African populations. Arrowroot starch is attracting interests from the industries that produce starch due to reports of its differentiated properties in bakery products, being used as a thickener in desserts and baked goods, food for elderly or patients with intestinal disorders. It may have additional health benefits to people following gluten-free diet or those managing their blood sugar and weight [7]. However, Studies revealed that Arrowroot is essentially composed of carbohydrate (90-92%) with very low level of proteins (2-3%), ash (2.5%) and lipids (2.1%) [7,8,9]. Hence, the need to enrich it with nutrient dense legumes like Soybeans, African yam beans, etc

Soybean sprouts are highly digestible and a good source of protein, vitamins and minerals [10]. Germination of soybean seeds is one of the best methods utilized in the improvement of nutritional profile of the soybean and which could be used for the food products development. It enhances bioavailability of the minerals, vitamins and dietary fibers which are of immense impact nutritionally and on health [11]. During germination, the protein content of soy flour is 6.90 percent higher with increase in essential amino acid content of mainly lysine, valine and threonine. In addition, there is increase in iron, vitamin A and vitamin B2 content as compared to the non-germinated soybean flour. Malted soybean protein constitutes about 40% of the total solids and plays a very important role in the enrichment of baked goods [12].

MATERIALS AND METHODS

Source of Raw Materials

Wheat flour, Soy bean, *Arrowroot (Tacca involucrata)* tubers and other baking ingredients such as eggs, baking powder, fat, sugar were obtained from Ortese market Mkar, Benue Gboko, Benue State Nigeria. All chemicals used were of analytical grade.

Methods

Preparation of arrowroot starch

Arrowroot starch was produced according to method of Chusut *et al.* [13]. with slight modification as shown in figure1

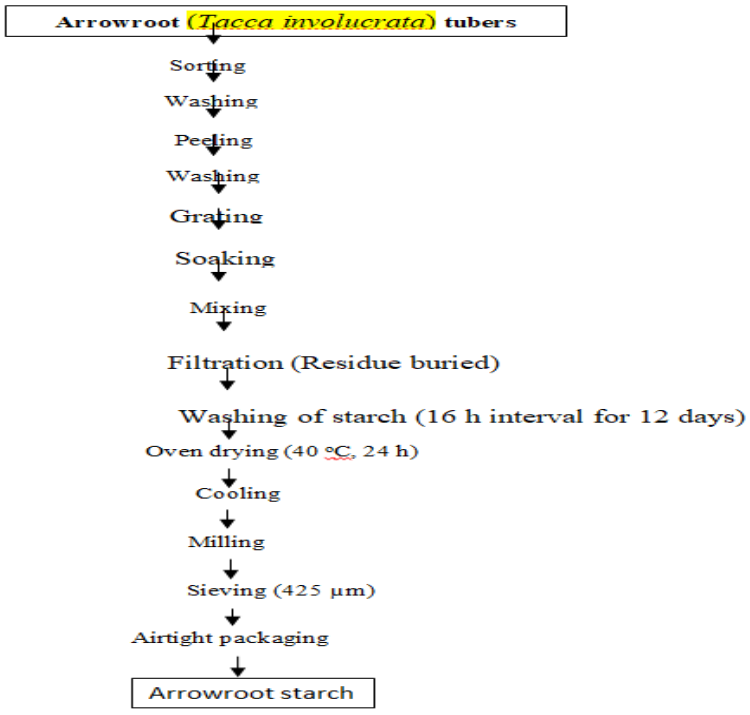

Figure 1: Flow Chart for Production of Arrowroot Starch

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Source: Chusut *et al*. [13].

Processing of malted soybeans flour

Malted Soybean flour was produced using method of Ayo et al. [14] with slight modification as shown in figure 2.

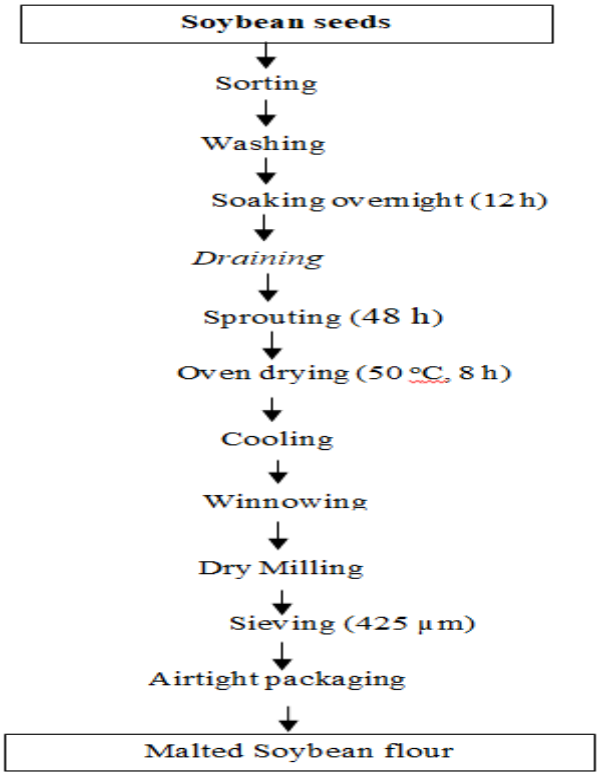

Figure 2: Flow Chart for Production of Malted Soybean flour

Source: Ayo et al. [14]

Blends formulation of arrowroot starch and malted soybean flour

Blend formulation of Arrowroot starch and malted Soybean flour with Wheat flour as the control sample is as shown in Table 1.

Table1: Blend Formulation of Arrowroot starch enriched with malted Soybean flour

Samples	**Wheat flour (%WF)**	**Arrowroot starch (%ARS)**	**Malted soybean Flour (MSF%)**
A (control 100WF)	100	0	0
B (100ARS:OMSF)	0	100	0
C (90ARS:10MSF)	0	90	10
D (80ARS:20MSF)	0	80	20
E (70ARS:30MSF)	0	70	30
F (60ARS:40MSF)	0	60	40

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Source: Modified method – Uthumporn, *et al.* [3].

Cookies recipe

The recipe of cookies from arrowroot starch enriched with malted soybean flour was according to the modified recipe of Kundam *et al.* [15] as shown in Table 2.

Table 2: Recipes for Cookies from Arrowroot starch enriched with malted Soybean flour

Ingredient	**Composition (g)**
Flour	54.5
Sugar	20
Fat	20
Eggs	5
Baking powder	0.5

Source: Kundam, *et al.* [15] Modified

Cookies from arrowroot starch enriched malted soybean flour

Cookies were prepared according to the method of Kundam, *et al.*[15] as shown in figure 3.

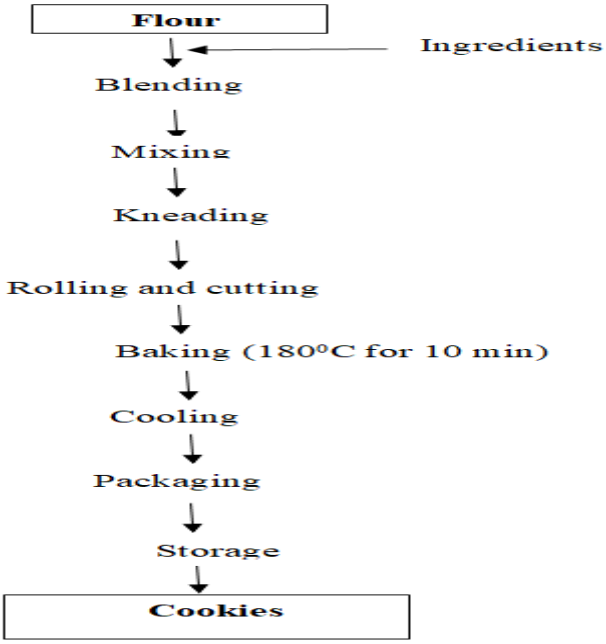

Figure 3: Flow Chart for Production of Cookies

Source: Kundam, *et al.*[15]

Analyses

Functional properties of flours

Functional properties such as bulk density, dispersibility, water absorption capacity, oil absorption capacity, swelling index, and swelling capacity were determined as described by the standard methods of AOAC [16].

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Proximate composition of cookies from arrowroot starch enriched with malted soybean flour

Proximate composition was determined using the standard AOAC, [16]. The samples were analyzed for moisture, ash, crude fiber, crude fat and crude protein. Carbohydrate was calculated by the difference. The energy content of the cookies was determined using the equation shown in (i).

$$Energy\ (kcal\ 100\ g/) = 4 \times \%Protein + 9 \times \%Fat + 4 \times \%Carbohydrate \qquad \text{(i)}$$

Vitamin content of cookies from arrowroot starch enriched with malted soybean flour

The methods AOAC [16] were used to determine vitamins A, B_1, C, D, E and K.

Mineral content of cookies from arrowroot starch enriched with malted soybean flour

Mineral content of samples: Sodium, Potassium, Calcium, Magnesium, Phosphorus, zinc and

Manganese were determined using the standard methods described by the AOAC [16].

Physical properties of cookies from arrowroot starch enriched with malted soybean flour

Physical properties of cookies were determined according to Kundam, *et al.* [15]. The spread factor (SF) was determined from the width and thickness figures as in equation (ii).

$$SF = \frac{W}{T} \text{ x C.F x } 10. \qquad \text{(ii)}$$

Where, C.F is the correction factor for adjusting $\frac{W}{T}$ to constant atmospheric pressure. For this work correction factor C,F = 1.00. Diameter and thickness of the cookies was used to determine the spread ratio (SP) as described by Sengev, et al. [17], in equation (iii).

$$SP = \frac{Diameter}{Thickness} \qquad \text{(Sengev, et al.) [17]} \qquad \text{(iii).}$$

Sensory properties of cookies from arrowroot starch enriched with malted soybean flour

The sensory evaluation of the cookies was determined according to the procedure of Kundam *et al.* [15] based on six attributes: appearance, aroma, crispiness, texture, taste and overall acceptability on a 9-point hedonic scale where a higher score indicates better quality attributes. Twenty-four hours after preparation of the cookies, sensory evaluation was carried out. A total of 50 semi-trained panellists were recruited from students (age's 20-24years) of the University of Mkar, Mkar. The criteria for selection of panellists were that, the students were familiar with and regular consumers of cookies and were not allergic to any food. They were instructed to rinse their mouths with water after every sample and not to make comments during evaluation to prevent influencing other panellists. They were also asked to comment freely on the samples on the questionnaires administered to them. The samples were identified with three-digit code numbers and presented in a random sequence to panellists.

Statistical Analysis

Determinations were carried out in triplicate. Results are presented as mean value ± standard deviation and analyzed by one way analysis of variance (ANOVA) using SPSS software package version 26. Significant differences between means were determined by Duncan multiple range test (DMRT) at 95 % confidence limit.

RESULTS AND DISCUSSION

Functional Properties of Flours from Arrowroot starch enriched with malted Soybean flour

Functional properties of a food material are parameters that determine its application and end use [18].

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Results on the functional properties of the flours are presented in Table 3. Significant ($p < .05$) differences were observed in functional properties of the flours. The bulk density (BD) ranged 0.41-1.73 g/ml; showed decreased as the incorporation of malted soybean flour increased. However, Chandra and Shamer [19] obtained higher values from a range of 0.72-0.91 g/cm3 which could be because their flours were from single wheat, rice, millet and potato flours and not blends. This result is in agreement with the results of Ohizua *et al.*[20] with a bulk density of 0.48-0.92g/ml. Higher bulk density is desirable for greater ease of dispersibility and reduction of paste thickness; while low bulk density of flour is a good physical attribute when determining transportation and storability [21].

Dispersibility is an index that measures how well flour or flour blends can be rehydrated with water. It ranged from 79.09-99.26%, which is higher than the dispersibilities of the flour blends (64.67-70.0 %) reported by Adeola *et al.*[22] for sorghum, pigeon pea and Soybean flour blends. All the flour blends had relatively high dispersibility, signifying that they would reconstitute easily to fine consistent dough or pudding during mixing [23].

Oil absorption capacity measures the ability of food material to absorb oil. It is the flavour retaining capacity of flour which is very important in food formulations [20]. The mechanism of fat absorption is attributed mainly to the physical entrapment of oil and the binding of fat to a polar chain of protein. Non-polar amino acid side chains can form hydrophobic interaction with hydrocarbon chains of lipids [24]. Oil Adsorption Capacity ranged from 55.27-95.15%. The oil adsorption capacity increased with increase in malted soybean flour addition. The highest oil absorption capacity was recorded in sample F as a result of its highest malted soybean content. Elochukwu *et al*. [25], reported similar increase of oil absorption capacity for wheat-plantain and wheat-defatted cashew kernel composite flours. Oil absorption capacities of foods increase with increased protein content since the protein in foods influences fat absorption. Sample F had higher oil absorption capacity as a result of the hydrophobic character of protein in the flour. The presence of protein exposes more non-polar amino acids to the fat and enhances hydrophobicity as a result of which the flour absorbs more oil [26].

Water Adsorption Capacity (WAC) characteristic represents the ability of the product to associate with water under conditions when water is limiting such as dough and pastes.It ranged 64.72-80.15%. The water adsorption capacity decreases with increase in malted soybean flour. Significant reduction of water absorption capacity was identified in sample F (64.72 g/cm3) having the least value. This result conforms to the work of Malomo *et al.* [27], where the WAC decreases with increasing protein content.

Swelling index of flours depends on size of particles, type of variety, and types of processing methods or unit operation [19]. Wheat flour (WF) had the highest swelling index value (0.54 ml/g) while the arrowroot (TC) flour had the lowest (0.10 ml/g). Increase in the inclusion of malted soybean flour resulted in the increase of swelling index. The ability of flour to absorb and retain water suggests better performance in texture and baked product as reported by Olaitan, *et al.* [28].

The swelling capacity is used in the determination of the amount of water that food samples can absorb and the degree of swelling within a given time. It ranged 147.52-204.27 %, there was significant ($p \leq 0.05$) different amongst samples. The Swelling capacity increased with increasing level of malted soybean flour inclusion. Highest swelling capacity was reported in sample F which had the highest quantity of malted soybean flour. High swelling capacity has been reported as part of the criteria for a good quality product [29].

Table 3: Functional Properties of Flours from Arrowroot starch enriched with malted Soybean flour

Samples (%)	Bulk density (g/ml)	Dispersibility (mL/G)	Oil absorption Capacity (g/Cm^3)	Water absorption Capacity(g/Cm^3)	Swelling Index (mL/g)	Swelling Capacity (%)
A (control 100WF)	0.83^{ab}±0	79.09^{d}±0.58	55.27^{f}±0.06	80.15^{a}±0.04	0.54^{a}±0.04	155.85^{e}±0.35

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B(100ARS: OMSF)	1.73^{a} ±0. 10	99.25^{a} ±0.01	70.39^{e} ±0.39	78.33^{a} ±0.02	0.10^{e}±0.01	147.52^{f}±0.04
C(90ARS:1 0MSF)	0.88^{b} ±0. 01	99.26^{a} ±0.01	80.22^{d} ±0.01	71.58^{b} ±5.91	0.17^{d}±0.02	162.90^{d}±0.35
D(80ARS:2 0MSF)	0.85^{bc} ±0 .01	98.84^{ab} ±0.02	82.52^{c} ±0.02	66.43^{c} ±0.01	0.29^{c}±0.06	184.56^{c}±0.70
E(70ARS:3 0MSF)	0.80^{c} ±0. 10	98.28^{a} ±0.51	85.19^{b} ±0.06	64.72^{c} ±0.09	0.30^{c}±0.04	195.12^{b}±0.52
F(60ARS:4 0MSF)	0.41^{d} ±0. 01	89.15^{c} ±0.01	95.15^{a} ±0.06	64.72^{c} ±0.08	0.38^{b}±0.02	204.27^{a}±0.89

Values are means± standard deviations of triplicates. Means in the same column with different superscripts are significantly ($p<0.05$) different

Proximate composition of Cookies from Arrowroot starch enriched with malted Soybean flour (%)

The proximate composition of foods is used to determine the nutritive value and acceptability of the food products. The result is presented in Table 4. Moisture, crude protein, ash, crude fiber, fat, carbohydrate and energy. The moisture content of the Cookies ranged 3.24-4.82%. It decreased with increasing malted soybean flour inclusion. Low moisture content is advantageous, as high moisture content has been associated with short shelf life of baked products, as they encourage microbial proliferation that lead to spoilage [30]. This results agree with Ikuomola *et al.*[31] who reported moisture content of 3.34-4.06% for cookies. The moisture content of a product is an index of the shelf life of that product.

The crude protein content of the Cookies samples ranged 7.34-23.46 %. Sample B had lowest and F highest. The protein content increase with increasing addition of malted soybean flour. due to its high protein content. The increase in protein content are within the range as the findings of Ikuomola *et al.*[31] and Ufot *et al*.[32]. The high protein content in the malted soybean fortified Cookies would be of nutritional importance in most developing countries like Nigeria where many people can hardly afford high proteinous foods because of high cost.

Fat is essential component of tissues and a veritable source for fat soluble vitamins (A, D, E and K). It is able to supply thrice the amount of energy required by the body. The values of the fat content ranged1.74-3.04%. The lowest value was observed in sample B and highest in F (3.04%) which could be resultant increasing malted soybean flour inclusions. These values are relatively low. However, the low-fat content of cookies is advantageous as high oil content in Cookies would affect the shelf stability.

The ash content of the cookies samples increased with increasing inclusion of malted soybean flour 2.65% to 4.50%. Higher ash contents indicated that the mineral content was higher in the malted soybean flour.

The crude fibre content of the cookies was lowest in sample B (1.75%) and highest in F (3.06%). This result indicated that malted soybean flour contains higher amount of crude fiber than arrow root and wheat flour. This could be the reason an increasing in fiber content was observed as increasing proportion of germinated soybean flour were added. The crude fibre contents of the Cookies, was within the recommended range of not more than 6 g dietary fibre and other non absorbable carbohydrates per 100 g dry matter [33]. Consumption of high fibre food products has been linked to reduction in hermorrhoids, diabetes, high blood pressure, and obesity [34].

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The carbohydrate content of the cookies decreased with increased addition of germinated soybeans flour from 81.70 %-62.68 %. The reason for the reduction could be due to the increasing in protein, fat, and fiber content of the cookies as the proportion of germinated soybean flour in the formulation was increasing. A similar reduction in carbohydrate content was also reported by Atobatele, *et al.* [35] in their study of blending wheat flour with residue from king palm processing which contains a higher fiber, ash and fat content than wheat flour. Energy is the amount of calorie available from food that is available through oxidation. Nutritionist usually talk about the number of calorie in a gram of a nutrient. Fats have the greatest amount of food energy 9kcal/g while proteins and most carbohydrates have about 4kcal/g [36]. The energy values ranged 369.32-374.92 Kcal/100g are higher than those reported in biscuits produced from wheat-orange-fleshed flour composite by Andualem *et al*. [37]. The high caloric values observed from this research result implies that, these cookies produced can provide consumers with requires energy for all bodily functions.

Table 4: Proximate Composition of Cookies from Arrowroot starch enriched with malted Soybean flour

Sample	**Moisture (%)**	**Ash (%)**	**Fiber (%)**	**Fat (%)**	**Protein (%)**	**Cho (%)**	**Energy Kcal/100g**
A	$4.58^{a}\pm0.47$	$3.35^{d}\pm0.07$	$2.14^{d}\pm0.03$	$2.24^{b}\pm0.39$	$10.87^{d}\pm0.43$	$76.82^{c}\pm0.46$	$370.92^{c}\pm1.47$
B	$4.82^{a}\pm0.48$	$2.65^{f}\pm0.10$	$1.75^{f}\pm0.01$	$1.74^{d}\pm0.06$	$7.34^{f}\pm0.01$	$81.70^{a}\pm0.49$	$371.82^{c}\pm1.97$
C	$4.08^{b}\pm0.27$	$3.08^{e}\pm0.15$	$1.93^{e}\pm0.01$	$1.87^{c}\pm0.02$	$9.66^{e}\pm0.31$	$79.38^{b}\pm0.18$	$372.99^{b}\pm1.88$
D	$4.37^{ab}\pm0.13$	$3.54^{c}\pm0.27$	$2.36^{c}\pm0.02$	$2.08^{b}\pm0.22$	$12.40^{c}\pm0.46$	$75.25^{d}\pm0.78$	$369.32^{d}\pm2.37$
E	$3.43^{c}\pm0.67$	$3.98^{b}\pm0.01$	$2.66^{b}\pm0.02$	$3.04^{a}\pm0.16$	$14.61^{b}\pm0.26$	$72.28^{e}\pm0.46$	$374.92^{a}\pm0.36$
F	$3.24^{c}\pm0.19$	$4.50^{a}\pm0.05$	$3.08^{a}\pm0.02$	$3.04^{a}\pm0.16$	$23.46^{a}\pm4.9$	$62.68^{f}\pm5.49$	$371.92^{c}\pm3.67$

Values are means± standard deviations of triplicates. Means in the same column with different superscripts are significantly ($p<0.05$) different

Minerals Content of Cookies from Arrowroot starch enriched with malted Soybean flour

Minerals are inorganic elements which are essential for the normal functioning of the body. They are necessary in smaller quantities in addition to proteins, carbohydrates, fats and vitamins, they are inorganic or "ash constituents" of foods which cannot be destroyed by heating. The higher the ash content, the more its mineral contents [38] The minerals compositions of the cookies are presented in table 5. Sodium ranged 69.3 -91.30 mg/100g

The control sample A had the highest (91.30 mg/100g) followed by sample F (86.53 mg/ 100g). The result demonstrated an increase in sodium content of composite flours with increasing inclusion of malted soybean flour. Sodium is the principal extracellular cation and is used for acid-base balance and osmo-regulation, Sodium stimulates cell proliferation, protein synthesis and increase cell mass [39].

The potassium content of samples ranged 98.56-117.04 mg/100g. Sample F having 115.04 mg/100g, compared favourably with the control. Samples showed significant difference ($p<0.05$) in their potassium content. The potassium content of Cookies from the blends, increased with increasing inclusion of malted soybean flour. The most abundant mineral in the composite cookies is potassium followed by sodium which corresponded with the finding of Ufot *et al*.[32].

Calcium plays a major role in muscle function, formation and strengthening of bones, teeth, conducting nerve impulses, and blood clotting, and maintaining a normal heartbeat [40]. This study revealed significant presence of calcium in cookies from the blends and this is attributed to the calcium contents of germinated soybean

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flour. The calcium ranged 46.78 - 57.46 mg/100g. The highest value (57.46 mg/100g) was observed in the sample F, because soybean is rich source of calcium.

Magnesium regulates diverse biochemical reactions in the body, including protein synthesis, muscle and nerve functions, blood glucose control and blood pressure regulation. It also keeps bones strong and heart rhythm steady [41]. The magnesium content of cookies samples ranged 58.19-77.51mg/100g. Sample F (72.56 mg/100g) compared favourably with the control.

Zinc is required for good immune system function, cell growth, wound healing, and insulin function [42]. Sample F was higher in zinc content (7.05 mg/100g) than all other samples, It was observed that increasing inclusion of malted soybean flour resulted in the progressive increase in zinc contents.

The iron content of cookies ranged 1.43-2.45 mg/100g. Result showed a progressive increase in iron content of cookies with increasing level of germinated soybean flour inclusion.

Iron aids in transport of oxygen in red blood cells and in muscles [43]. Hence, an indication of Iron presence in these cookies is very vital.

Table 5: Minerals Content of Cookies from Arrowroot starch enriched with malted Soybean flour (mg/100g)

Samples	Sodium	Potassium	Calcium	Magnesium	Zinc	Iron
A	91.30^{a} ±0.02	117.04^{a} ±0.02	50.06^{c} ±0.04	77.51^{a} ±0.02	4.85^{f} ±0.02	1.43^{f} ±0.02
B	69.3^{f} ±0.05	98.56^{f} ±0.05	46.78^{e} ±0.03	58.19^{f} ±0.02	4.93^{e} ±0.03	1.54^{e} ±0.03
C	75.03^{e} ±0.01	106.06^{e} ±0.04	48.58^{d} ±0.02	62.57±0.03	5.84^{d} ±0.03	1.72^{d} ±0.01
D	82.38^{d} ±0.03	107.07^{d} ±0.03	50.02^{c} ±0.09	65.79^{d} ±0.02	5.96^{c} ±0.02	1.87^{c} ±0.03
E	85.03^{c} ±0.10	110.48^{c} ±0.04	54.47^{b} ±0.03	70.27^{c} ±0.03	6.04^{b} ±0.02	2.08^{b} ±0.04
F	86.53^{b} ±0.01	115.04^{b} ±0.03	57.46^{a} ±0.04	72.56^{b} ±0.05	7.05^{a} ±0.03	2.45^{a} ±0.02

Values are means± standard deviations of triplicates. Means in the same column with different superscripts are significantly ($p<0.05$) different

Vitamin Content of Cookies from Arrowroot starch enriched with malted Soybean flour

Vitamin content of Cookies samples is presented in Table 6. Vitamins are essential organic compounds having a high impact on human health. They are vital for plant and animal metabolism since they serve as enzymatic cofactors [44]. Deficiencies of vitamins could lead to disorders which can be severe and even fatal so adequate intake can be prevention as humans cannot synthesize vitamins, they must be assimilated from diets [44]. It was observed that increasing inclusion of malted soybean flour resulted in increasing vitamin content of the samples.

Vitamin A content ranged from 988 to 1530 mg / 100 g. This results are similar to the one published by Logue, [45].

The vitamin C content of cookies ranged 10.46-22.36 mg/100g demostrating significant ($p<0.05$) difference amongst samples. Higher vitamin C content was recorded for wheat flour cookies, but sample F compared favourably with wheat cookies. High vitamin C content of the cookies suggests that the various Cookies were a good sources of vitamin C.

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The vitamin D content of Cookies samples ranged 0.06 - 0.13 mg/100g indicating vitamin D content was in small quantities in the samples. Sample F having just more than the others.

Result demonstrated a progressive increase in the vitamin E content of cookies with increasing inclusion of malted soybean flour. It ranged1.85-5.34 mg/100g. The higher content was in sample F which compares favourably with Mirwais *et al.[46]* who reported 5.91 mg/100g in germinated soybean. This is in consonance with Aguilera *et al.[47]*, who reported that germination is a cheap and current technology to enhance the nutritional quality of vegetables, by its improving antioxidant capacity, digestibility of proteins, increasing vitamins C and E content and reducing anti-nutritional factors.

Vitamin k was observed to be present in minute quantities ranged 0.002 to 0.007 mg/100g.

Table 6: Vitamin Content of Cookies from Arrowroot starch enriched with malted Soybean flour (mg/100g)

Sample	VIT A	VIT C	VIT D	VIT E	VIT K
A	1141^{d} ±1.65	22.36^{a} ±0.43	0.07^{bc} ±0.12	3.30^{d} ±0.01	0.002^{e} ±0.00
B	988^{f} .±1.88	10.46^{f} ±1.12	0.06^{c} ±0.1	1.85^{f} ±0.00	0.002^{e} ±0.00
C	1007^{e} ±1.66	14.32^{e} ±0.40	0.06^{c} ±0.01	2.15^{e} ±0.01	0.003^{d} ±0.00
D	1186^{c} ±1.45	17.07^{d} ±2.28	0.08^{b} ±0.01	3.58^{c} ±0.00	0.004^{c} ±0.00
E	1530^{b} ±1.47	19.15^{c} ±1.14	0.09^{b} ±0.00	3.65^{b} ±0.01	0.006^{b} ±0.00
F	1658^{a} ±1.66	20.52^{b} ±0.23	0.13^{a} ±0.00	5.34^{a} ±0.02	0.007^{a} ±0.00

Values are means± standard deviations of triplicates. Means in the same column with different superscripts are significantly ($p<0.05$) different.

Physical properties of Cookies from Arrowroot starch enriched with malted Soybean flour

Physical properties the cookies are presented in Table 7. Results revealed that the physical characteristics of the prepared cookies varied with the variation in the proportion of malted soybean flours in the different samples. Similar observations have been reported by other authors [48, 5]. The diameter of cookies ranged 5.04-5.36 Mm and decreased as the proportion of germinated soybean increased. This could be due to the fact that, germinated soybean is gluten free, the high sugar, fat and fibre contents of the malted soybean absorbed much water, leading to swelling, gelling and binding together, thus preventing spreading

The thickness of Cookies ranged 2.60-4.77 Mm. There was increased in the thickness with increase in malted soybean inclusion which could be due to the swelling and binding of the cookie components due to water absorption. This is consistent with the findings of Chinma and Gernah [49], who reported a similar observation when wheat was substituted with cassava/soybean/mango flour. Djantou *et al*. [50] reported high sugar content in MMF, which probably competes for the limited free water due to the presence of hydrophilic sites, thereby increasing the thickness.

The cookies weight ranged 9.33-11.00 g. Sample F, had the least weight (9.33g), while B; (11.00g) had the highest. This is in agreement with the reports by Dabel, *et al.[51], who* recorded lower weight of cookies with increase in germinated soybean flour addition which could be as a result of higher fat content in the germinated soybean flour relative to other flours as fat is lighter in weight than water.

The spread ratio of cookies ranged 1.07-1.94. Sample F had the least (1.07) while the highest (1.94) was A.

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Cookies with higher values of spread ratio are considered to be more desirable than those with lower values [5].

Table 6: Physical properties of Cookies from Arrowroot starch enriched with malted Soybean flour

Sample	Width (Mm)	Thickness (Mm)	Diameter (Mm)	Weight (g)	Fragility (g)	Spread ratio (D/T)	Spread factor (W/T*10*1)
A	30.27±0.25^{c}	2.60±0.10^{c}	5.04±0.04^{c}	10.00±1.00^{b}	616.67±28.87^{a}	1.94±0.08^{a}	116.54±4.99^{a}
B	32.20±1.13^{a}	3.77±0.15^{b}	5.36±0.18^{a}	11.00±1.00^{a}	366.67±28.87^{b}	1.42±0.03^{bc}	244.55±359.38^{a}
C	31.50±0.20^{ab}	3.80±0.10^{b}	5.25±0.04^{ab}	11.00±1.00^{a}	296.67±5.77^{c}	1.38±0.51^{c}	68.51±1.74^{a}
D	31.00±0.46^{bc}	4.60±0.10^{a}	5.15±0.05^{bc}	9.67±1.53^{a}	283.33±28.87^{c}	1.20±0.04^{b}	82.43±4.62^{a}
E	30.90±0.53^{bc}	4.77±0.21^{a}	5.15±0.09^{bc}	9.33±1.53^{a}	290.00±36.06^{c}	1.07±0.06^{b}	81.38±3.48^{a}

Values are means± standard deviations of triplicates. Means in the same column with different superscripts are significantly ($p<0.05$) different

Sensory properties of Cookies from Arrowroot starch enriched with malted Soybean flour

Sensory properties are presented in the Table 7. The cookies ranges were; appearance 6.96-7.68, taste 6.44-8.28, texture 6.64-7.76, aroma 6.56-7.60, crispiness 6.52-7.88 and overall acceptability 6.72-8.28 respectively. The beautiful golden brown colour observed in the appearance of the cookies samples was due to Maillard reactions and caramelization of sugars [52]. Taste is an important sensory attribute of any food because of its influence on acceptability. Increase in addition of malted soybean flour resulted in taste that compared fairly to wheat cookies (the control). Also, addition of germinated soybeans flour improved the texture of the cookies. These findings agreet of Akubor and Ukwuru in Elisa el ta. [53].

Table 7: Sensory properties of Cookies from Arrowroot starch enriched with malted Soybean flour

Samples	Appearance	Aroma	Taste	Crispiness	Texture	Overall acceptability
A	7.68^{a} ±1.14	7.60^{a}±0.96	8.28^{a} ±1.24	7.60^{a}±0.9b	7.76^{a} ±0.83	8.28^{a} ±0.84
B	7.64^{a} ±1.18	7.20^{ab} ±1.20	7.68^{a} ±0.94	7.88^{a} ±1.12	7.68^{a} ±0.94	8.12^{a} ±0.88
C	7.28^{a} ±1.21	6.64^{b} ±1.15	6.80^{b} ±1.22	6.56^{b} ±1.32	6.80^{bc} ±1.22	7.32^{bc} ±1.34
D	7.12^{a} ±1.09	7.20^{ab} ±1.08	6.44^{b} ±1.91	6.60^{b} ±1.32	6.64^{c} ±1.22	7.02^{c} ±1.10
E	7.23^{a} ±1.27	6.56^{b} ±1.00	6.72^{b} ±1.24	6.52^{b} ±1.39	6.80^{cb} ±1.47	7.28^{bc} ±1.24
F	7.36^{a} ±1.32	6.76^{b} ±1.39	7.04^{b} ±1.24	6.84^{b} ±1.43	7.36^{ab} ±1.15	7.64^{ab} ±1.28

Values are means± standard deviations of 15 determinations. Means in the same column with different superscripts are significantly ($p<0.05$) different

CONCLUSION

The study established that acceptable cookies could be produced from Arrowroot starch enriched with malted

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soybean flours. There was an increase in protein, vitamin and mineral content of the Arrowroot starch based cookies with increasing substitution level of malted soybean flour. The study also showed revealed that inclusion of malted soybean flour did not alter the consumer acceptability of the cookies especially sample C (90:10). However, samples E (70: 30) and F (60:40) are recommended as best based on protein recommended dietary allowance (RDA: 10%-35%). Industrial production of these Cookies from flour blends of Arrowroot starch and malted soybean flour should be done to increase the utilization of the lesser known Arrowroot tuber, prevent its extinction and reduce total dependence on wheat flour. It is recommended that further research be carried out to determine shelf life of the cookies and the appropriate packaging material.

Authors' Contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

Competing Interests

Authors have declared that no competing interests exist

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