International Journal of Food Science and Nutrition
ISSN: 2455-4898
Impact Factor: RJIF 5.14
www.foodsciencejournal.com
Volume 3; Issue 5; September 2018; Page No. 71-79

Preparation and improved quality production of flour and the made biscuits from the taro

Nguyen Van Toan[1*], Phan Thi Thanh Thanh[2]

[1-2] Department of Food Technology, School of Biotechnology, International University, Vietnam National University, Ho Chi Minh City, Block 6, Linh Trung Ward, Thu Duc District, Ho Chi Minh City, Vietnam

Abstract

Among various biological properties, the fleshed taro has been increasingly paid special attention to the basis of nutritional aspects as they are excellent sources of powerful natural antioxidants of which, provide various health beneficial effects. As a consequence, a successful combination of The Taro flour with wheat flour for biscuits production would be nutritionally advantageous. In this study, the Taro flour was incorporated with wheat flour in ratio of 10%, 20%, 30%, 40% and 50%. The physico-chemical analysis and sensory evaluation was done to know the acceptability of taro-wheat composite biscuits. On the basis of nutritional value, biscuits containing 40% and 50% taro flour is acceptable as it contains higher nutritional contents than other samples, whereas at all levels of taro substitution, the composite biscuits samples were either acceptable as or better (30 % substitution) than 100 % wheat biscuit. The obtained results of this study have indicated that the taro-wheat composite biscuits were not only improved in terms of nutritional value and health benefits, but also had high potential of being accepted by consumers.

Keywords: taro flour, taro biscuits, physicochemical analysis, sensory evaluation, nutritional values, functional foods

Introduction

Taro is a tropical root crop belonging to the monocotyledonous family Araceae. Taro (Colocasia spp) is widely cultivated in tropical areas of the world such as South East Asia, the Pacific Islands, the Mediterranean, Africa and the United States of America [1]. According to the Food and Agriculture Organization of the United Nations (FAO, 2013). Between 1993 and 2013, the leading producer of taro was Africa with 75.2% of world production, followed by Asia (20.8%), Oceania (3.8%) and the Americas (0.3%). Nigeria accounted for 40% of world production with 3.4 million per year and other top producers were China, Ghana and Cameroon. Taro, a staple food source of central Vietnam, is an important crop for two main reasons. The first is that it is a basic food source that can serve as safety net during times of hardship. The second is that with the right materials and levels of care, it is a relatively resilient and easy plant to grow; it is one of a few crops found in the region that is able to flourish in highly degraded, infertile and sandy land. Taro is one of three crops targeted by the Global Project for Strengthening the Scientific Basis of In situ Conservation of Agricultural Biodiversity on-farm in Vietnam [2].

Taro deteriorates rapidly as a result of its high moisture and has been estimated to have a shelf-life of up to one month if undamaged and stored in a shady area. Post-harvest losses of up to 30% have been reported and is said to be caused by mechanical damage during harvesting, respiration, sprouting and microbial rotting. One of good ways to reduce postharvest losses, expand its scope of usage and consequently benefit immensely from its economic potential, taro is processed into flour for use as a starting material for preparing certain customary delicacies and for industrial purposes [3].

According to Hossain (2016) [4], a substitution level of 10% taro flour in bread making was showed physical properties similar to wheat bread samples, especially for products from taro-wheat composite flour. The taro-wheat composite flour had the lowest setback and processing stability, which indicated low staling or aging of dough for bread substituted with taro flour. The composite bread would serve as functional food because of the high trace element content. The composite bread with taro-flour substitutions will be nutritionally superior (have higher minerals and crude fiber content) to whole wheat bread. In addition. Noorfarahzilah (2014) [5] stated that blends of refined wheat flour with colocasia, Taroand water chestnut flours respectively at a replacement level of 25% were assessed for their suitability for noodles making. Noodles prepared from respective flour blends of Taroand colocasia flour with refined wheat flour showed lower cooking time, higher cooked weight, higher water uptake and higher gruel solid loss. Noodles with acceptable quality characteristics and a decreased level of gluten may prove beneficial for coeliac persons.

Over the past years, the confectionery sector in Vietnam had a high and stable growth rate, with an annual output of over 150,000 tons, and a turnover of 27 trillion VND in 2014. The average annual revenue growth rate of the entire industry in 2010-2014 is 10%, while the figure for the period 2006-2010 is 35%, it is forecasted that from 2015to 2019 the growth rate will be around 8-9%.Vietnam confectionery statistics are listed in two product groups: confectionery products including biscuits, cookies and crackers, snacks, sweets and chocolates; and bakery products include bread, cake and pastry (Agro food Research Report, EU- Vietnam Business Network, STINFO 12-2015).

Biscuits are a very significant part of the food industry in most countries of the world. A biscuits a small baked product; the exact meaning varies markedly in different parts of the world. The origin of the word "biscuit" is from Latin via Middle French and means "cooked twice" (similar to the German Zwieback). Some of the original biscuits were British naval hard tack. That was passed down to American culture, and hard tack (biscuits) was made through the 19th century. Biscuits contributes to over 33 percent of the total production of bakery and above 79 percent of the biscuits are manufactured by the small scale sector of bakery industry comprising both factory and non-factory units. Biscuits are easy to carry, tasty to eat, cholesterol free and reasonable at cost. It is an unleavened crisp, sweet pastry made from wheat flour, shortening (hydrogenated fat) and sugar, and is usually made light by the addition of baking powder. Wheat flour constitutes the basic ingredient for biscuit production because of its gluten proteins, which are not present in flour of other cereals.

Wheat contributes considerably to the source of proteins in the diet, these proteins are unique among the cereal proteins because of their ability to form viscoelastic dough, which can be attributed to the formation of gluten when flour and water are mixed. The viscoelastic properties of the gluten in dough systems are generally considered important in determining the baking properties of the wheat flour. In addition to using wheat flour in making bread, wheat entered into other use and encouraged the growth and development of many industries such as biscuits, cakes, macaroni, pastas and others [6].

Recently it was noticed that some people show symptoms of coeliac disease (gluten intolerance or gluten sensitivity) which is an example of a chronic food allergy [7]. Some researches study have successfully produced acceptable biscuits from non-wheat flour.

Biscuits were made from sorghum and wheat composite flours in Nigeria [8] and in the Sudan [9]. Although the overall quality of the biscuits was reduced by the addition of more than 50% sorghum flour, and the presence of 10% and 20% sorghum flour improved the quality [9]. In addition, biscuits also were made from Taroand wheat composite flours. On the basis of nutritional value SPF biscuits containing 50% Taro flour is acceptable as it contains higher fiber content than other samples, at the same time on the basis of sensory evaluation SPF biscuit containing 50% Taro flour scored high score for over-all acceptability [10]

Taro is especially useful to persons allergic to cereals and can be consumed by children who are sensitive to milk [11]. Besides its importance as a food source, taro contains high levels of gum, which has also been shown to play a role in the reduction of high blood pressure, in hypercholesterolemia and in the management of diabetes [12]. For supplying nutrients, the corms may be considered as a good source of carbohydrates and potassium. Large servings of taro corms can become a significant source of dietary protein, especially if taken more than once a day. Taro is also a good source of thiamin, riboflavin, iron, phosphorus and zinc and a very good source of vitamin B6, vitamin C, niacin, potassium, copper and manganese. Taro also contains greater amounts of vitamin B-complex than whole milk [13]. The corms are low in fat (0.5–1.2 %), proteins (2.9–4.6 %) and vitamins, but are a good source of carbohydrates (90.8–95.5 %) and minerals (1.6–5.5 %) especially magnesium (32.9–382 mg/100 g), calcium (25.4–192 mg/100 g) and potassium (3.5–59.7 mg/100 g) [12]

Despite the taro cultivation potential, nutritional value and the diversity of products that can be prepared from taro, there is still little available on the use of taro our as an ingredient to substitute wheat our in confectionery products, such as bread and biscuits. The objective of this work was to study the influence of partial substitution of wheat with taro (Colocasia esculenta) on the physical, nutritional and sensorial properties of cookies.

Though, numerous studies on the evaluation and utilization of Taro flour have been conducted as mentioned above, there is no information about how to produce the high quality of flour and the made biscuits from Taro. So, it is scientifically and economically important to know whether the made flour from Taro can be used for the production of high nutritional biscuits from the Taro flour. Also, consequence of various proportion of Taro to wheat flour in biscuits formation needs to be determined in order to make high quality final biscuits products. In summary, this study has been conducted to determine the suitable process for production of flour and the made biscuits from Taro.

Materials and Methods

Research object and location

20kg good quality of Taro without any bruises and wheat flour, were purchased from the local market of Ho Chi Minh City

Fig 1: Taro tubes used in this study

Other major ingredients needed to prepare biscuits such as wheat flour, sugar, baking powder, and butter were obtained from Vinmart supermarket, Ho Chi Minh City, Vietnam. Chemicals used in sample analysis such as sulfuric acid, sodium hydroxide, hexane, etc were purchased from local agents in Vietnam.

The experimental studies were carried out in laboratories of Food technology department of International University – Vietnam National University in Ho Chi Minh City.

Preparation of Taro flour

The raw taro was washed in running water for two hours and then peeled. The samples were diced into one cm size, washed again then were soaked in water overnight. The samples were steamed for 15 minutes then were mashed, spread evenly on different trays, and dried at 55°C for 24h. The dried samples were milled into flour using the laboratory grinder and passed through 250 µm sieve to obtain uniform sized flour. The flour was then packed in sealed plastic bag and stored at ambient temperature till further used.

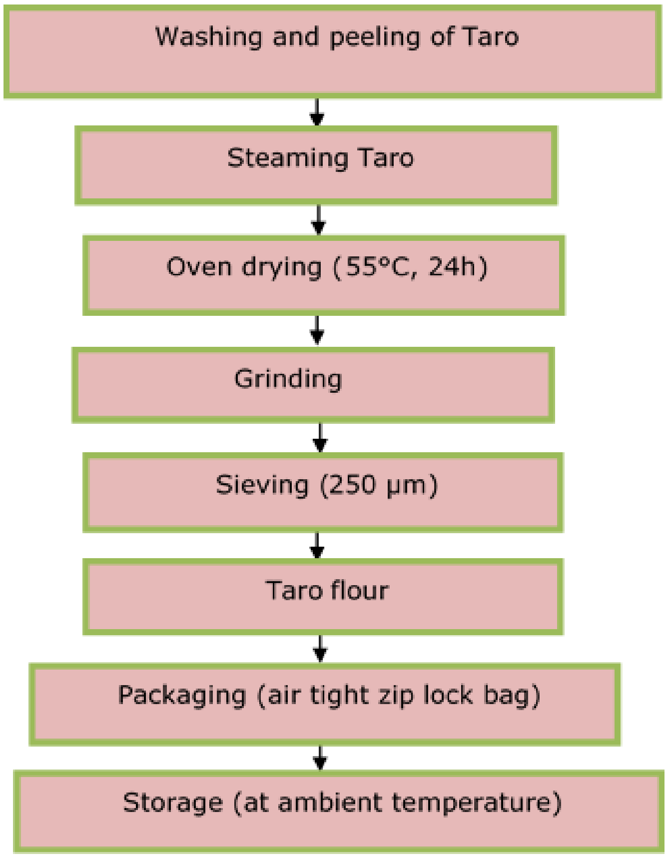

Fig 2: Flow chart for the preparation of Taro flour

Preparation of Wheat- Taro biscuits

The Wheat- Taro flour composites were prepared at different ratios (of 100:0; 90:10; 80:20; 70:30; 60:40; and 50:50) with other ingredients were weighed accurately as the formulations shown in Table 1. Shortening and sugar were creamed in a mixer before the homogenized mixture of dried ingredients was added. Smooth dough was formed and rolled to a 3-5mm sheeted size with the help of a rolling pin. A round cutter of 4cm diameter was used to create a uniform shape for all biscuits. Then, they were transferred to a lightly greased baking tray and baked at 165ºC for 13 minutes in a preheated oven. After baking, all biscuits were allowed to cool completely (about 30 minutes) and stored in air tight containers for 12 hours before further analysis.

As shown in the all well prepared tables, A is symbol marked biscuits produced from 100% wheat flour. Similarly, B is marked biscuits produced from 90% wheat and 10% Taro flour, C is marked biscuits produced from 80% wheat and 20% Taro flour, D is marked biscuits produced from 70% wheat and 30% Taro flour, E is marked biscuits produced from 60% wheat and 50% Taro flour, and F is marked biscuits produced from 60% wheat and 50% Taro flour.

A = 100: 0 ratio of wheat- Taro flour in biscuits
B = 90: 10 ratio of wheat- Taro flour in biscuits
C = 80: 20 ratio of wheat- Taro flour in biscuits
D = 70: 30 ratio of wheat- Taro flour in biscuits
E = 60: 40 ratio of wheat- Taro flour in biscuits
F = 50: 50 ratio of wheat- Taro flour in biscuits

Table 1: Ingredients used in the preparation of biscuits

Ingredients	Samples (g)					
	A	**B**	**C**	**D**	**E**	**F**
Wheat flour	100	90	80	70	60	50
Taro flour	0	10	20	30	40	50
Powdered sugar	15	15	15	15	15	15
Butter	40	40	40	40	40	40
Baking powder	1.5	1.5	1.5	1.5	1.5	1.5
Salt	0.5	0.5	0.5	0.5	0.5	0.5

Preparation of composite flour (wheat flour: Taro flour flour) at different ratios

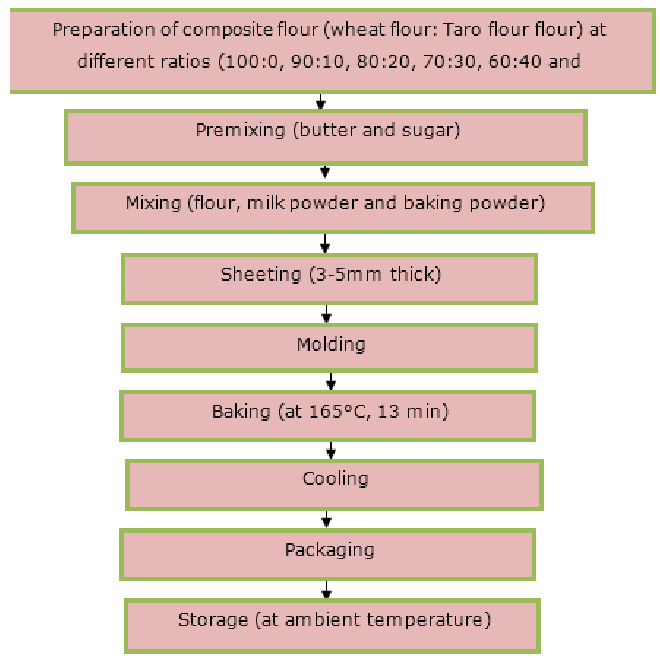

Fig 3: Flow chart for the preparation of biscuits

Proximate analysis of sweet Taro flour

The proximate analysis of the composite flours and developed biscuits moisture, protein, ash, crude fiber, fat content, and energy values was determined using the methods described by AOAC [14].

Moisture content

The flour sample (3g) was taken in a pre-weighed porcelain crucible, was dried to constant weight at 105°C for 14 hours. Loss in weight was taken as the moisture content of the sample (AOAC, 2012) [14].

% Moisture = Weight loss (g) x 100 / sample weight (g)

Ash content

The crucibles containing 1g of sample was charred on a heater before kept in the muffle furnace at 550ºC for 4 hours until only white matters can be seen. Then, the crucible with ash content was then cooled in a desiccator and weighed accurately to a constant weight (AOAC, 2012) [14].

Fat

Fat content was determined by extracting 3g of sample with hexane using Soxhlet apparatus for 6 hours. The residual hexane was removed from the extracted sample by evaporation. The extracted fat was then dried and weighed.

Protein

Protein content was analyzed by using the Kjeldahl method according to the AOAC methods (2012). 1g of sample was placed in a digestion tube; 0.2g CuSO4, 1g K2SO4, and 20ml concentrated H2SO4 were added to the tube with taro flour. The sample was let digested on digestion block until white fumes can be seen and continue heated for about 60 – 90 minutes until cleared with no charred material remaining. Tube was placed in the distillation apparatus and 50ml NaOH 32% was added. The ammonia in the sample was steam-distilled for 5 minutes into a receiving flash containing 4% boric acid. The sample was titrated with H2SO4 0.1N solution. The protein was calculated by the equation: %Nitrogen x 6.25.

Crude fiber

Crude fiber could not determine following the approved AOAC method 962.09 in the laboratory equipment's of Food Technology Department, International University, Ho Chi Minh City. Laboratory equipment's could not perform experiment if samples containing high starch content. Thus, samples were sent to Center analytical services and experimentation HCMC to checked crude fiber content. Crude fiber was determined following CASE.NS. O022 method (Ankom technology method 10).

Total Carbohydrate content

Total carbohydrate was determined by the difference [14]

% Carbohydrate = 100 – % (protein+ fat + ash+ fiber + moisture)

Functional properties analysis of the flour samples

Bulk density

Bulk density was determined following the method described by Eleazu and Ironua[15], and Onabanjo and Dickson (2014)[16]. A (10ml) graduated cylinder, previously tarred, was gently filled with 5g of sample. The bottom of the cylinder was gently tapped on a laboratory bench several times until there was to a constant. The bulk density of the sample (g/ml) was calculated as weight of the sample per unit volume of sample.

Water Absorption Capacity (WAC)

The WAC of the sample was determined using the method as described by Eleazu and Ironua (2013)[15] and Onabanjo and Dickson[16] with minor modification. A measured quantity (1g) of the sample was dispersed in 10 ml of distilled water in a conical graduated centrifuge tube. The sample was thoroughly mixed for 30 seconds and allowed to stand at room temperature for 30 minutes before being centrifuged at 4000 rpm for another 20 minutes. The volume of the supernatant was measured directly from the graduated centrifuge tube. The amount of the absorbed water was multiplied by the density of water (1 g/ml) and results were expressed as g/100 g.

Oil Absorption Capacity (OAC)

Oil absorption capacity of the flour was determined using the method as described by Adepeju, Gbadamosi *et al*. (2011) [17] and Eleazu and Ironua (2013) [15]. One gram of sample was mixed with 10ml of pure canola oil for 60 seconds. The mixture was set to stand for 10 minutes at room temperature, centrifuged at 4000rpm for 30 minutes and the oil that separated was carefully decanted. The tubes were allowed to drain at an angle of 45° for 10 minutes and then weighed. Oil absorption was expressed as percentage increase of the sample weight.

Proximate analysis of Wheat-taro composite biscuits

Moisture, fiber, ash, and fat content of prepared biscuits were determined by the same methods used for taro flour analysis.

Physical properties measurements of biscuits

The width was measured by placing 6 biscuits edge-to-edge to get the average value in millimeters. The thickness was measured by stacking 6 biscuits on top of each other to get the average value in millimeters. Width divided by the thickness gave the spread factor. Digital weighing scale was used to determine the weight (in grams) of biscuits. Volume of biscuits was defined as the area multiplied by thickness. After calculating volume, density was obtained by ratio of weight of volume [18, 19].

Sensory evaluation

The consumer acceptance of four different samples of biscuits was evaluated using a 9-point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely [20].

Statistical analysis

Data was subjected to analysis of variance using the "Statistical Package for Social Sciences" (SPSS) version 20.0. Results were presented as means ± standard deviations of triplicate experiments. Significant difference was established at $p \leq 0.05$.

Results and Discussion

Proximate analysis of taro flour

The results of analysis proximate attributes of taro flour derived from taro tubes are presented in Table 2. Moisture content of the flour samples was 8.09 ± 0.04 below 9%, thereby giving the flours a better shelf life. Moisture is an important parameter in the storage of flours, levels greater than 12% allow for microbial growth. Low levels are favorable and give relatively longer shelf life [21]

Table 2: Proximate values of taro flour

Components (%)	Value*
Moisture (DWB)	8.09 ± 0.04
Ash	3.39 ± 0.42
Fat	0.77± 0.17
Protein	2.57 ± 0.11
Crude fiber	1.53 ± 0.00
Total carbohydrate	83.65 ± 0.14

*Values in the table represent the means ± standard deviations (n = 3 replicates) DWB = dry weight basis

The results showed that carbohydrate was (83.65 ± 0.14) the most important chemical component in the flours while the protein and fat were very limited. Taro is an important staple food in several regions of developing countries because it contains high amounts of carbohydrates and is an excellent energy supplier [11]. Onwueme (1978) [22] reported that taro corm is a source of carbohydrate for diabetics and for those with gastrointestinal disorders.

The results also showed that besides carbohydrates, ash represents another important group of components in taro flour (3.39 ± 0.42). Since the ash content of the analyzed food represents the mineral content of the food material, it has long been identified to containing calcium, phosphorus, magnesium, sodium, potassium, iron, zinc and copper as they are the main mineral constituents in taro roots [12]. The minerals such as iron, copper, zinc and manganese are essential since they play an important role in biological system (Taira, 2013) [23].

Discriminated with other roots and tubers, taro is known as low in fat content and protein [12]. The fat content of the studied taro flour was considerably low, valued of 0.77± 0.17. Irrespective of the cultivar's taro flour low in protein content, valued of 2.57 ± 0.11.

The result also showed that besides carbohydrates, total ash and crude fiber represented another important group of components in taro corm flours. Their content in flours ranged from 1.20±0.02 to 1.78±0.01, respectively. And the result obtained from the taro flour in this study was within that range, of 1.53%. This finding is important because crude fiber has useful role in providing roughage that aids digestion (Eva, 1983) [24]. The importance of fiber clinically has been reported by (Umoh *et al*., 1984) [25] which stated that fiber depleted diets cause pathological effects which manifest in the gastro-intestinal tracts as well as other anatomical structures such as the arteries, lower limb veins and gall bladder, suggesting therefore that there is need for minimum obtainable level of fiber in diets. The results obtained for taro flour in the present study corroborated well with those reported by Abubakar *et al*., 2008[12] for six varieties of Cameroon taro flour. These workers reported moisture, ash, fat, protein and carbohydrate contents in the range of 8.2–9.6%, 1.3–5.5%, 0.30–1.17%, 2.9–4.6% and 90.5–95.5%, respectively in taro flour.

Functional properties of composite flour

Table 3: Effect of incorporating taro flour on the functional properties of the composite flours

Sample	Bulk density (g/cm3)	Water absorption Capacity (g/g)	Oil absorption capacity (g/g)
TF	1.06 ±0.01	3.48±0.08	1.38±0.03
A	0.74 ± 0.02^{a}	0.90 ± 0.03^{a}	1.24 ± 0.03^{a}
B	0.76 ± 0.04^{a}	0.92 ± 0.03^{a}	1.21 ± 0.02^{ab}
C	0.78 ± 0.03^{a}	0.94 ± 0.04^{a}	1.20± 0.02^{ab}
D	0.85 ± 0.03^{b}	1.35 ± 0.02^{b}	1.19 ± 0.06^{ab}
E	0.87 ± 0.02^{b}	1.68 ± 0.04^{c}	1.18 ± 0.01^{ab}
F	0.92 ± 0.02^{c}	1.86 ± 0.03^{d}	1.15 ± 0.02^{b}

*Values in the table represent the means ± standard deviations (n = 3 replicates) The values denoted by different letters in the same column are significantly different ($p \leq 0.05$)

Functional properties of foods are those properties which adjudicate the applications and use of food material during processing, storage and preparation because they impact on the general quality of foods as well as their acceptability. The important functional properties that are usually assayed include: water absorption capacity, bulk density, oil absorption capacity, viscosity, foam stability, etc. [15]. The results of functional properties of taro flour and the composite flour samples are as presented in Table 3

Bulk density

Value of bulk density for wheat flour (sample A) was 0.74 g/cm3 while taro flour calculated 1.06 g/cm3. As can be seen from table 4, bulk density of composite flour increased with increase in the incorporation of different flours with wheat flour. The values for the samples ranged between 0.74 to 0.92 g/cm3, with sample F recorded the highest value and the lowest was sample A. It is clear that decreased the proportion of wheat flour increase the bulk density of composite flours. The values of bulk density among studied samples were reported insignificantly different (P>0.05).

Scientifically and economically, bulk density is generally affected by the particle size and density of the flour and so, it is a important approach to determining the packaging requirement, material handling and application in wet processing in the food industry (Adeleke, 2010). Hence, the higher the particle size, the lower the bulk density. Consequently, increase in bulk density is desirable because it offers greater packaging advantage, as a greater quantity may be packed within a constant volume [15]

Water Absorption Capacity (WAC)

The water absorption capacity for composite flours is given in Table 3. The WAC ranged from 90% to 186% for all samples. The WAC was observed highest in F (90 %) and lowest in A (186 %). The results were similar among sample A, B and C, there were significant differences (p<0.05) in the WAC of remain flours comparing with the control sample A. This suggested that when more taro flour was added to wheat flour, the WAC of the blended samples was increased. A similar trend also observed by Hossain (2016) [4]

Water absorption capacity measures the ability of flour to absorb water and swell for improved consistency in food. It is a property desirable in food systems to improve yield, consistency and give body to the food (Eleazu, 2013) [15]. The increase in the WAC has always been associated with increase in the amylose leaching and solubility, and loss of starch crystalline structure (Baidoo, 2014) [3].

Oil Absorption Capacity (OAC)

Data shown in the Table 3 indicates that the OAC ranged between 115 to 124% among all the composite flours. The composite flours B had highest OAC (121 %) and lowest for F (115 %) as compared to wheat flour A (124 %). It is clear that the OAC of composite flours decreased with increase in the proportion of taro flours. The presence of higher fat content in wheat flour might have affected adversely the OAC of the composite flours. The OAC was found to be insignificant to each other and significant F as compared to A at $p \leq 0.05$ level of significance. 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 [26, 27]. Therefore, the low protein content in taro flour was the possible reason for the decrease in the OAC of composite flours when increasing the level of substitution.

Physical properties of taro-wheat composite biscuits

Blending ratio was showed significant increase (P<0.05) in spread ratio (table 4). The spread ratio is considered as one of the most important quality parameters of biscuits because it relates to texture, grain finesse, bite and overall mouth feel of the biscuits (Jothi, Hashem *et al*. 2014) [28]. Figure 4 shows that the more level of composite flour significantly increased the spread ratio of the final product (p<0.05). The highest value was of sample F (11.24), while the lowest value belonged to sample A (10.59). An increase in taro amount significantly increased the spread ratio of the biscuits, which was directly correlates with their thickness, whereas the diameter was generally not affected. The significant difference in term of spread ratio among samples was due to the low protein content of the taro flour. As reported by (Singh, 1993) [29] a decrease in spread with increased protein in the cookies was noticed. The study of (Aziah, 2012) [30] and (Miller, 1997) [31] revealed that the amount of protein in the flour affects the formation of continuous gluten web which increases the viscosity and stops the flow of the dough. As a result, the biscuits made from composite flour had higher spread ratio of than that of the wheat biscuits.

The volume of biscuits was ranged from 15.32 to 16.58 cm3, with the highest value was showed in sample A and the lowest value was of sample F. The higher the supplement of taro flour, the lower the volume of the biscuits. This is possibly due to the fibers present in the taro flour, which might interfere in the structure of the matrix, diminishing the gas retention capacity in the dough (María V. Ostermann-Porcel *et al*, 2017) [32]. Volume of biscuits were significantly decreased (P<0.05) as taro flour increased in blending, and density increased in the similar manner. However, the differences of two attributes among samples were insignificant (p<0.05). Mean densities of biscuits ranged from 0.40 to 0.42 g/cm3, with the highest value was of sample F and the lowest value was of sample A. Density was the best index of sensory texture of biscuits. Lower density means greater crispiness and higher textural value (Dogan, 2006) [33]. As reported by Manohar and Rao (2002) [34] there was a positive correlation between dough firmness and density.

Table 4: Physical properties of wheat-taro composite biscuits

Sample	Width (cm)	Thickness (cm)	Spread ratio	Weight (g)	Volume (cm^3)	Density (g/cm^3)
A	6.07 ± 0.01^a	0.57 ± 0.01^a	10.59 ± 0.09^a	6.55 ± 0.02^a	16.58 ± 0.22^a	0.40 ± 0.01^a
B	6.04 ± 0.02^a	0.56 ± 0.01^{ab}	10.79 ± 0.16^{ab}	6.43 ± 0.03^{bc}	16.06 ± 0.39^{ab}	0.40 ± 0.01^a
C	6.05 ± 0.01^a	0.56 ± 0.01^{abc}	10.85 ± 0.09^{abc}	6.44 ± 0.01^{bc}	15.96 ± 0.23^{ab}	0.40 ± 0.01^a
D	6.03 ± 0.02^a	0.55 ± 0.01^{bc}	11.04 ± 0.08^{bc}	6.39 ± 0.02^c	15.62 ± 0.27^{ab}	0.41 ± 0.01^a
E	6.04 ± 0.01^a	0.54 ± 0.01^{bc}	11.19 ± 0.22^c	6.49 ± 0.04^{ab}	15.46 ± 0.26^b	0.42 ± 0.01^a
F	6.03 ± 0.02^a	0.54 ± 0.01^c	11.24 ± 0.13^c	6.40 ± 0.04^c	15.32 ± 0.20^{ab}	0.42 ± 0.01^a

*Values in the table represent the means ± standard deviations (n = 3 replicates). The values denoted by different letters in the same column are significantly different ($p \leq 0.05$)

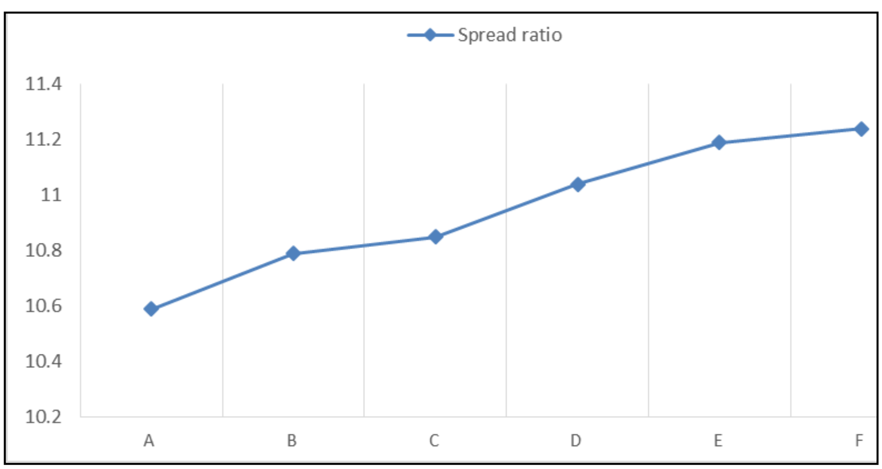

Fig 4: Effect of incorporating different levels of sweet taro flour on the spread ratio of biscuits.

Blending ratio was caused a significant decrease (P<0.05) in weight of biscuits as taro flour supplementation level increased in blending (Table 4). The weight of the experimental biscuits was between 6.40 and 6.55g with the highest value was of sample A and the lowest was found in sample F. The results differed significantly among samples (p<0.05). As the result, the higher-level taro flour substituted, the more the weight loss of the biscuits. The taro flour had higher water absorption capacity than the wheat flour, hence, this resulted in the higher initial moisture content of the dough and the higher loss of water during baking of the biscuits (Dogan, 2006).

Proximate values of Taro-Wheat composite biscuits

Table 5 was showed the proximate composition taro biscuits. The results presented in the Table revealed that there was a gradual decrease of moisture content of biscuits from sample A to F (from 5.96% to 4.89%). The difference in moisture between the control sample A and other samples was significant when more than 20% taro flour incorporated in the biscuit formulation (p<0.05).

The results for moisture content of the biscuit were similar with the results obtained by Srivastava *et al*. (2012) [10], who incorporated taro flour in preparation of the biscuits. The reduction in moisture content was due to the application of heat which caused the loss of water from food as a result of evaporation. The higher reduction in moisture content of taro cookies was due to the higher temperature used in baking which is 150°C compared to the 50°C used in drying which resulted in the rapid evaporation of water. When a food is placed in a hot oven, the low humidity of air in the oven creates a moisture vapor pressure gradient, which causes moisture at the surface of the food to evaporate and this in turn creates movement of moisture from the interior of the food to the surface (Baidoo *et al*., 2014). In addition, the biscuits contained more taro flour had higher affinity for water which was informed by their lower moisture content (Adeleke R and Odedeji J, 2010) [26].

The ash content of biscuits increased from A to F (0.88% to 1.73%) significantly due to higher ash content of taro and due to externally added fat during biscuits preparation.

The concentration of fat in the biscuits ranged between 24.26% and 25.36%, with highest concentration of fat was seen in biscuits A. Though there was a slight variation in the fat content in different types of biscuits, it was statistically similar (p>0.05).

Both refined wheat flour and taro flour were having lower fat content and hence the total fat content in samples were similar whereas there was slight reduction in fat content with increase in taro flour incorporation. The results of proximate composition of taro-based biscuits are similar with the results obtained by (Hossain, 2016) [4].

The value of crude fiber content of biscuits also increased significantly (p< 0.05) as more taro flour was added to wheat flour in biscuits production. The highest value of crude fiber was found in sample D (0.59%) having 30% taro flour substitution insignificant in sample E and F (0.5%). On the other hand, the lowest were seen in sample A (0.24%). This suggested that taro flour had more crude fiber than wheat flour. The result was in agreement with the observation of Onabanjo O and Dickson A (2014) [16]

Sample A (9.51%) had the highest protein content and sample F (7.52%) had the lowest (Table 5). Results showed that there was a significant difference in the crude protein between ratios. There was a noticeable reduction in the protein content from A to F when increased incorporation taro flour. The observed decrease in protein content by the boiling process was due to the denaturation of protein wherein the hydrogen bonds and non-polar hydrophobic interactions of the secondary and tertiary structures of proteins are disrupted by heat (Olajide R *et al*., 2011)[36] and the soluble amino acids leached out in the cooking medium (FAO, 1990). Moreover, taro had lower protein content than wheat flour thus decreasing protein content from A to F.

Table 5: Proximate values of composite biscuits

Sample	Moisture (%)	Fat (%)	Ash (%)	Fiber (%)	Protein (%)	Carbohydrate (%)
A	5.52 ± 0.06[a]	25.26 ± 0.79[a]	0.88 ± 0.05[a]	0.24	9.51 ± 0.14[a]	64.11 ± 0.93[a]
B	5.45 ± 0.03[ab]	25.22 ± 0.55[a]	1.04 ± 0.04[b]	0.31	9.23 ± 0.19[a]	64.21 ± 0.73[a]
C	5.39 ± 0.04[b]	24.83± 0.84[a]	1.11 ± 0.06[b]	0.51	8.60 ± 0.16[b]	64.95 ± 0.80[a]
D	5.34 ± 0.04[b]	24.71 ± 0.33[a]	1.37 ± 0.04[c]	0.59	8.42 ± 0.08[bc]	64.91 ± 0.43[a]
E	5.21 ± 0.04[c]	24.55± 0.84[a]	1.55 ± 0.04[d]	0.5	8.13 ± 0.10[c]	65.26 ± 0.72[a]
F	4.85 ± 0.05[d]	24.36 ± 0.72[a]	1.73 ± 0.08[e]	0.5	7.52 ± 0.12[d]	65.98 ± 0.75[a]

*Values in the table represent the means ± standard deviations (n = 3 replicates). The values denoted by different letters in the same column are significantly different *(p ≤0.05)*

The carbohydrate content of wheat taro composite biscuits increased insignificantly from control A (64.11) to F (65.98) (Table 6). The high level of carbohydrate content observed in taro powder and cookies agrees with the findings reported by FAO that the main nutrient supplied by taro, as with other roots and tubers, is dietary energy provided by the carbohydrates (FAO, 1990) [35]. Moreover, the higher carbohydrate content of F compared to A was due to the other ingredients added like sugar and egg thus increasing the amount contributed by taro powder.

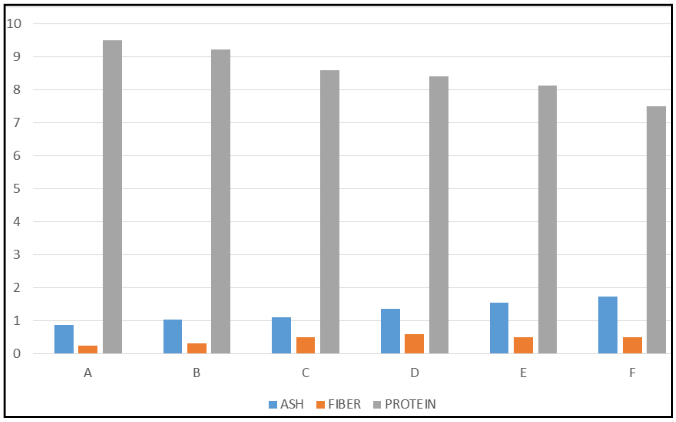

Fig 5: Effect of incorporating different ratio of taro flour on the Ash, Fiber and Protein content of biscuits.

Sensory evaluation of biscuits

The analyses of the mean sensory scores for the biscuits are shown in table 6. A look at the table revealed biscuits made at 40% and 50% taro substitution levels were significantly (P<0.05) different in all of the attributes tested (color, taste and flavor) except texture from the control biscuits hence control biscuits being more preferred by the panelists. However, at 10%, 20% and 30% taro flour substitution levels there were no significant (P>0.05) difference in the mean acceptability of control biscuits and taro supplemented biscuits. The panelists mean score test revealed that the 30% biscuits were scored higher in all the tested attributes when compared to control biscuits. This does not mean that other biscuits samples were not acceptable, even at 50% substitution level the panelists seem to like the flavor and taste of biscuits produced from taro and wheat flour blend. Despite the fact that control biscuits were more preferred to taro supplemented biscuits, the average mean score of overall acceptability of up to 30% taro flour composite biscuits are above 7 (like moderately) suggesting that they are acceptable range by panelist. This higher sensory attribute scoring for control biscuits compared with taro and wheat flours composite biscuits could be due to the familiarization of the consumers to the normal wheat biscuits (Srivastava *et al*., 2012)[10]. This result was agreed with previous works of Onabanjo O and Dickson A (2014) [16] and Srivastava *et al*. (2012) [10].

Table 6: Sensory evaluation scores of developed biscuits in term of color, taste, flavor, texture and overall acceptability in 9 - point scale.

Sample	Color	Taste	Flavor	Texture	Overall acceptance
A	7.50^{a}	7.58^{a}	7.46^{a}	7.56^{a}	7.98^{a}
B	7.22^{a}	7.38^{ab}	7.32^{a}	7.28^{a}	7.66^{ab}
C	7.06^{a}	7.28^{ab}	7.36^{a}	7.30^{a}	7.60^{b}
D	7.44^{a}	7.5^{a}	7.44^{a}	7.42^{a}	7.70^{ab}
E	6.04^{b}	7.16^{b}	7.06^{ab}	7.12^{a}	7.36^{b}
F	6.20^{b}	7.00^{b}	6.82^{b}	7.06^{a}	7.34^{b}

*Average of 50 evaluations. The values denoted by different letters in the same column are significantly different (p ≤0.05)

4. Conclusions

- In this study, the replacement potential of the wheat flour by sweet Taro flour in biscuits to improve nutritional values and the development of new recipes to make good quality biscuits from the Taro were successfully and thoroughly investigated.
- The result of present study indicated that supplementation of taro flour to wheat flour greatly decreased dough stability and size (volume and spread ratio) due to the dilution of gluten matrix in wheat flour. Composite flours have lower level of wet gluten content and higher level of water absorption capacity than control (wheat) flour. Biscuits prepared from taro flour supplemented had significantly increased levels of ash, fiber, carbohydrate content than control (wheat) biscuits. This was due to the high levels of these nutrients in taro flour. On the other hand, there was a decrease in protein and fat content of biscuits as substitution of taro flour increased in blending ratio.
- In contract, all nutritionally rich food products may not be always desired to consumer acceptance. Based on results of sensory test demonstrated that control bread was more preferred by panelists than taro supplemented biscuits. However, biscuits made up-to using 30% taro substituted level accepted by panelists (scored above like moderately range), this leads to the conclusion that nutritional improved, and panelist acceptable biscuits can be prepared by supplementing up to 30% level taro flour in wheat flour.

References

1. Durward SS, *et al*. Processing Vegetables: Science and Technology, CRC Press, 1997.
2. Nguyen Ngoc Hue, *et al*. On-farm management of agricultural biodiversity in Vietnam, International Plant Genetic Resource Institute, Rome, Italy, 2001.
3. Baidoo EA, Akonor PT, Tortoe C. Effect of Pre-treatment and Storage Condition on the physicochemical Properties of Taro (Colocasia esculenta [L.] Schott) Flour. International Journal of Food Science and Nutrition Engineering, 2014.
4. Hossain MB. Effect of Taro Flour Addition on the Functional and Physiochemical Properties of Wheat Flour and Dough for the Processing of Bread. Nutrition & Food Science International Journal, 2016.
5. Noorfarahzilah M, Lee JS, Sharifudin MS, Mohd FAB and Hasmadi M. Applications of composite flour in development of food products. International Food Research Journal, 2014.
6. Ahmed SE. Proximate composition and flour quality of wheat cultivars grown in the Sudan. M.Sc. Thesis, University of Khartoum, 1995.

7. Gopinath L. Food allergy and intolerance. The newsletter of the International Food Information Service (IFIS) 2002.
8. Orewa GO Iloh A. Current status of composite flour technology and prospects with particular reference to the production of biscuits in Nigeria. Food and Agriculture Organization of the United Nations, 1990.
9. Mustafa AI, Mahgoub S, Abdo S. Ginger biscuits from Dura (Sorghum Vulgare). Sudan Journal of Food and Technology, 1971.
10. Srivastava S, Genitha TR, Vrijesh Y. Preparation and Quality Evaluation of Flour and Biscuit from Sweet Potato. Journal of Food Processing & Technology. 2012.
11. Huang CC, Chen WC, Wang CCR. Comparison of Taiwan paddy- and upland-cultivated taro (*Colocasia esculenta* L.) cultivars for nutritive values. Food Chem, 2007; 102:250-256.
12. Aboubakar NYN, Scher J, Mbofung CMF. Physicochemical, thermal properties and microstructure of six varieties of taro (Colocasia esculenta L. Schott) flours and starches. J Food Eng. 2008; 86:294-305.
13. Soudy ID, Delatour P, Grancher D. Effects of traditional soaking on the nutritional profile of taro flour (Colocasia esculenta L. Schott) produced in Chad. Revue Méd Vét, 2010; 1: 37-42.
14. Latimer G. Official Methods of Analysis of AOAC International. Gaithersburg, Md. AOAC International, 2012; ISBN: 978-0-935584-83-7
15. Eleazu C, Ironua C. Physicochemical composition and antioxidant properties of a sweetpotato variety (*Ipomoea batatas* L) commercially sold in South Eastern Nigeria." African Journal of Biotechnology. 2013, **12**(7).
16. Onabanjo O, Dickson A. Nutritional, functional and sensory properties of biscuit produced from wheat-sweet potato composite. Journal of Food Technology Research, 2014; 1(3):111-121.
17. Adepeju AB, Gbadamosi SO, Adeniran AH, Omobuwajo TO. Functional and pasting characteristics of breadfruit (Artocarpus altilis) flours. African Journal of Food Science. 2011; 5(9):529-535.
18. Srivastava S, *et al*. Preparation and quality evaluation of flour and biscuit from sweet potato." Journal of Food Processing & Technology, 2012.
19. Jothi J, *et al*. Effect of Gluten-free Composite Flour on Physico-chemical and Sensory Properties of Cracker Biscuits. Journal of Scientific Research. 2014; 6:521-530.
20. Meilgaard M, Civille V, Carr B. Sensory Evaluation Techniques. Boca Raton: CRC Press. 1991, 354.
21. Aryee FNA, Oduro I, Ellis WO, Afuakwa JJ. The physicochemical properties of flour samples from the roots of 31 varieties of cassava.
22. Onwueme I. The tropical tuber crops: yam, cassava, sweet potato, cocoyams. John Wiley and Sons, New York, 1978, 234.
23. Taira J. Mineral determination and anti-LDL oxidation activity of sweet potato (Ipomoea batatas L.) leaves. Journal of food composition and analysis, 2013; 29(2):117-125.
24. Eva R. A Book on Nutrition with Special Reference to East Africa. In: Food, Health and you. London: Macmillan Publishers. 1983, 14-25.
25. Umoh IB, Ogunkoya FO, Maduagwu EN, Oke OL. Effets of thiamin status on the metabolism of linamarin in rats. Anim. Nutr.Metabolism, Switzerland. 1984, 319-324.
26. Adeleke R, Odedeji J. Functional properties of wheat and sweet potato flour blends. Pakistan Journal of Nutrition. 2010; 9:535-538.
27. Chandra S, *et al*. Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. Journal of food science and technology. 2015; 52:3681-3688.
28. Jothi J, Hashem S, Rana M, Rahman MRT, Shams-Ud-Din M. Effect of Gluten-free Composite Flour on Physico-chemical and Sensory Properties of Cracker Biscuits. Journal of Scientific Research. 2014; 6(3):521-530.
29. Singh B, *et al*. Studies on the development of high-protein biscuits from composite flours. Plant Foods for Human Nutrition (Formerly Qualitas Plantarum). 1993; 43(2):181-189.
30. Aziah A, *et al*. Physicochemical and organoleptic properties of cookies incorporated with legume flour. International Food Research Journal, 2012, 19(4).
31. Miller R, *et al*. Effect of formula water content on the spread of sugar-snap cookies. Cereal chemistry. 1997; 74(5):669-671.
32. María V. Ostermann-Porcel *et al*. Incorporation of Okara into Gluten-Free Cookies with High Quality and Nutritional Value. Journal of Food quality, 2017.
33. Dogan IS. Effect of Oven Types on the Characteristics of Biscuits Made from Refrigerated and Frozen Doughs. Food Technology & Biotechnology. 2006, 44(1).
34. Manohar RS, Rao PH. Interrelationship between rheological characteristics of dough and quality of biscuits; use of elastic recovery of dough to predict biscuit quality. Food Research International, 2002; 35(9):807-813
35. FAO. Carbohydrates in Human Nutrition, Rome, Italy, 1990.
36. Olajide R, Akinsoyinu AO, Babayemi OJ, Omojola AB, Abu AO, Afolabi KD. Effect of Processing on Energy Values, Nutrient and Anti-nutrient Components of Wild Cocoyam [*Colocasia esculenta* (L.) Schott] Corm. Pakistan Journal of Nutrition. 2011; 10:29-34.