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Original Paper

Functional Properties of Sausage Rolls Made from Cocoyam and Wheat Flour Enriched with Soybean Flour

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Abstract

Functional properties of sausage rolls made from cocoyam and wheat flour enriched with soybean flour was studied. Cocoyam cormels and soybean were processed into flour, which were later used to formulate composite flour blends, with wheat flour in the ratio of: 90:10:0 (control 1), 80:10:10, 70:10:20, 60:10:40, 50:10:30, respectively, while 0:10:90 served as control 2. The result of the functional properties showed variation in behavior. There were no significant difference (p≥0.05) in pH, bulk density, swelling index, foam capacity and emulsion capacity of the flour samples while significant difference (p≤0.05) existed in water absorption capacity, oil absorption capacity and wettability.

Keywords

Composite flour, amino acids, bulk density, swelling index, oil absorption capacity

1. Introduction

Sausage roll is a British savory snack, popular in Commonwealth nations and beyond (http://www.wikipedia.com/what-is-sausage-roll/). The basic composition of a sausage roll is sheets of puff pastry formed into tubes around sausage meat. The pastry is glazed with egg or milk before being baked (http://www.foodnetwork.com/sausage-roll-recipe/html). Sausage roll in the modern sense of meat, surrounded by rolled pastry, appears to have been conceived at the beginning of 19th century in France. Sausage rolls are popular and widely consumed all over the world by people of all ages. They are traditionally made from wheat, a cereal, which is cultivated in many parts of the world. Wheat is imported by countries with unfavorable climatic conditions (Aziah et al., 2009). Hence, such importing countries spend a lot of foreign exchange on importation of wheat. Ndife et al. (2011) reported that the growth of wheat crops could be affected by natural disasters such as hurricane, flood etc which will in turn affect the yield and price of wheat. Ojinnaka and Nnorom (2015) also reported that many farmers are beginning to switch from growing wheat to growing "more lucrative" crops (like corn and soy beans), which could be used in the production of bio-fuels. Therefore, it is important to develop an adequate substitute for wheat. In the quest for a wheat substitute, flour with improved nutritional quality than wheat would be highly desirable, especially in developing countries where malnutrition is prevalent.

Composite flour can be defined as a mixture of different ratios of non-wheat flours obtained from roots and tubers, cereals, legumes, etc., with or without the addition of wheat flour (Okpala & Okoli, 2011). Composite flour is considered advantageous in developing countries as it reduces the importation of wheat flour and encourages the use of locally grown crops as flour (Hugo et al., 2000). Aziah and Komathi (2009) reported that there is an increase in the substitution for wheat flour with local raw materials as a result of a growing market for confectioneries. Nigeria has not been able to produce wheat in commercial quantities because of climatic and soil conditions. Consequently, nearly all the wheat flour used for snacks and other products are imported. However, efforts are being made to partially replace wheat flour with non-wheat flours. This will possibly increase the utilization of indigenous crops cultivated in Nigeria as well as contribute to low cost of bakery products (Ayo & Gaffa, 2002). Usually, the aim of producing composite flour is to get a product with improved properties, performances, or improved economies (Okpala & Okoli, 2011). The nutritional value of cereal flours that are poor in lysine but rich in the sulfur containing amino acids could be improved. This is achieved by the addition of legume flours (Eneche, 1999) such as soybeans. Moreover, fortification of root and tuber flours with cereal flours can improve their nutritional value (FAO, 1990) and baking quality. According to Ihekoronye and Ngoddy (1985), cereals and legumes are good sources of protein which complement each other with respect to their amino acid profile.

Soybean (*Glycine max*) is a leguminous plant widely grown for its edible bean which has numerous uses (Liu, 2000). It is the only plant source that provides all the essential amino acid (Ihekoronye & Ngody, 1985), phyosterols, B-vitamins and minerals. Soybean is one of the richest and cheapest sources of plant protein that can be used to improve the diet of millions of people (Lui, 2000).

Cocoyam (*Xanthosoma sagittifolium*) is an edible root crop grown in the tropics of which Nigeria is a major producer. It belongs to the family *Araceae* (Ihekoronye & Ngoddy, 1985). Cocoyam is regarded as the third most important root crop, after yam and cassava, in West Africa (Obomeghevie et al., 1998). Key (1987) stated that the higher protein and amino acid profile of cocoyam is considered as a nutritional advantage over other tropical root or tuber crops. Cocoyam has small size granules with high starch content, which results in high digestibility (Howeler et al., 1993; Huang et al., 2000).

As there is a growing interest in the production of flours from locally available grains that can be used as substitutes for wheat in baked goods, this study was undertaken to produce sausage rolls of acceptable quality from cocoyam, soybean and wheat flour blends. Cocoyam is not utilized properly. It is mostly used as thickener in soup and few indigenous recipes. Therefore, its conversion into flour could be used efficiently in baking technology.

Cocoyam is an indigenous root crop that has not been utilized like other root crops such as cassava and yam. Despite the high nutritional value of cocoyam and soybean in relation to other root crops and legumes, lack of knowledge of their uses has limited their adoption, production and processing (Osho et al., 2009). To bridge the gap, efforts are being made by research institutes, Non-Governmental Organizations (NGOs) and industries to promote the production, processing and utilization of cocoyam in Nigeria (Osho, 2003). Nigeria faces one of the most serious nutritional problems in protein-energy malnutrition. Nigeria has not been able to produce wheat in commercial quantity due to climatic and soil conditions (Okpala & Okoli, 2011). Celiac disease is associated with the consumption of gluten which is common in wheat and wheat products. This disease occurs due to interaction of gluten in genetically predisposed individuals (Vijay et al., 1992). Therefore, the use of cocoyam which is gluten-free to produce food products would be suitable for consumption by individuals allergic to gluten.

The main objective of the study was to determine the functional properties of sausage rolls made from cocoyam and wheat flour blends enriched with soybeans. However, the specific objectives of the study were production of Cocoyam flour and Soybean flour; formulation of composite flour from blends of cocoyam, soybean and wheat and production of sausage rolls from different ratios (90:10:0, 80:10:10, 70:10:20, 60:10:30, 50:10:40, and 0:10:90) of cocoyam, soybean and wheat flour blends respectively

2. Materials and Methods

2.1 Material Collection

Cocoyam (*Xanthosoma sagittifolium*) cultivar, *Ede uhie*, soybeans (*Glycine max*) and wheat flour were purchased from Eke-ukwu market, Owerri, Nigeria. All other reagents used were of analytical grade.

2.2 Processing of Cocoyam into Flour

Cocoyam comels were processed into flour using the method described by Oti and Akobundu (2007). Cocoyam cornels, cultivar *Ede Uhie* were peeled, sliced and washed with water. The slices were blanched at 75 ℃ for 15 minutes in portable water. The blanched slices were oven dried at 60 ℃ for 9 hours and milled to obtain flour which was subsequently sieved to yield flour of fine texture.

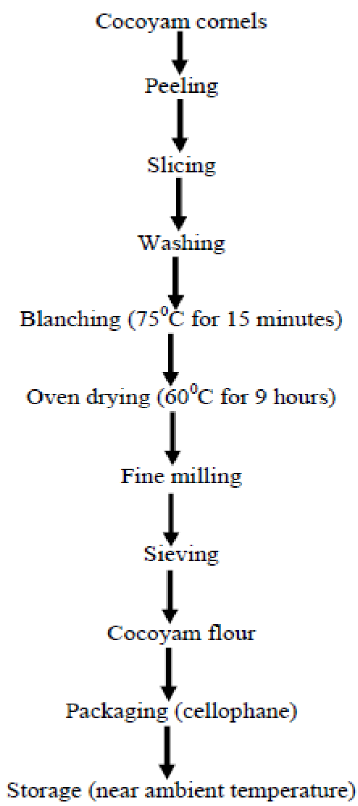

Figure 1. Flow Diagram of the Preparation of Cocoyam Flour

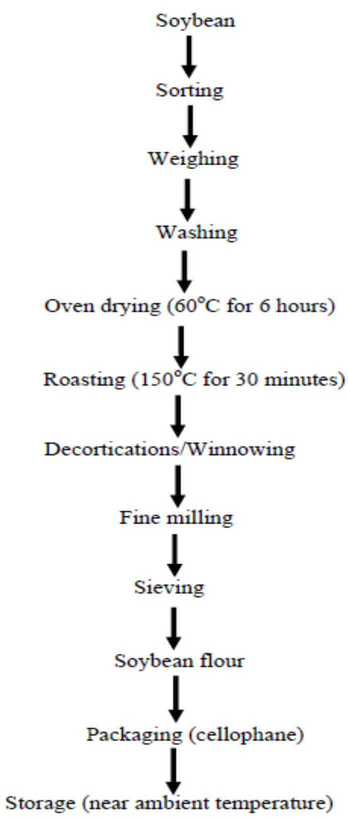

Figure 2. Flow Diagram of Preparation of Soybean Flour

2.3 Preparation of Soybean Flour

Soy flour was prepared according to the method described by Ndife et al. (2011). The soybeans (1 kg) were thoroughly cleaned to remove dirt and other extraneous materials such as stones and sticks. It was then washed and oven dried. The soybeans were roasted, decorticated, winnowed and milled into fine flour using hammer mill (Model EU 5000 D) and sieved through 250 μm aperture sieve. The flour was packed and sealed in polyethylene bags until analyzed.

2.4 Formulation of Flour Blend

Six blends of composite flour were prepared by mixing cocoyam flour, soybean flour and wheat flour in the percentage ratio of 90:10:0, 80:10:10, 70:10:20, 60:10:30, 50:10:40and 0:10:90 respectively. (90:10:0) and (0:10:90) served as control.

2.5 Sausage Roll Preparation

The formulated flour blend samples were used in producing sausage roll respectively. The ingredients used for the production and their right proportions are shown in Table 2. Sausage rolls were prepared according to the method of Nigerian Sausage roll preparation (http://www.nigerianfoodtv.com) with some modifications in the recipe. The meat filling was first prepared. The boneless beef was ground and seasonings (salt, nutmeg, mixed spices and stock cube) were thoroughly mixed using a Binatone blender (Model N0: BLG-650). The mixture was set aside. The dry ingredients (flour, baking powder, salt and sugar) were thoroughly mixed in a bowl by hand. The margarine was added in scoops and rubbed into the dry mixture till it formed crumbs. Thereafter cold water was added in bits till a non-sticky smooth dough was formed. The dough was kneaded for 5 minutes. The dough was cut out in a rectangular shape, rolled to a flat size. The spiced beef placed on the edges of the dough and folded into a cylindrical shape. Whisked egg was brushed on the dough and they were placed on oil-greased baking trays, leaving 25 mm spaces in between and were baked at 170^{O}C for 35 minutes in the baking oven. Following baking, the sausage roll was cooled at ambient temperature, packaged in polyethylene chin-chin bags and stored at near ambient temperature (28 ± 2^{O}C) prior to subsequent analysis and sensory evaluation. The procedure is shown in Figure 3.

Table 1. Formulation of Flour Blends

Blend	***Cocoyam Flour, C (%)***	***Soybean Flour, S (%)***	***Wheat flour, W(%)***
CS0	**90**	**10**	**0**
CSW1	**80**	**10**	**10**
CSW2	**70**	**10**	**20**
CSW3	**60**	**10**	**30**
CSW4	**50**	**10**	**40**
0SW5	**0**	**10**	**90**

Table 2. Ingredients for Sausage Roll Preparation

Ingredient	Proportion
Flour	100g
Baking Powder	2.15g
Margarine	100g
Salt	0.76g
Sugar	1.90g
Beef	100g
Nutmeg	0.76g
Mixed spices	0.76g
Stock cube	0.76g
Egg	1 medium size
Cold Water	600ml

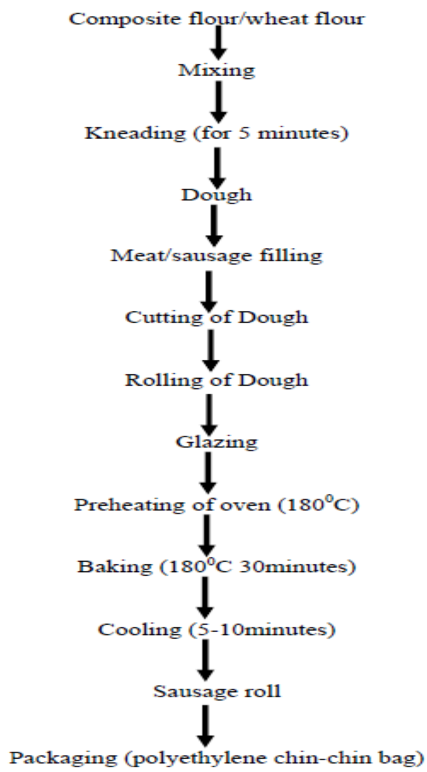

Figure 3. Flow Diagram of Production of Cocoyam-Soybean-Wheat Flour Sausage Roll

2.5.1 Evaluation of Functional Properties

The functional properties of the flour composites are determined using the following methods.

2.6 pH

pH of the flour was determined according to Onwuka (2005). 10 g of the flour was suspended in 100 ml of distilled water and mechanically stirred for 2 hours at room temperature. Using pH meter, the pH of the flour was determined and was done in triplicates.

2.7 Bulk Density

Using the procedure of Onwuka (2005, 2018), about 5 g flour was put into a 10 ml measuring cylinder gently. The bottom of the cylinder was tapped gently on the laboratory bench severally until there was no further change of the sample level to a constant volume. The volume was recorded and the cylinder plus sample was weighed and recorded. Triplicates determination were made and average result taken. The bulk density was calculated using the formula below.

$$\text{Bulk Density} = \frac{Mass\ of\ Flour\ sample}{Volume\ of\ Flour} \quad (1)$$

2.8 Determination of Water Absorption Capacity

The method of Sosulski (1962) was described by Abbey and Ibeh (1988) and it was adopted. One gram (1 g) of each sample was weighed out into a dry, clean centrifugal tube and both weight noted. 10 ml of distilled water was poured into the tube and properly mixed with the sample to make a suspension. It was then centrifuged at speed of 3500 rpm for 15 minutes. After which supernatant was discarded then the tube and its content re-weighed and noted. The gain in weight is the water absorption capacity of the test sample (Ibeabuchi, 2014).

$$\text{WAC (g/g)} = \frac{weight\ gain}{weight\ of\ sample} \quad (2)$$

2.9 Determination of Oil Absorption Capacity

The method of Onwuka (2005) was employed. 1g of the flour sample of each blend was weighed separately and placed into clean centrifuge tubes of known weight. 10ml of vegetable oil was mixed with the flour and stirred mechanically. The tubes were centrifuged at 3500 rpm for 15 minutes. The supernatant was decanted and the tubes together with the sample weighed. The amount of oil gain in mass is the oil absorption capacity of the flour samples. The amount of oil absorbed (total - free) is multiplied by the density of oil for conversion of grams. The gain in weight is the oil absorption capacity of the sample (Ogunbusola et al., 2012). The oil absorption capacity of the test sample was repeated three times for each sample and the average was calculated.

$$\text{OAC (g/g)} = \frac{weight\ gain}{weight\ of\ sample} \quad (3)$$

2.10 Determination of Swelling Index

The Swelling Index of the flour samples was determined as reported by Njoku and Banigo (2006). Three grams (3 g) of each flour sample were transferred into a clean dry graduated 50 ml cylinder. The samples were gently leveled and their volumes noted. Then, 30 ml of distilled water was added into each of the samples. The cylinder was swirled and allowed to stand for 1hour while changes in volume (swelling) were noted. The swelling index of the test sample was repeated three times for each sample and the average was calculated.

$$\text{Swelling Index} = \frac{\text{volume occupied by sample after swelling}}{\text{volume occupied by sample before swelling}} \quad (4)$$

2.11 Determination of Wettability

The method of Onwuka (2005) was employed. 1 g of the flour sample was added into a 25 ml graduated cylinder with a diameter of 1 cm. A finger was placed over the open-end of the cylinder which was inverted and clamped at a height of 10cm from the surface of a 200 ml beaker containing 500 ml distilled water. The finger was removed and the rest of the sample was allowed to be dumped. The wettability is the time required for the sample to become completely wet.

2.12 Determination of Emulsion Capacity

The procedure of Onwuka (2005) was adopted. 2 g of the flour sample was mixed with 25 ml of distilled water in a warring blender. A complete dispersion was obtained by blending at 1600 rpm for 30 seconds. Subsequently, 25 ml of vegetable oil was gradually introduced into the dispersion and blending action continued for another 30seconds. The dispersion was then transferred into graduated centrifuge at 1600 rpm for 5 minutes. The volume of the oil separated from the sample after centrifuge was read directly from the centrifuge tube.

$$\text{Emulsion Capacity} = \frac{volume\ of\ emulsified\ layer}{volume\ of\ whole\ solution\ in\ the\ centrifuge\ tube} \quad (5)$$

2.13 Determination of Foam Capacity

The method as described by Onwuka (2005) was adopted in the determination of foam capacity. One gram of the flour was whipped into 100 ml distilled water and its volume noted. The suspension was blended with a warming blender 1600 rpm for 5 minutes. It was then poured into a 250 ml measuring cylinder, its volume noted and recorded. Using Abbey and Ibeh (1988) formula, foam capacity is expressed percentage increase in volume is as follows:

$$\text{Foam capacity} = \frac{\text{volum after whipping} - \text{volume before whipping}}{\text{volume before whipping}} \quad (6)$$

3. Results and Discussion

3.1 Functional Properties

The result of the functional properties of the flour samples are shown in Table 3.

Table 3. Mean Values of Functional Properties of Flour Blends

Sample	pH	BD (g/ml)	W (second)	S I	OAC (g/g)	WAC (g/g)	FC (g/g)	EC (g/g)
CS0	6.27 ± 0.11^{a}	0.77 ± 0.00^{a}	76.00 ± 0.07^{a}	1.99 ± 0.01^{a}	2.81 ± 0.01^{a}	3.20 ± 0.01^{a}	1.61 ± 0.11^{a}	2.41 ± 0.01^{a}
CSW1	6.28 ± 0.01^{a}	0.79 ± 0.02^{a}	65.00 ± 0.07^{a}	2.10 ± 0.01^{a}	2.63 ± 0.01^{a}	3.13 ± 0.07^{a}	1.63 ± 0.02^{a}	2.43 ± 0.01^{a}
CSW2	6.29 ± 0.58^{a}	0.80 ± 0.12^{a}	64.00 ± 0.01^{b}	2.00 ± 0.00^{a}	2.57 ± 0.00^{ab}	3.10 ± 0.08^{ab}	1.60 ± 0.00^{a}	2.43 ± 0.11^{a}
CSW3	6.29 ± 0.55^{a}	0.79 ± 0.01^{a}	61.00 ± 0.11^{c}	2.05 ± 0.01^{a}	2.43 ± 0.43^{bc}	2.90 ± 0.33^{bc}	1.62 ± 0.00^{a}	2.44 ± 0.01^{a}

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CSW4	6.25 ±0.01^{a}	0.82 ±0.03^{a}	57.00 ±0.01^{d}	2.00 ±0.00^{a}	2.36 ±0.01^{cd}	2.80 ±0.57^{c}	1.57 ±0.02^{a}	2.44 ±0.01^{a}
0SW	6.10 ±0.33^{a}	0.80 ±0.01^{a}	35.00 ±0.01^{e}	1.66 ±0.00^{b}	2.24 ±0.00^{d}	2.71 ±0.00^{c}	1.60 ±0.21^{a}	2.45 ±0.11^{a}
LSD	**0.3**	**0.26**	**0.75**	**0.26**	**0.15**	**0.22**	**0.23**	**0.38**

Mean ± Standard deviation of triplicate

Means with the same superscript within a column are not significantly different (p≤0.05)

CS0: Cocoyam-soybean flour (90:10) (control 1)

CSW1: Cocoyam-soybean-wheat flour (80:10:10)

CSW2: Cocoyam-soybean-wheat flour (70:10:20)

CSW3: Cocoyam-soybean-wheat flour (60:10:30)

CSW4: Cocoyam-soybean-wheat flour (50:10:40)

0SW: Soybean-wheat flour (10:90) (control 2)

BD=Bulk density

W=Wettability

SI=Swelling index

OAC=Oil absorption capacity

WAC=Water absorption capacity

FC=Foam capacity

EC=Emulsion capacity

3.2 pH

pH of the flour samples ranged from 6.10 (0SW: 90% wheat flour; 10% soybean flour) to 6.29 (CSW2: 80% cocoyam; 10%-soybean, 10% wheat flour) with CSW2 and CSW3 (70% cocoyam-10% soybean-20% wheat flour) having the highest pH values. There was significant difference (p≥0.05) among the samples. The pH values of the flour samples indicate that they are low acid food samples and might support the growth and proliferation of microorganisms, especially in slurry form (Ogunjobi and Ogunwolu, 2010). Similar pH values (4.2-5.78) were observed for other cocoyam cultivars (Owuamanam et al., 2010). Therefore, it is important to involve preservation which includes water activity reduction, use of chemical anti-microbial agent and anti-oxidant in the case of prolong storage of the samples (Owuamanam et al., 2010).

3.3 Bulk Density

Bulk Density is very vital in determining the packaging requirement, material handling and application in wet processing in food industry (Karuna et al., 1996). Values for bulk density ranged from 0.77 g/ml (CS0) to 0.82 g/ml (CSW4). CSW4 (50% cocoyam 10% soybean 40% wheat flour) had the highest value while CS0 (90% cocoyam 10% soybean flour) had the least value. The bulk density for the flour samples were not significantly different (p≥0.05). The bulk density of the flour samples is in the same range of 0.69 g/ml and 0.81 g/ml as reported for cocoyam flours by Amandikwa (2012). Flours with bulk density (>0.7 g/ml) are used as thickeners in food products (Akubor & Badifu, 2004), therefore, the cocoyam flour blends in this study could also be suitable as thickeners.

3.4 Wettability

The flour samples have wettability from 35.00 to 76.00 seconds. Wettability was found to be highest 76 seconds in CS0 (90% cocoyam 10% soybean flour) while 0SW (90% wheat flour 10% soybean flour) was the least 35 seconds. Significant difference ($p \leq 0.05$) existed within the samples. There was an increase in the rate at which the flour sample got wet; as the cocoyam substitution decreased down the trend. The low wettability of the flour samples could be attributed to high temperature treatment using oven, hence making them absorb moisture faster (Amandikwa, 2012). Flour sample with least time of wettability would perform better in textured comminuted meat and baked products (Achinewhu et al., 1998).

3.5 Oil Absorption Capacity

Oil Absorption Capacity (OAC) ranged from 2.24 g/ml to 2.81 g/ml. CS0 had the highest value (2.81 g/ml) while SW0 had the least value (2.24 g/ml). There was significant difference ($p \leq 0.05$) within the samples. OAC is the ability of flour to absorb oil. Oil gives soft texture and good flavor to food, therefore, the absorption of oil by food product improves texture and mouth feel (Aremu et al., 2006). A high oil absorption capacity is valuable in ground meat formulations, meat replacers and extenders, doughnuts, pancakes and soups (Onimawo & Egbekun, 1998).

3.6 Water Absorption Capacity

Water Absorption Capacity (WAC) ranged from 2.71 ml/g (0SW) to 3.20 ml/g (CS0). There was significant difference within the flour samples. WAC is the ability of a product to associate with water under limiting condition. It has been suggested that flours with high WAC as seen in this study, will be very useful in bakery products, as this could prevent staling by reducing moisture loss (Obatolu et al., 2007). Water and oil absorption capacities are useful to indicate whether flours can be incorporated into aqueous food formulation especially those involving dough handling. Niba et al. (2001) also stated that water absorption capacity is important in bulking and consistency of products as well as baking applications.

3.7 Swelling Index

There was no significant difference ($p \leq 0.05$) among the flour samples in swelling index. CS0 (control 1) had the highest value (2.10 ml) while 0SW (control 2) had the least (1.66 ml). The swelling index increased with higher substitution with cocoyam flour. According to Arathi et al. (2003), the presence of protein bodies around starch granules may restrict granule swelling and hence, reduce the susceptibility to enzymatic attack. Generally cocoyam samples shows good swelling index when compared to other root crops like cassava (Ojinaka et al., 2009). This is because of the type of granules cocoyam starch has and its highly digestible nature. The extent of swelling with the presence of water depends on the temperature, availability of water, species and starch damage due to thermal and other carbohydrates such as pectin, hemicelluloses and cellulose and protein.

3.8 Foaming Capacity

Foaming capacity values ranged from 1.57 to 1.63. CSW1 had the highest value while 0SW had the least value. There was no significant difference ($p \geq 0.05$) in the foam capacity of the samples. Foam formation and stabilization is a surface active function of proteins.

3.9 Emulsion Capacity

The emulsification capacities of the flour samples were not significantly different ($P>0.05$). The emulsification capacity is within the range of 2.41(CS0) - 2.45 (0SW). The emulsion capacity of the flour samples increases as cocoyam substitution decreases. Emulsification property plays a significant role in many food systems including meat products, batters and dough and salad dressings. One of the important functions proteins perform in certain food system is emulsification. Efficiency of emulsification varies with the type of protein, as concentration, pH, ionic strength, viscosity of the system, temperature and the method of preparation of emulsion capacity is influenced by equipment design, rate of oil addition, salt (type and concentration), sugar and water content (Mcwatters et al., 2003).

4. Conclusion

The result of the functional properties of the composite flour blends showed that they could be suitable for other food formulations. Sausage roll sample (CSW1), from composite flour (80% cocoyam, 10% soybean and 10% wheat) can be recommended for diabetes, heart disease, obesity and weight management due to its high fiber content. Furthermore, this study has created the utilization of cocoyam, so as to add value to it, and help in reducing the dependency on wheat flour. This will go a long way to conserve our economy by saving the huge foreign reserve used for wheat importation. Our indigenous tuber crop (cocoyam) will no longer be wasted in terms of excess. Again, this technology can simply be used in homes to create variety in meals and prevent monotony in feeding wastes also. The formulation and use of composite flours in baking is gaining popularity in food industries. It is one of the various means of fighting malnutrition resulting from nutrient deficiencies.

4.1 Recommendations

Based on the results obtained and conclusion, the following recommendations are necessary. Further studies should be done to improve the color and texture of the sausage roll to make it more appealing and palatable. Shelf-life, packaging and storage studies should be done because no preservative was added to the sausage roll and they spoilt within few days of production.

Farmers of cocoyam will be encouraged as they will be making more sales since a conversion product for their produce has been developed. Globally, convenience is the main focus, producing a snack with our local raw material which can compete with the conventional, will be a welcomed development.

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Appendix

Plate 1. Oven-dry Slices of Cocoyam (*Xanthosoma Sagittifolium*) *Ede Uhie*

Plate 2. Cocoyam Flour (*Ede Uhie*)

Plate 3. Soybean Flour

Plate 4. Sausage Roll (CSW4) (50%Cocoyam-10%Soybean-40%Wheatflour)