Suitability of Cassava Starch in Making Baked and Fried Composite Flour Products

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Abstract
Except for carbohydrate, cassava is a poor source of protein, fats, minerals, and vitamins, but when blended with other foods it makes products of high nutritional quality. The suitability of cassava starch in making baked and fried products was investigated in this study. Materials used were cassava starch and soy flour obtained from former main Morogoro Market. Cassava starch-soy flour formulations (100:0, 80:20, 60:40, 40:60, 20:80, 0:100) were carried out based on percentage by weight. There was an increase in nutrient content of the composite flour as percentage of soy flour increased. Cassava starch (100%) was unsuitable for bread, pan cakes and buns as it gelatinized to form products of rubbery texture. Cassava starch: soy flour (80:20) produced highly acceptable breads. Incorporating 20-60% soy flour in cassava starch was observed to be suitable in making pan cakes. Addition of 20-40% soy flour to cassava starch produced fried buns of good sensory characteristics. Sensory evaluation of breads, buns and pan cakes was carried out to determine acceptance of the products. Products made from a composition with more than 60% soy flour were not accepted because of strong grassy-beany flavour and bitter taste of soybean. It was concluded that, cassava starch 100% and 100% soy flour were unsuitable in baking and frying of products. However, at certain ratios (60:40 and 80:20) when cassava starch was mixed with soy flour, it became suitable for baking and frying. It was recommended that cassava starch can be exploited in making baked and fried food products.

Keywords: Cassava starch, Soybean, Baked products, Acceptability

Introduction

Cassava is one of the important tropical food crops, for instance it is used as a staple food in some parts of Tanzania. It is an excellent energy source (80-90% carbohydrate) forming an important source of energy in the human diet worldwide. However, cassava has low protein content (Folake *et al.,* 2012). Cassava can withstand poor climatic conditions and poor soils and is able to grow in various ecological zones where other crops fail (Bull *et al.,* 2011). Therefore, its production increases total agriculture production, making the possibility of exploiting marginal land for its cultivation compared to other crops (Nyerhovwo, 2004). Most of African countries are facing both food and nutritional insecurity which manifests itself in the form of low intake of macronutrients and micronutrients in the diets of people. Cassava is recognized as a suitable crop for micronutrient intervention in Africa (Olusola, 2008). This can be achieved through strategies like; promotion of fermentation process, micronutrient fortification and changing of dietary attitude that will allow consumption of cassava products (Olusola, 2008). Cassava fortification with enough vitamins, minerals and protein can provide the poor and malnourished with a day's worth of nutrition in a single meal (Ohio University, 2008).

Despite the multifunction of cassava starch in other domains, in food industry cassava starch is used in food processing as in extruded snacks, as a thickener, flavouring and a binding agent (Nyerhovwo, 2004). Cassava starch can be mixed with other food ingredients to enhance nutritive value, flavour, taste, texture, colour and appearance. This approach as well as improving cooking techniques can increase cassava consumption.

Baked products including breads and buns are usually prepared from flour or meal derived from some forms of grain. Though rich in carbohydrate, cassava flour has not been properly exploited for making bakery products mainly because of its low protein content. Composite flours are extensively used in bakery industry to develop food products having specific or functional properties (Jisha and Padmaja, 2008).

Shortage and high cost of animal protein calls for interest in use of soy flour as an alternative source, due to its low cost and high-quality protein (Shurtleff and Aoyagi, 2004). Soy flour can be used to develop food mixtures which are nutritionally adequate to meet demand of vulnerable groups. However, its utilization in Tanzania is still low (Gowele *et al.,* 2009) regardless of the existence of high levels of protein-energy malnutrition among under five children (NBS, 2010).

The objective of this study was to explore opportunities for cassava starch consumption by developing composite breads, pan cakes and burns.

Materials and Methods

Materials

Raw materials used in this study were; fresh cassava, dried soya beans, margarine, cooking oil, salt, wheat flour and sugar. These items were purchased from the former main Morogoro market.

Methods

Cassava starch preparation

Fresh cassava roots were peeled, washed and chipped. The chips were then macerated and filtered through muslin cloth. The filtrate was allowed to settle and supernatant was discarded. The sediment was washed twice before being thinly spread on trays and sundried in a solar drier for one day. The dried cake was milled by a hammer mill and sieved, as described by Laswai *et al.,* (2009). Starch yield was 20% of the dried cassava.

Soy flour preparation

Soybeans were sorted to remove dirty and unwanted materials, then soaked in water for five hours, followed by dehulling by hand and boiled for 20 minutes to remove anti-trypsin inhibitors as described by Folake *et al.,* (2012). The dehulled and boiled soy beans were dried at 70ºC in an oven, ground to flour and sieved to pass through 1mm sieve to obtain soy flour.

Preparation of cassava starch-soy flour breads, pan cakes and burns

Production of various composite breads was done according to Shittu *et al.,* (2007). In the production of breads, each sample mixture of cassava starch-soy flour (100g) based on percentage composition (Table 1) was bended with sugar (6 g), salt (1.5 g), yeast (1.5 g) and margarine (10 g) and mixed for 1 minute by using a food mixer to obtain homogenous mixture. This was followed by addition of 90-120 mls of water. The mixture was poured into a greased baking pan and allowed to leaven for 60 minutes. The leavened mixture was baked in an oven set at 200ºC for 30 minutes to produce breads.

Table 1: Composition of different formulations

Formulation (sample)	Ratio of flours	
	Cassava flour	Soy flour
A	0	100
B	20	80
C	40	60
D	60	40
E	80	20
F	100	0

For the same formulations, mixture of cassava starch-soy flour (100 g), boiling water was added in a ratio of 1:1 flour to water before kneading. Then composite flour of 20-30% cassava soy bean was added with 1.5 g salt and 10 g margarine and mixed for 1 minute. The dough was made into small balls which were flattened and shallow fried to obtain pan cakes.

In the production of buns, cassava starch-soy flour (100 g), sugar (6 g), salt (1.5 g) yeast (1.5 g) and margarine (10 g) were mixed for 1 minute by food processor to obtain homogenous mixture. After this, 100 mls of water was added to the homogenous mixture and mixed at a high speed. The mixture was then left to stand for 60 minutes and made into small balls before deep frying to get burns.

Acceptability of the Products

Acceptability tests were carried out using semi-trained consumer panel selected randomly where 30 panelists assessed each product in terms of colour, texture, smell, taste, appearance and overall acceptability. This was based on a 5- point hedonic scale. In this rating, 1 = dislike extremely, 2 = dislike, 3 = neither like nor dislike, 4 = like 5 = like extremely. Scores were analysed using Analysis of Variance (ANOVA) and Statistical Analysis System (SAS) to get the mean score attributes to determine the degree of acceptance.

Chemical Analysis

Proximate composition of the formulated flours was carried out to determine nutrient contents of cassava starch mixed with soy bean flour. Dry matter, crude protein, ether extract, crude fibre, ash and carbohydrate content were determined using AOAC (1995) methods.

Energy content

This was calculated using the Atwater conversion factors of 4 kcal/g for protein and carbohydrate and 9 kcal/g for fat (Southgate and Durnin, 2007)

Results and Discussion

Results of the proximate composition and nutrient contents of different formulations are summarized in Table 2. Results show that, nutrient content of cassava starch increased as percentage of soy flour was increased in the formulation. Also, pure cassava starch was poor in protein and contents compared to pure wheat flour. Suitability in baking depended on the amount of soy flour added. On the other hand, pure soy-flour had high content in protein, fiber, and fat content. Therefore, mixing these two products resulted into a product with high nutritive value. This observation was also reported in a stud by Nair *et al.* (2013)

Table 2: Proximate composition and energy content of cassava- starch soy composite flour

Flour ratio by weight (%) CS: SF	Dry matter (%)	Ash (%)	Crude protein (%)	Crude fibre (%)	Fat (%)	Carbo-hydrate (%)	Energy kcal/100g
0:100	96.51	4.17	51.41	7.60	21.01	15.80	457.93
20:80	96.78	3.43	40.22	6.78	17.22	32.36	445.30
40:60	96.70	2.90	29.98	4.61	9.27	53.23	416.27
60:40	97.74	2.36	20.29	1.33	8.88	67.14	429.64
80:20	97.68	1.39	10.84	1.32	4.92	81.53	413.76
100:0	98.52	0.64	0.37	0.09	0.46	98.44	399.38
100 wheat flour	87.03	1.02	10.97	0.09	2.08	7.00	350.60

Results also showed that, composite mixture with 80% cassava starch and 20% soy flour produced good (sensory wise) breads and buns similar to pure wheat flour but with higher nutritive value. Similar results were also reported by Nair *et al.* (2013) who observed that nutrition value (protein and fat) increased when 20% soy flour was added to rice-based flour. Formulation of 60% cassava starch with 40% soy flour produced bread of acceptable quality with high nutritive value. The formulation produced buns similar to wheat buns and there was no significant (p>0.05) difference in acceptance between the cassava - soy and wheat buns. This type of formulation can ultimately replace wheat flour and become a suitable diet for poor and low-income families and gluten intolerant people (Lopez ***et al.,*** 2004).

Flour composition of up to 60% soy flour mixed with cassava starch produced pan cakes of acceptable characteristics though their acceptance was significantly (p<0.05) lower compared to pure wheat pan cakes. Flours with 80% cassava starch and 20% soy flour, 60% cassava starch and 40% soy flour, and 40% cassava starch and 60% soy flour produced pan cakes of acceptable soft texture due to increase in protein content. Similar results were reported by Udofia *et al.,* (2013). Cassava starch (100%) produced unacceptable baked and fried products due to lack of gluten hence unable to retain gases during fermentation. When percentage of soy flour to cassava flour increased, there was an increase in ash, crude fiber, protein and fat content in the flour composite mixture. These results were similar to those reported by Nair *et al.,* (2013) who observed increase in protein and fat with the addition of soy flour to the cassava mixture.

Sensory Evaluation of Breads

Bread made from 100% cassava starch was not accepted by panelists as shown by low scores (Table 3) due to coarse crumb structure with a rubbery texture. This was due to the fact that the dough lacked gas cells for retaining gases during fermentation. Consequently, the dough did not rise to produce good structured bread thus affected the appearance and texture of bread. This observation was in line with those by Lopez *et al.* (2004), who reported that bread made from 100% cassava starch presented a gummy crumb with dense granulation. This was an important characteristic of gluten free breads. Bread made from 80% cassava starch and 20% soy flour was accepted in terms of appearance, colour, smell, texture, and general acceptance. The acceptance was not significantly (p>0.05) different from that of pure bread (100% wheat) which was used as a control during bread making process. The use of 20% soy flour in 80% cassava starch improved the protein content and gas retention capacity of the dough.

Bread made from 60% cassava starch and 40% soy flour was slightly accepted by panelists in terms of appearance, colour and texture although it was significantly (P<0.05) different from the pure wheat bread in terms of appearance, colour, smell, taste and texture. This could be due to intensity of beany flavour which affects taste and smell of the product. Bread made from 40% cassava starch and 60% soy bean flour; 20% cassava starch and 80% soy bean flour and 100% soy flour were not accepted. There

Table 3: Mean scores of 5- point hedonic tests for sensory evaluation of cassava starch-soy bean bread

Level of inclusion			Mean scores					
CS	:	SF	Appearance	Colour	Smell	Texture	Taste	Overall acceptability
0	:	100	2.1d	2.4c	2.6c	2.0c	2.7cd	2.1c
20	:	80	2.4cd	2.3c	2.5c	2.1c	2.4c	2.2c
40	:	60	2.7c	2.5c	2.8c	2.4c	2.4c	2.3c
60	:	40	3.6b	3.6b	3.2b	3.5b	2.8b	3.2b
80	:	20	4.3a	4.3a	4.0a	4.3a	4.4a	4.4a
100	:	0	2.4cd	2.6c	2.5c	2.2c	1.9d	2.1c
PWF		4.6a	4.6a	4.4a	4.5a	4.6a	4.6a	4.6a

CS- Cassava Starch; SF- Soy Flour; PWF Pure Wheat Flour

Means bearing different superscripts in the same column are significantly different at P < 0.05 were no significant differences (P>0.05) in acceptance among them, but their acceptability was significantly (P<0.05) different from bread made from 80% cassava starch. As percentage of soy bean flour increased from 60 to 100% the bread produced were relatively softer in texture, with strong beany flavor and poor appearance. Bread with 60, 80, and 100% soy bean flour had strong and bitter flavour. According to Lock (2007) this could be attributed by presence of compounds like alcohol, aldehydes, ketones and phenols in the soy bean flour which affect the smell and taste of breads.

Table 4: Mean scores of 5- point hedonic tests for sensory evaluation of cassava starch- soy bean pan cakes

Level of cassava starch - soy flour by weight (%)	Appearance	Colour	Smell	Taste	Texture	General acceptance
CS : SF						
0 : 100	-	-	-	-	-	-
20 : 80	3.2b	3.5 c	2.6 c	2.6 c	2.5 c	2.7c
40 : 60	3.5b	3.6 b	3.1 c	3.2 b	3.3 b	3.3b
60 : 40	3.7ab	3.8ab	3.4bc	3.4b	3.4 b	3.6 b
80 : 20	3.6ab	3.6b	3.6b	3.6b	3.1b	3.6 b
100 : 0	2.0c	2.4c	2.4d	2.4c	2.1c	2.3 c
Pure wheat pan cakes	4.1a	4.2a	4.4a	4.4a	4.5 a	4.5a
Std. Error	0.2	0.2	0.2	0.2	0.2	0.15
CV (%)	32.5	30.09	27.9	29.8	31.06	25.28

Sensory Evaluation of Pan Cakes

Unblended soy flour was found to be unsuitable for making pan cakes due to poor rolling characteristics. This was because of high protein content, which acted as a binder and lowered starch content (Sana *et al.,* 2012). Pan cakes made from 80% soy flour and 20% cassava starch ware not accepted by panelists, although the score on appearance was significantly (p<0.05) lower than that of pure wheat pan cakes. High proportion of soy flour imparts a strong grassy bean and bitter flavour affecting the smell and taste of pan cakes (Lock, 2007).

The mean acceptance of pan cakes made from 80% cassava starch and 20% soy flour, 60% cassava starch and 40% soy flour; 40% cassava starch and 60% soy flour were slightly accepted but significantly lower compared to pure wheat pan cakes. Appearance, colour, taste and texture were also lower compared to pure wheat flour pan cakes. This could be due to increased amount of nutrients during flour formulation (Udofia *et al.,* 2013).

Pan cakes made from 100% cassava starch were not accepted. This was because cassava starch was not suitable in pan cake making as it produced sticky crumb structure and firm appearance (Table 4). This could be attributed to restriction in swelling and gelatinization of starch as starch granules are lightly locked within the endosperm cells. (Alcázar-Alay and Meireles, 2015) Soya fortified pan cakes were softer than whole wheat pan cakes, therefore acceptable protein rich pan cakes can be prepared by incorporation of 20% soy flour to wheat flour (Brijlata *et al.,* 2008). Size of pan cakes were dependent on the ratio of soy bean flour to starch flour. An increase in soy bean flour led to increase in diameter of pan cakes made of the same thickness and equal weight of the dough. This could be a result of low carbohydrate content, which made soy flour to lower water binding capacity thus spreading more when rolled.

Sensory Evaluation of buns

Use of 100% soy bean flour 80% soy bean flour and 20% cassava starch were found unsuitable for making buns (Table 5). This was attributed to high protein content as the dough seemed to melt away when deep fried. Soy protein has a quaternary structure made of ß-conglycinin and glycinins that have solubility properties sensitive to high temperatures. Buns made from 40% cassava starch and 60% soy bean flour were not accepted by panelists. Acceptance score was significantly ($p<0.05$) lower than that of pure wheat buns. The colour was much brown thus affecting appearance. This was due to increased heat treatment of soy protein which caused darkening probably due to browning reactions. Buns made from 60% cassava starch and 40% soy bean flour and 80% cassava starch mixed with 20% soy flour had no significant ($p<0.05$) difference in sensory parameters when compared to pure wheat buns. These composite buns were mostly accepted similar to pure wheat buns. These similarities could be due to increased gas retention during fermentation and binding capacity of starch granules (Kusunose *et al.,* 1999; Alcázar-Alay and Meireles, 2015). Buns made from 100% cassava starch were not accepted as they appeared to have sticky crumb structure. Cassava starch has low protein content thus no expansion during leavening and frying was observed which resulted to shrinkage of the crumb structure during cooking as starch granules fuse together during gelatinization.

Table 5; Means scores of 5-point hedonic tests for sensory evaluation of cassava starch-soy buns

Level of cassava starch - soy flour by weight (%) CS : SF	Appearance	Colour	Smell	Taste	Texture	General acceptance
0 : 100	-	-	-	-	-	-
20 : 80	-	-	-	-	-	-
40 : 60	2.5c	2.9b	2.6b	2.2b	2.2b	2.5b
60 : 40	4.1a	3.7a	3.7a	2.4a	3.5a	3.8a
80 : 20	4.2a	3.8a	3.6a	3.4a	3.4a	3.7a
100 : 0	3.2b	3.3a	2.3b	2.3b	2.3b	2.7b
Pure wheat burns	4.4a	3.9a	3.6a	3.6a	3.6a	4.0a
Std. Error	0.15	0.14	0.17	0.17	0.17	0.14
CV (%)	23.03	20.83	23.21	29.01	31.6	22.99

CS- Cassava Starch SF- Soy Flour

Conclusion and Recommendations

From the results of this study, it was observed that pure cassava starch was not suitable for production of baked and fried products. However, when cassava starch was mixed with soy flour at certain ratios, it became suitable for the production of baked products. Therefore, from these observations, cassava consumption in developing countries could be enhanced through compositing with legume flours to produce flour suitable for making baked and fried products (breads, pan cakes and buns). Different cooking techniques such as baking, deep frying and shallow frying can be used to make these products. Successful production and marketing of these products will ultimately depend on availability of cassava starch to the bakers and if economic constraints can be overcome. The increase of food demand especially in sub-Saharan Africa reflects the need to increase use cassava flour. This increased consumption with the aid of policy measures should stimulate the production and establishment of starch-based industries, such that starch becomes readily available for making composite food products.

Starch that is used for other non-food uses could be used for making composite flour products. The findings in this work provide evidence that tuber starches could be used as a partial substitute for wheat flour in making some wheat-based products.

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