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Nutritional evaluation of composite flour based on root and tuber crops and sensory acceptability of the developed products

Lyimo M.E., Gimbi D.M. and Shayo N.B.
Sokoine University of Agriculture, Department of Food Science and Technology,
Faculty of Agriculture, P. O Box 3006, Morogoro, Tanzania

Abstract. A study was conducted to evaluate the nutritive value of composite flour based on root and tuber crops and sensory acceptability of the developed products. Fresh tubers and roots of cocoyam, sweetpotato and cassava, respectively, were washed separately, peeled and sliced. The sliced pieces of each crop were soaked separately in water for 1-2 h to reduce toxic and anti-nutritional factors and sun dried for 4-5 days. The dried slices were milled and sieved. The flour was used in the formulation of six types of composite flour for the preparation of baked products and weaning foods. The formulated mixtures included: cocoyam: wheat: soybeans (50:20:30), cassava: wheat: soybeans (50:20:30), sweetpotato: wheat: soybean (50:25:25), cocoyam: maize:soybean (50:20:30), cassava: maize: soybean (50:25:25), sweetpotato: maize: soybean (50:25:25). The nutritive content of formulated flour mixtures contained 9.96 to 15.60, 67.98 to 74.11, 2.57 to 3.19 and 1.66 to 2.89 percent of protein, carbohydrate, fat and crude fibre, respectively. Mineral content of formulated mixtures ranged from 13.0-480.0 mg/100g for iron, calcium, phosphorus, and magnesium while the energy value ranged from 360.07 to 363.13 kcal. Sensory acceptability of the products developed from the formulated flours was carried out to asses taste, texture, smell, colour and general acceptability using a five point hedonic scale. Breads and porridges prepared were generally accepted in terms of taste, texture, smell and colour. It was therefore concluded that flour from root and tuber crops can be blended with cereal and legume flours to produce weaning foods and baked products.

Introduction

Root and tuber crops refer to any growing plant that store edible materials in subterranean roots, corm or tuber. Root and tuber crops play a very important role in food security, as they are tolerant to environmental stress and produce reasonable yields under marginal soil conditions. Root and tuber crops are basic to diets of millions of people of temperate zones and vast areas of tropics and subtropics where most of the world's undernourished people live (FAO, 1990). In West Africa root and tuber crops are very popular and are consumed in large quantities. The technology of “gari” processing has accelerated the development of root and tuber crops in West Africa (FAO, 1990).

Generally, root and tuber crops require little care and other inputs used in production and have relatively fewer pests and diseases compared to cereals and legumes. In Tanzania these crops are mainly intercropped with other crops like legumes (beans, peas and cowpea). Cassava is usually intercropped more frequently than other crops such as sweetpotato and cocoyam. The crops are usually subsistence, grown mainly as food for farmers and only selling the surplus. They are largely consumed in fresh form after boiling or roasting. Limited amounts of these crops are dried to produce flour which is used to prepare stiff porridge "ugali". Cassava is fermented and dried to produce "makopa" and "udaga", sweetpotato is dried to produce "michembe" and boiled and dried to produce "matobolwa" (Mlingi, 1995). Cocoyam is rarely dried.

Roots and tubers normally undergo some form of processing and cooking before consumption. The methods of processing and cooking ranges from simple boiling to elaborate fermentation, drying, grinding to make flour, depending on the varieties of roots and tubers (Akaroda, 1999). Processing of root and tuber crops provides a range of utilizable products, reduces post harvest losses, enhances the taste of the products and eliminates anti-nutrition factors like cyanide (Akaroda, 1992).

The nutritional value of root and tuber crops (cassava, cocoyam, sweetpotato, yams) lies in their ability to provide one of the cheapest sources of dietary energy in form of carbohydrate. They are also good sources of dietary fibre. In developing countries as a whole, they provide 9% of the total calorie intake (Onwueme, 1994). In some regions, particularly in parts of equatorial Africa they contribute almost half of the total calories consumed (FAO, 1990). Potato and sweetpotato contain substantial levels of protein, vitamins and minerals although other root and tuber crops are relatively low in protein (Akaroda, 1992).

Historically, governments and research institutions have paid little attention to root crops as compared to grains. These crops have been regarded as inferior and produced and consumed only by the subsistence farmers in the developing parts of the world. However, in recent years tropical root and tuber crops have gained interests by research communities and others who are concerned with food and nutrition problems of low income people. There is an increase in scientific research and investigation in well established research centres like International Institute of Tropical Agriculture (IITA), International Centre for Tropical Agriculture (CIAT), International Potato Centre (CIP) (Janick and Simmon, 1990). Therefore, the objective of this study was to formulate composite flours using root and tuber crops in combination with cereals to develop various utilizable options. Composite flour using different proportions of cassava, cocoyam and sweetpotato with wheat, maize and soybeans were used in preparation of weaning foods and breads.

Materials and Methods

Materials. Fresh roots and tubers of cassava, cocoyam and sweetpotato used in this study were purchased from Morogoro Municipal market. Wheat, maize, and soybean flour, cooking oil (Korie), yeast, and sugar were purchased from Pira Cash and Carry Supermarket in Morogoro Municipality, Tanzania.

Sample preparation. Fresh roots and tubers of cassava, cocoyam and sweetpotato were washed separately to remove soils and other debris. They were then peeled, sliced cross sectionally into 3 - 5mm slices using clean knife. In case of cassava, the mid-rib was removed. The sliced pieces of each crop were soaked separately in water at a ratio of 1:3 (crop:water) for 1-4h. The soak water was discarded after which the samples were spread thinly on mats and sun-dried under shade for 4-5 days. The dried samples were milled into flour. The flour was used in formulation of composite flour, which was used to prepare bread and porridge.

Formulation of composite flour. The three types of flour obtained were used to formulate composite flour based on energy requirements. According to Protein Advisory Group (1973) six formulations of different proportion were prepared as follows**:**

A Cocoyam:wheat:soybeans (50:20:30)
B Cassava:wheat:soybean (50:20:30)
C Sweetpotato:wheat:soybean (50:25:25)

D Cocoyam:maize:soybeans (50:20:30)
E Cassava:maize:soybeans (50:25:25)
F Sweetpotato:maize:soybeans (50:25:25)

Formulations (A,B and C) were used in making bread, while formulations (D, E and F) were used to prepare porridge, each formulation contained a total of 500g.

Analyses. Nutrient composition of the six types of composite flours was carried at Sokoine University of Agriculture in the laboratories of Food Science and Technology, Animal Science and Soil Science Departments. Proximate composition were determined in duplicate using the standard procedures described by Association of Official Analytical Chemists (AOAC, 1995) methods. The moisture content was determined by drying using an air oven (WTC binder type E115 RWF 12/5 at 130^{o}C) for 1 h (method 930.1). Crude protein was determined by the micro Kjeldahl , method 955.04 (% protein = N x 6:25); the crude fat content was determined by soxhlet extraction (method 972.28); the crude fibre content by dilute acid and alkali hydrolysis (method 930.10), the ash content by using muffle furnace (Carbolite type RWF12/5 Sheffield, England) at 600^{o}C for 2h to constant weight (method 942.05).

The carbohydrate content was determined by difference. The energy content was determined by multiplying percentages of crude fat, crude protein, and carbohydrate by factors of 9,4, and 4 respectively (Egan *et al.*, 1981).

The amounts of calcium, magnesium, phosphorus, and iron of the six formulations were determined in duplicate by using an automated atomic absorption spectro-photometer model 3030 (Perkin Elmer Norwalk Connecticut, USA) (method 967.21).

Bread preparation. To 500 g of formulation A which contain cocoyam: wheat: soybean, one table spoon of instant yeast, 2 table spoons of sugar, 3 table spoons of cooking oil and a pinch of salt, were added. The mixture was kneaded into soft dough. The dough was covered with a clean white cloth and left to rise (about 1 h). After rising the dough was kneaded again and small portions were cut, kneaded and placed in baking tins, where they were left to rise again (20 - 30 minutes) then baked in pre-heated oven at 200^{o}C for 20 minutes. They were removed from the oven placed on dry clean trays to cool. The same procedure was repeated for formulations, B (Cassava: wheat: soybeans) and (Sweetpotato: wheat: soybeans).

Porridge preparations. A litre of clean tap water was poured in a saucepan and brought to boil. Two hundred grams of sample D flour (Cocoyam: Maize: Soybean) was added to the pan while stirring. The mixture was heated while continuously stirred to avoid formation of lamps until boiled, 3 table spoon sugar was added and allowed to boil for 10 minutes. Porridge was poured in a thermos flask ready for sensory evaluation. The procedure was repeated for sample E and F.

Testing of bread samples. The bread samples were sliced into 3 – 4 mm slices. Each slice was coded with 3 digit numbers and presented to 20 semi trained panellists. The panellists consisted of Sokoine University of Agriculture staff and students from the Department of Food Science and Technology. The panellists were asked to evaluate taste, smell, texture, colour, and general acceptability using 5 point hedonic scale where 5 represented the highest order of preference and 1 the least order of preference as described by Larmond (1977).

Statistical Analysis. Data obtained were subjected to analysis of variance using MSTAT C statistical software package (Freed *et al*., 1990) and mean separation done using Duncan's Multiple Range Test (Snedecor and Cochran, 1990).

Results and Discussion

Nutrient composition of the formulated composite flour. The results in Table 1 and

Table 2 show that there was a significant difference (P<0.05) between the tested samples. The protein content of the composite flour formulations ranged from 9.96 – 15.60%. These results show that mixing of legumes, such as soybean and cereals like wheat with sweetpotato, cassava and cocoyam crops have a great influence on the protein level of the resulting mixtures. Soybean is often times used in preparation of infants formulae due to its high content of protein (30-46%) and fat (12 - 14%) (Annan and Plahar, 1995). The results in Table 1 show that the protein in the formulated flour satisfies the requirements for bread baking flour which is about 10 - 12% protein as reported by West *et al.* (1988). The results in Table 2 show that the protein content of the formulated composite flours (13.15-15.6%) falls within the range of protein requirements for babies, which is 15% as recommended by Codex Alimentarius Commission (1994). These results support FAO reports (1990), which show that cocoyams contain high protein content, followed by cassava and lastly sweetpotato.

Fat content of formulated composite flours ranged from 2.57 to 3.19% (Tables 1 and 2), which is lower than 10 – 20% recommended fat for the formulation of supplementary foods (Anna and Plahar, 1995). However, the fat content of the formulated composite flour in this study is close to wheat flour (2%) as reported by West *et al.* (1988).

Table 1: Nutrient composition of composite flours for baking (in dry basis).

Composite flour	Crude protein	Crude fibre	Crude fat	Carbonhydrate	Ash	Ca	Mg	P	Fe
			%				mg/100g		
Cocoyam: wheat:soybean (50:20:30)	13.26a	2.04a	2.73b	70.98c	2.64a	320b	150b	460a	15.20a
Cassava:wheat:soybean (50-:20:30)	9.96c	1.92b	2.83a	74.11a	2.51b	320b	150b	430b	15.00a
Sweetpotato:wheat:soybean (50:25:25)	12.22b	1.66c	2.57c	72.78b	2.51b	330a	190a	390c	14.30a

Means followed by the same superscript letter within the column indicate no significant difference (P>0.05) according to DMRT.

Table 2: Nutrient composition of composite flours for weaning foods (in dry basis).

Composite flour	Crude protein	Crude fibre	Crude fat	Carbonhydrate	Ash	Ca	Mg	P	Fe
			%				mg/100g		
Cocoyam: wheat:soybean (50:20:30)	15.6a	2.65c	2.88c	67.98c	1.91c	360.00a	200.00a	480b	14.30a
Cassava:wheat:soybean (50-:20:30)	14.28b	2.89a	3.19a	70.26a	2.97a	320.00b	160.00b	479.20a	14.70a
Sweetpotato:wheat:soybean (50:25:25)	13.15c	2.83b	2.83b	68.83b	2.94b	300.00c	130.00c	460.00c	13.00b

Means followed by the same superscript letter within the column indicate no significant difference (P>0.05) according to DMRT.

On the other hand the fat content in the tested samples is not likely to cause rancidity in the flour when stored at room temperature.

The crude fibre of the formulated composite flours show significant difference (P> 0.05) and ranged from 1.66 – 2.89% (Table 1 and Table 2). These values are in accordance with the allowable levels of food fibres of 1.6-2.8% as reported by FAO/WHO (1971). The results of the present study show that the fibre content of the composite flour for weaning formulations (Table 2) agree with the crude fibre of 2.5% recommended by Protein Advisory Group (1973).

The carbohydrate content of the formulated composite flours in the present study (Table 1 and Table 2) is within the range required for wheat flour for bread baking and weaning food mixtures which is between 60 - 90 % dry weight basis (West *et al.*, 1988). Physical properties of starch grains influences the digestibility and processing qualities of root and tuber crops. Most of the starch granules like those in cocoyam are very small which improves the starch digestibility, hence making the flour suitable for infants and invalids food formulations (FAO, 1990). The results for calcium, phosphorus and iron of the formulated composite flours vary significantly (P> 0.05%) (Table 1 and Table 2). Calcium content of the formulated flours is within the range required for wheat flour and for weaning food formulations. Felicity (1993) recommended that the calcium content for infants weaning foods is 400 mg/100g, which is sufficient when an infant is able to take at least 300g of the weaning mixture per day.

Sweetpotato: maize: soybean (50:25:25) mixture had the lowest total energy 360.07 kcal while that of sweetpotato: wheat: soybean (50:25:25) had the highest total energy of 363.13 kcal (Table 3). Among the formulated composite flours in this study cocoyam: cassava and sweetpotato with wheat and soybean flours respectively (Table 3) were within the recommended values of flour for bread baking of about 340 kcal as recommended by West *et al.* (1988). The energy content of the formulated mixtures for weaning food (cassava/sweetpotato/ cocoyam : maize : and soybean) is in accordance with the recommended energy values of 360-400 kcal (Codex Alimentarius, 1994).

Generally the composite flour obtained in this study have added advantages

Table 3: Energy content of formulated composite flour (kcal).

Composite flour	Protein	Fat energy	Carbohydrate	Total
Cocoyam: wheat:soybean (50:20:30)	53.04	24.57	283.92	361.53
Cassava:wheat:soybean (50:20:30)	39.82	25.47	296.44	361.73
Sweetpotato:wheat:soybean (50:25:25)	48.88	23.13	291.12	363.13
Cocoyam:maize:soybean (50:25:25)	62.40	25.92	271.92	360.24
Cassava:maize:soybean (50:25:25)	52.60	28.71	281.04	362.35
Sweetpotato:maize:soybean (50:25:25)	57.14	27.92	275.32	360.07

nutritionally in terms of protein, carbohydrate, and minerals, but low in fat content which is compensated in energy content, showing that all six formulations were within the recommended energy required for baked and weaning foods.

Sensory acceptability of the products prepared from composite flour. Sensory acceptability of the bread made from the composite flour of cocoyam: wheat: soybean, cassava: wheat: soybeans, and sweetpotato: wheat: soybeans show that there was no significant difference ($P < 0.05$) in taste texture, colour and general acceptability (Table 4). However, significant ($P>0.05$) variation was observed in smell of bread prepared from sweetpotato: wheat: soybean mixture compare to bread prepared from cassava and cocoyam: wheat: soybeans (Table 4). Generally some of the panellists (40%) reported that the breads had some beany smell which was not liked much. The beany smell was due to the presence of soybeans flour in the mixture as reported earlier by Protein Advisory Group (1973) that legumes contain strong smell which affect the acceptability of the products. The results in Table 5 show that there was no significant difference ($P<0.05$) in texture, smell and general acceptability in all the porridge samples prepared from the formulated root and tuber composite flour in this study. However, significant differences ($P>0.05$) were observed in taste and colour of porridge prepared from cocoyam:maize ;soybeans as shown in Table 5.

Conclusion

The results of this study show that formulation of composite flour of root and tubers such as cocoyam, cassava and sweetpotato up to 50% with cereals (wheat and maize) and legumes (such as soybeans) are good sources of carbohydrate therefore, they may be adopted as an alternative and cheap source of energy for most people. Also the mixtures are good source for protein, crude fibre, and minerals including calcium, and magnesium. Hence root and tuber flour can be used in Tanzania to substitute for wheat flour in producing good composite bread products and with cereals such as maize to produce weaning mixtures, which will ensure food security.

Bread and porridge prepared from formulated root and tuber composite mixtures were generally accepted suggesting that root and tuber crops can be utilized in form of breads, both for adults and children, and porridge for children under five years and school children. These products need to be

Table 4: Mean scores of breads made from root and tuber based composite flours.

Sample	Taste	Texture	Smell	Colour	General acceptability
Cocoyam:wheat:soybean	3.0a	3.10a	3.5a	3.20a	3.05a
Cassava:wheate:soybean	3.53a	3.89a	3.5a	4.16a	3.60a
Sweetpotato:wheat:soybean	3.15a	3.79a	2.8b	3.05b	3.16a

Table 5: Mean scores of porridges from root and tuber based composite flours.

Sample	Taste	Texture	Smell	Colour	General acceptability
Cocoyam:maize:soybean	2.8b	3.8a	3.4a	2.8b	3.2a
Cassava:maize:soybean	3.9a	4.3a	3.8a	4.0a	4.2a
Sweetpotato:maize:soybean	3.7a	4.0a	3.2a	3.3a	3.8a

promoted and encouraged in the communities, which grow these crops. This will help to reduce the dependence on cereal crops in the household food security.

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