Proceedings of the 13th ISTRC Symposium, 2007
pp. 559 - 567

Pasta production: Another under-exploited way of increasing cassava utilization

Ballegu W.R.W.[1], Laswai H.S.[1], Mpagalile J.J.[1], Silayo V.C.K.[2] and Mansour H.[1]
[1]Department of Food Science and Technology, Sokoine University of Agriculture,
P.O. Box 3006, Chuo Kikuu, Morogoro, Tanzania
[2]Department of Agricultural Engineering and Land Planning, Sokoine University of Agriculture,
P. O. Box 3003, Chuo Kikuu, Morogoro, Tanzania

Abstract. One of the contributory factors to low cassava utilization, despite its promising potential, has been attributed to limited utilization options. Whereas one area has been cited as poor utilization in the fresh state in the form of *kibabu*, other potential options have not been exploited fully in Tanzania. This study was conducted to establish possible levels of blending wheat flour with cassava flour, soybean flour or cassava starch, singly or in combination, to produce acceptable pasta and assess its acceptability. Wheat flour was used at a level not lower than 50% in the formulations. Also in each of the formulations, soy and cassava flour or cassava starch were used at 5, 10, 15, 20, 25, 45, and 50%. Results showed that it was possible to produce pasta from simple household Italian pasta making machine with all formulations except those with 45% or more of soy flour. All formulations with less than 80% wheat flour easily broke into small pieces, the extent of which depended on their composition, even prior to cooking. To produce cassava-based pasta, it was easier to work with the flour than pure cassava starch. The samples with 50:45:5 wheat:cassava starch:soy became porridge-like after cooking. Sensory evaluation results showed that pure wheat pasta was significantly ($p<0.05$) more accepted than the remaining formulations in terms of colour, smell, taste, texture and general acceptability. The sample with 20% cassava inclusion was the next most preferred. Formulations with more than 20% cassava flour and 10% soy flour were the least accepted in all sensory attributes investigated. It was therefore concluded that, for production of acceptable pasta products, the proportion of wheat flour in the formulation should not be below 80%. Further research is required to establish other factors, which could enhance acceptability of cassava- and soy-based pasta.

Introduction

Pasta is widely recognized as dough made by combining durum wheat flour – commonly known as semolina with a liquid, usually water or milk. In recent days, pasta formulations including non-wheat ingredients like sweetpotato flour and tapioca starch have been reported (Limroongreungrat and Huang, 2002; Muhammad *et al.*, 1999). The dough is made into different shapes and sizes then dried and stored (Herbest, 1995; Dexter and Matsuo, 1980). When it is needed to prepare a certain dish, the pasta is simply boiled with salt and served with sauces, curry, etc. If kept dry, pasta products can be stored, without refrigeration, for several years without noticeable deterioration in either nutritional or organoleptic qualities. For this reason, among others, pasta products remain among the popular foods of modern-day societies (Vansteelandt and Delcour, 1998; Herbest, 1995).

Food insecurity is one characteristic of most developing countries like Tanzania. As a consequence of this insecurity, protein-energy malnutrition (PEM) is rampant in most of these countries. Most people in these countries do not utilize fully the available staple foods, like cassava. This anomaly has been partly attributed to the limited utilization options and limited processing and/or preservation options (Mansour, 2003). Cassava, a high energy root crop, has limited utilization options which include; boiling the fresh root, grilling the fresh root, deep-frying the fresh root, and preparing thick porridge (*ugali*) from cassava flour. Most of these utilization options do not fit well in the life style of modern-day societies. Likewise, soybean – a high-protein legume crop – finds limited food applications in most developing countries, except those in Asia. There is still lack of appropriate small-scale processing options to produce organoleptically acceptable soy-based products.

In this study, cassava and soybeans were chosen as ingredients to be incorporated in pasta products. Cassava is a root crop that is cheap and readily available in most areas in Tanzania. It is a high yielding crop and can grow in many areas of the country. Cassava does not require high rain fall, it needs little inputs and care, and is resistant to diseases. Cassava flour of acceptable organoleptic and nutritional quality is easily produced from dried cassava roots. Soybean grows well in tropical countries like Tanzania. Despite this fact, many people in Tanzania do not commonly utilize this crop in their diets. Soybeans contain an enormous amount of high quality protein, about 42 – 46% by weight, which is known to be superior to all proteins of plant origin. Inclusion of cassava and soybean in pasta formulations was thus anticipated to serve three purposes; (i) to increase the consumption of cassava and soybean by modern-day, urban-based societies, (ii) to increase the income of cassava and soybean producing farmers by increasing the demand of the two crops, and (iii) to reduce the PEM problem among pasta consumers by developing nutritionally balanced pasta products. Therefore the main objective of this study was to investigate the feasibility of producing, at a household level, acceptable wheat-cassava-soy pasta products for food security and income generation.

Materials and Methods

Preparation of materials. Acquisition of raw materials. Three raw materials were needed to produce the composite flours used in this study; wheat flour, fresh cassava roots, and soybeans. Wheat flour and other minor ingredients, like table salt and vegetable cooking oil, were obtained from a local supermarket. Fresh cassava roots and soybeans were obtained from the municipal market.

Preparation of cassava flour. Fresh cassava roots, as obtained from the market, were processed into cassava flour and cassava starch. For cassava flour, the roots were washed to remove sand and other impurities, peeled and split longitudinally into two halves to remove the mid rib. The rib-free halves were cut into several medium-sized pieces that were washed to remove any unwanted materials. The clean cassava pieces were then soaked in distilled water for 12h. After soaking, the pieces were washed again to remove mucilage and chipped using a manually operated cassava chipper into thin chips. The chips obtained were sun dried and milled into flour. The steps involved in the preparation of cassava flour, cassava starch and soybean flour are summarized in Figure 1.

Preparation of cassava starch. Clean, medium-sized cassava pieces (obtained as explained above), were grated by help of an engine-powered grater to obtain a fine cassava mash. The mash was thoroughly mixed with a big volume of distilled water (about 10 times the volume of the mash). The resulting slurry was sifted through a muslin cloth to remove cassava chunks and fibres. The chunk-free

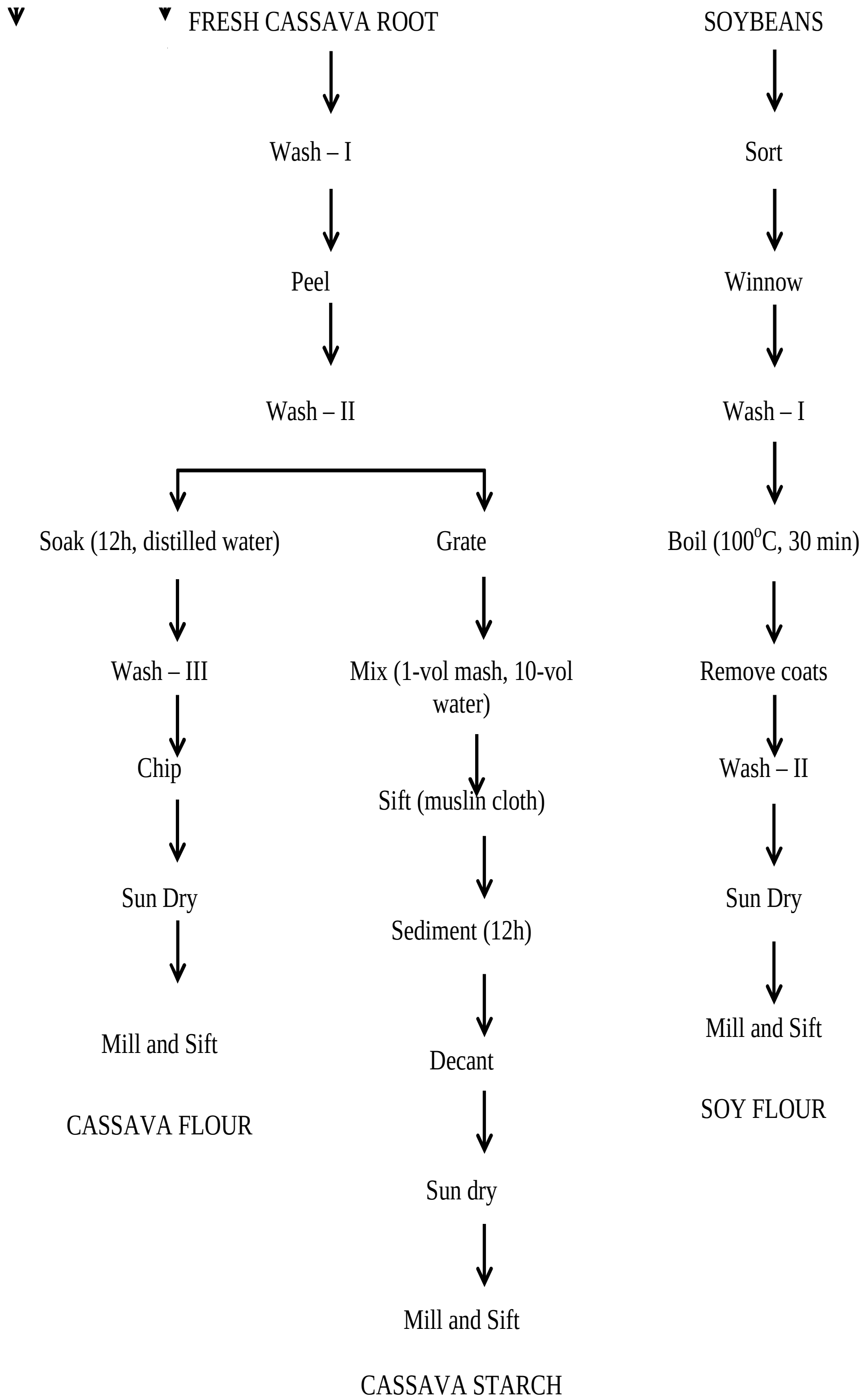

Figure 1: Steps for raw material preparation.

slurry was then rested for 12h, to allow starch particles to settle, before decanting the water and sun drying the starch. Finally the lumps of dry starch were milled to obtain cassava starch.

Preparation of soy flour. Dry soybeans, as obtained from the market, were sorted to remove unsound seeds, winnowed and washed. The beans were immersed in a pot of boiling water at about 100^{o}C and allowed to boil for 30 minutes. The beans were hand-peeled to remove the seed coat, washed again and sun dried. When dry, the beans were milled to obtain full-fat soy flour.

Formulation of samples. Samples of composite flours were formulated by thoroughly hand-blending three ingredients in desired proportions. The three ingredients were; wheat flour, cassava (flour or starch, but not both) and soy flour. In all formulations, wheat flour constituted at least 50% by weight. Each of the other ingredients accounted for 0, 5, 10, 15, 20, 25, 45 or 50% by weight. A total of 18 samples were formulated and coded as detailed in Table 1.

Production of Pasta. Production of pasta from the formulated composite flours followed a simple sequence shown in Figure 2.

Mixing. Dough of about 31% moisture (wet basis) was produced manually by working a mixture of composite flour (500g) and distilled water (about 225ml). The dough was hand-kneaded until it was smooth and homogeneous.

Extrusion. The dough, obtained after mixing, was cut into six approximately equal pieces. Each piece was flattened and run through the widest setting of a simple, family-sized, table-top Italian pasta-making machine (Marcato–

Table 1: Formulation of composite flour samples.

Sample code	Sample composition (% w/w)			
	Wheat flour	Soy flour	Cassava flour	Cassavastarch
A	100	0	0	0
Z	80	20	0	0
T	80	15	5	0
C	80	15	0	5
E	80	10	10	0
J	80	10	0	10
B	80	5	15	0
F	80	0	20	0
D	75	10	15	0
N	75	10	0	15
S	70	10	20	0
R	70	10	0	20
L	65	10	0	25
K	65	10	25	0
W	50	50	0	0
X	50	45	0	5
M	50	5	0	45
O	50	0	0	50

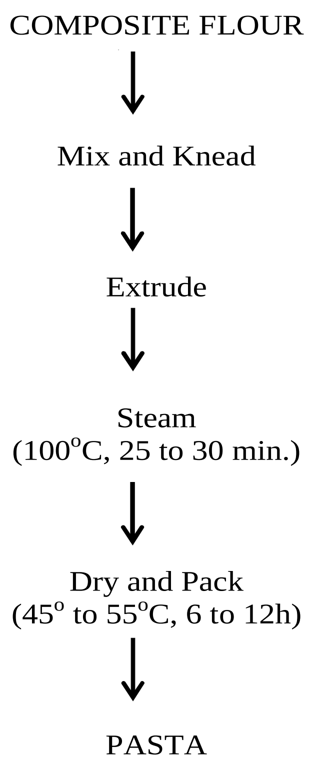

Figure 2: Steps involved in pasta production

ATLAS, Noodle Maker Machine, Italy). The dough piece was repeatedly run through the pasta-making machine, progressively reducing the nip between rollers, until a sheet of desired thickness was obtained. The dough sheet was rested for about 10 minutes before passing it through the cutting rollers of the pasta-making machine to obtain long run pasta strands (spaghetti).

Steaming. The freshly obtained pasta strands were steamed for 25 to 30 minutes. The pasta strands were carefully placed in a small cooking pot and covered with a clean piece of muslin cloth. The pasta-containing small pot was subsequently placed in a covered big pot containing boiling water on a hot plate. The level of boiling water in the big pot was kept low to avoid the water splashing into the pasta-containing small pot.

Drying and packaging. After steaming, the pasta strands were quickly separated from one another (as otherwise they tended to stick together), spread on the solar dryer trays and solar-dried for six to 12h. The dry pasta strands were packed in polyethylene bags ready for storage.

Sensory evaluation. Sensory evaluation was carried out to assess the acceptability of the formulated pasta products. Fourteen of the 18 samples were tested. The remaining four samples (M, W, O and X) were outright rejected as extreme cases and were not included in sensory evaluation. Five quality attributes were assessed; appearance, colour, texture, smell and general acceptability. A nine-point hedonic scale was used, where one stood for dislike extremely and nine stood for like extremely. The taste panel was constituted of a total of 25 untrained panelists.

Laboratory analysis. Samples of pasta products were analyzed for two important quality attributes of pasta; water absorption and cooking loss during cooking. Twenty grams of a sample were cooked for five minutes in 200ml of boiling distilled water. Water absorption, the difference in weight of the sample before cooking and after cooking and draining the cooking water, was expressed as a percent of the weight of uncooked sample. Similarly, cooking loss – the difference in weight of sample before cooking and after cooking, draining the cooking water and evaporating to dryness, was also expressed as a percent of the weight of uncooked sample.

Data analysis. Data analysis for results of sensory evaluation tests was done using a statistical package; Statistical Analysis System – SAS version 6.12 (SAS Institute Inc., Cary NC. USA). Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) were employed for gathering inference on the data obtained in this study.

Results and Discussion

Pasta Production. It was possible to process most formulations into long run pasta products (spaghetti). However, for formulations X (WF:SF:CF:CS = 50:45:0:5) and W (50:50:0:0), it was difficult to get a sound dough. The dough obtained was very stiff and lacked elasticity. The low quality of the dough obtained was attributed to the high proportion of soy flour incorporated in the formulations (45% and 50%). It has long been established that the quality of pasta depends to the large extent on the amount and quality of gluten present in the dough (Delcour *et al.*, 2000). Although soy flour is rich in proteins, about 42% to 46% (Gueguen and Cerletti, 1994; Smith and Circle, 1972), this protein lacks viscoelasticity, characteristic of wheat gluten (Gueguen and Cerletti, 1994). Sample O (50% WF and 50% CS), was too sticky. It was difficult, for this sample, to separate the pasta strands after steaming prior to drying. Also this sample was unique as it gave the lowest values for cooking loss and water absorption. This sample was therefore not included in sensory evaluation.

Cooking Loss. Cooking loss for the investigated samples ranged between 4.10% for sample O and 22.27% for sample R (70:10:0:20) (Table 2). The cooking loss for the wheat-alone sample (A) was 8.77%, which compared favourably with a value of 5.58% to 8.48% reported by Limroongreungrat and Huang (2001) for pasta products made out of modified sweetpotato flour supplemented with 15% to 30% defatted soy flour. Sample O

Table 2: Water absorption and cooking loss for composite flour-based pasta*,** .

Code	Sample				Sample weight (g)			Water absorption (%)	Cooking loss (%)
	Composition (%)***				Uncooked	Cooked and drained	Cooked drained, dried		
	WF	SF	CF	CS					
A	100	0	0	0	20.06	85.04	18.30	323.93	8.77
F	80	0	20	0	20.01	108.43	18.11	441.88	9.50
C	80	15	0	5	20.07	55.32	18.25	175.64	9.07
N	75	10	0	15	20.00	73.69	17.50	268.45	12.50
T	80	15	5	0	20.03	69.23	17.48	245.63	12.73
B	80	5	15	0	20.03	108.46	18.00	441.49	10.13
J	80	10	0	10	20.05	90.27	18.45	350.22	7.98
D	75	10	15	0	20.00	116.94	16.40	484.70	18.00
K	65	10	25	0	20.03	74.82	17.15	273.54	14.38
E	80	10	10	0	20.04	103.02	18.24	414.07	8.98
L	65	10	0	25	20.00	73.42	17.79	267.10	11.05
S	70	10	20	0	20.04	79.94	16.09	298.90	19.71
Z	80	20	0	0	20.00	61.63	16.29	208.15	18.55
R	70	10	0	20	20.03	96.02	15.57	379.38	22.27
M	50	5	0	45	20.07	141.65	17.17	605.78	14.45
W	50	50	0	0	20.07	84.50	17.51	321.03	12.76
O	50	0	0	50	20.00	60.81	19.18	204.05	4.10
X	50	45	0	5	20.07	86.77	16.47	332.34	17.94

* Entries are means of 2 replicates

** Samples were cooked in 200ml of boiling water for 5min.

*** WF = Wheat flour, SF = Soy flour, CF = Cassava flour, CS = Cassava starch had the lowest cooking loss of 4.10%, implying very strong binding of its particles. This sample had 50% cassava starch, and as observed by Güler *et al.* (2002), the changes in starch particles shape during drying have the greatest influence on pasta's cooking properties including levels of starch loss. On the other hand, sample R exhibited the highest cooking loss of 22.27%, suggesting weak binding of its particles. The cooking loss did not follow any clear pattern with regard to sample composition.

Water absorption. Water absorption for the investigated samples, also known as cooking yield, ranged between 175.64% for sample C (80:15:0:5) and 605.78% for sample M (50:5:0:45). The wheat-alone sample had water absorption of 323.93%, which was reasonably close to the value of 335.68% to 346.75% reported by Limroongreungrat and Huang (2001) for the sweetpotato/soy flour-based pasta. Heat-induced modifications on the starch ultrastructure have been reported to influence the water uptake of pasta products and other low water content food systems (Lo and Ramsden, 2000). Increasing the proportion of cassava flour in the formulation seemed to increase the water absorption, while increasing the proportion of soy flour had the opposite effect. However, the effect of cassava flour and soy flour in the formulation, on water absorption, could not be confirmed conclusively.

Sensory evaluation. A taste panel of 25 untrained panelists was used to evaluate five sensory attributes (appearance, colour, texture, smell and general acceptability) of the investigated samples. The evaluation was based on a nine-point hedonic scale, with one standing for dislike extremely and nine standing for like extremely. A score of five was taken as a neutral point (neither like nor dislike), acting as a borderline between liking and disliking the product.

Appearance. A wheat-alone sample (A) was significantly superior ($P < 0.05$) in terms of appearance than the rest. The only exception to this generalization was sample C (80:15:0:5) (Table 3). Ten of the 14 evaluated samples had acceptable appearance. The four samples with unacceptable appearance were D (75:10:15:0), L (65:10:0:25), S (70:10:20:0) and K (65:10:25:0) in that order of increasing unacceptability. The percentage of wheat flour in the formulation had a positive correlation with appearance ($r^2 = 0.703$). That is, increasing the proportion of wheat flour in the formulation improved the appearance of the product, and vise versa. For the non-wheat ingredients (soy flour, cassava flour and cassava starch), the correlation was poor, with r^2 values in the range 0.0013 to 0.3198. Nevertheless, there was a consistent trend of worsening appearance as the proportion of these non-wheat ingredients increased.

Colour. For this attribute, a wheat-alone sample was not significantly different ($P > 0.05$) from samples F (80:0:20:0), C (80:15:0:5), N (75:10:0:15) and J (80:10:0:10). The acceptability of pasta products, in terms of colour, increased as the proportion of wheat flour increased ($r^2 = 0.5261$) and decreased as the proportion of non-wheat ingredients increased. Three of the 14 evaluated samples had unacceptable colour; K (65:10:25:0), S (70:10:20:0) and E (80:10:10:0) in that order of increasing unacceptability.

Texture. The texture of a wheat-alone sample was in a class of its own, significantly better ($P < 0.05$) than that of the other samples. Like the other attributes, texture also improved with increasing proportion of wheat flour in the formulation ($r^2 = 0.6702$). The texture of four samples was not acceptable; L (65:10:0:25), E (80:10:10:0), S (70:10:20:0) and K (65:10:25:0).

Smell. The smell of a wheat-alone sample was superior to that of the other samples but not significantly different ($P > 0.05$) from that of samples F (80:0:20:0) and J (80:10:0:10). Again, the smell improved with increasing proportion of wheat flour in the formulation

Table 3: Scores based on a nine-point hedonic scale for five sensory attributes of composite flour based pasta (appearance, colour, texture, smell and general acceptability)*, **

Code	Sample				Sensory attribute				
	Composition (%)***				Appearance	Colour	Texture	Smell	General acceptability
	WF	SF	CF	CS					
A	100	0	0	0	7.833[a]	7.167[a]	7.500[a]	6.967[a]	7.533[a]
F	80	0	20	0	6.484[bc]	6.613[ab]	6.548[b]	6.129[ab]	6.677[bc]
C	80	15	0	5	6.936[ab]	6.613[ab]	6.355[b]	5.968[b]	6.323[bcd]
N	75	10	0	15	6.032[bcd]	6.323[ab]	6.161[bc]	5.484[bc]	5.774[bcd]
T	80	15	5	0	5.226[de]	5.613[bcd]	5.677[bcd]	5.710[bc]	5.516[cde]
B	80	5	15	0	5.645[cde]	5.774[bcd]	5.742[bcd]	5.613[bc]	5.774[bcd]
J	80	10	0	10	6.000[bcd]	6.226[abc]	6.000[bcd]	6.129[ab]	6.258[bcd]
D	75	10	15	0	4.742[ef]	5.645[bcd]	5.365[de]	5.516[bc]	5.452[cde]
K	65	10	25	0	3.290[g]	4.839[d]	3.355[f]	4.807[c]	3.807[f]
E	80	10	10	0	5.290[de]	4.807[d]	4.452[e]	5.097[bc]	5.000[e]
L	65	10	0	25	4.677[ef]	5.194[cd]	4.516[e]	5.323[bc]	5.355[e]
S	70	10	20	0	4.097[g]	4.807[d]	4.194[ef]	5.581[bc]	4.807[e]
Z	80	20	0	0	5.742[cde]	5.742[bcd]	5.645[bcd]	5.258[bc]	6.161b[cd]
R	70	10	0	20	5.388[de]	6.032[bc]	5.161[cde]	5.839[bc]	6.516[bc]

* Entries are average scores for 25 untrained panelists.
** Entries in the same column followed by different letters differ significantly (P < 0.05).
*** WF = Wheat flour, SF = Soy flour, CF = Cassava flour, and CS = Cassava starch.

($r^2 = 0.5647$). Not surprisingly, the smell worsened with increasing proportion of the non-wheat ingredients, particularly soy flour. Only one sample had objectionable smell; K (65:10:25:0).

General acceptability. The general acceptability of a wheat-alone sample was significantly superior ($P < 0.05$) over the other samples. As expected, the general acceptability improved with increasing proportion of wheat flour in the formulation ($r^2 = 0.5261$). Only two of the 14 evaluated samples were generally unacceptable; S (70:10:20:0) and K (65:10:25:0) with sample K being the most unacceptable.

Conclusions

This study revealed that it is feasible to produce acceptable pasta products by blending wheat flour with soy flour, cassava flour and cassava starch. Inclusion of these non-wheat ingredients will undoubtedly increase the utilization of cassava and soybeans, particularly to the urban-based, modern-day societies. Also these non-wheat ingredients, particularly soy flour, will certainly improve the nutritional quality of the resulting pasta products. However, this should be done with care if the acceptability of the resulting pasta products is not to be compromised. The proportion of wheat flour in the formulations should be kept high (not less than 80% w/w) as this has the strongest influence on all the five tested sensory attributes, as well as other non-sensory quality attributes of pasta, like water absorption and cooking loss. The proportion of soy flour in the formulations should be kept low as this ingredient has adverse effect on all the five tested sensory attributes, particularly smell. Cassava starch is the most interesting ingredient. It has the minimum effect on all the tested quality attributes of pasta (both sensory and non-sensory attributes) compared to the other non-wheat ingredients. However, the presence of cassava starch in the formulation makes the production of pasta a lot more cumbersome than the other ingredients.

Acknowledgements

The authors express their appreciation to the Tanzania Agricultural Research Project – Phase II (TARP II-SUA) and Sokoine University of Agriculture (SUA) for funding the reported study. The assistance of the technical staff in the Department of Food Science and Technology, SUA, is highly appreciated.

References

Delcour, J.A., Vansteelandt, J., Hythier, M.C., Abecassis, J., Sindic, M. and Deroanne, C. 2000. Fractionation and reconstitution experiments provide insight into the role of gluten and starch interactions in pasta quality. Journal of Agriculture and Food Chemistry. 48:3767- 3773.

Dexter, J.E. and Matsuo, B.A. 1980. Relationship between durum wheat protein properties and pasta dough rheology and spaghetti cooking quality. Journal of Agriculture and Food Chemistry. 28:899-902

Gueguen, J. and Cerletti, P. 1994. Proteins of Some Legume Seeds: Soybeans, Peas, Faba beans. In: New and Developing Sources of Food Proteins. B.J.F Hudson (Ed) Chapman and Hall.

Güler, S., Köksel, H. and Ng, P.K.W. 2002. Effects of industrial pasta drying temperatures on starch properties and pasta quality. Food Research International. 35:421-427.

Herbest, S.T. 1995. The Food Lover's Companion. 2nd Edition. Baron's Educational Services, Inc.

Limroongreungrat, K. and Huang, Y.W. 2002. A Novel approach for the Development of Pasta Products using Sweetpotato flour. In: Proceedings of the Annual Meeting of the Institute of Food Technologists. June 23 – 27, 2001. New Orleans, Lousiana USA.

Lo, C.T. and Ramsden, L. 2000. Effects of xanthan and galactomannan on the freeze/ thaw properties of starch gel. Nahrung 44(3):211- 214.

Mansour, H. 2003. Production, Chemical Composition and Acceptability of Cassava-Soy-Based Pasta. B.Sc. Dissertation, Sokoine University of Agriculture, Morogoro, Tanzania (unpublished).

Muhammad, K., Kusuandar, F., Hashim, D.M. and Rahman, R.A. 1999. Application of native and phosphorylate tapioca starches in potato starch noodle. International Journal of Food Science and Technology. 34:275-280.

Smith, A.K. and Circle, S.J. 1972. Soybean Chemistry and Technology.

The AVI Publishing Co. Inc., Westport Connecticutt, USA.

Vansteelandt, J. and Delcour, J.A. 1998. Physical behaviour of durum wheat (Triticum durum) during industrial pasta processing. Journal of Agriculture and Food Chemistry. 46:2499-2503.