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Full Length Research Paper

Effect of Heat-Moisture Treatment (HMT) on cooking quality and sensory properties of starch noodles from eleven sweetpotato varieties

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Abstract

Cooking quality and pasting properties of noodles from sweetpotato starch were evaluated. Extracted starch was subjected to HMT (110˚C for 3 hours at 30% moisture). Noodles were produced by extrusion process. Noodle cooking quality was evaluated by solid loss and extent of swelling during cooking. A descriptive sensory panel was employed to evaluate the sensory attributes of the dry and cooked noodles. HMT was found to restrict the release of amylose into the aqueous phase and facilitated an increase in water absorption capacity of the starch. This led to a significant reduction in cooking loss and an increase in swelling index of the HMT starch noodles. HMT starch noodles also showed improved firmness, reduced stickiness and hardness because of improved stability to disintegration and formation of strong internal bonds between polymer chains. Further, HMT starches from Salera, LU96/274, LU96/303 and LU96/304 were outstanding in producing noodles of acceptable quality.

Keywords: Sweetpotato starch; Heat-moisture treatment; Starch noodle.

INTRODUCTION

Sweetpotato (Ipomoea batatas (L.) Lam) is a high yielding crop with wide adaptation and high resistance to drought. In Malawi, utilization of sweetpotatoes have largely been limited to boiling and roasting because they are bulky, perishable and lack appropriate processing technologies (Moyo et al., 1998). The tubers are usually stored in pits using ash or in sacks. However, pit storage has been found to be effective for at least four months and is constrained by sweetpotato weevil damage, rotting and rodents (Moyo et al., 2004). In addition, this storage protocol has been found to produce unattractive and low market value tubers due to shrinkage (Mbeza et al., 1997). Therefore, there is need for continued effort to develop sweetpotato production towards improved processing technology and value added products. Utilization of sweetpotato for industrial raw materials like flour and starch is non-existent although it has the potential of adding value to the produce and helping create new domestic and export market niches for new products. Increase in utility would depend on development of appropriate processing technologies to process sweetpotato flour and starch with desirable functional properties, and on thorough understanding of the effect of processing on their properties and functionality.

A potential novel use of sweetpotato starch in Africa would be in the manufacture of starch noodles which are widely consumed in eastern Asia. Mung bean starch is favoured for starch noodle production because it gives a product with desired appearance and texture (Chen, 2003). The good quality achieved from mung bean starch is thought to be as a result of high amylose content (35%), restricted granule swelling and a type C viscoamylogram pattern. A type C pattern is characterised by no pasting peak, high stability during the heating stage and high setback during cooling (Lii and Chang, 1981). Sweetpotato starch generally lacks in these properties as its amylose content ranges from 8.5 – 38%. In addition, it has an A – type viscoamylogram pattern that is characterised by a high pasting peak followed by rapid and major thinning during cooling (Tian et al., 1991).

These requirements could be met by modifying native starch using chemical or physical methods. Of interest are the physical (heat-treatment) methods because chemical reagents are not required to impart a modifying effect (Jacobs and Delcour, 1998), and therefore, relatively cheaper to produce. HMT involves heating starch at temperatures above its gelatinization point (70-130°C) for one to several hours but with insufficient moisture (15-35%) to cause gelatinization.

Considerable work has previously been carried out on effect of heat treatment on starch and its products. In one study with sweetpotato starch, hydrothermal treatment was found to alter swelling, crystalline type and crystallinity (Shin et al., 2005). Overall, the structure contained very rigid amorphous regions and partially disrupted crystalline regions. This was attributed to the change in the packing arrangement of hydrothermal treated starch and partial crystal melting during the hydrothermal treatment (Shin et al., 2005). Collado et al (2001) observed a viscoamylograph similar to a type-C in heat-moisture treated sweetpotato starch (HMTSPS). Purwani et al (2006) observed that noodles made from heat-moisture treated sago starch had improved quality as shown by higher firmness, elasticity and less cooking losses. On the other hand, stickiness was reduced while cooking time increased.

However, a lot of studies on relationships among starch quality parameters have shown that even where correlation coefficients were significant, they might not always be consistent because of the wide diversity of sweetpotato genotypes (Lu et al., 2006). Furthermore, there is no publication to date, for Malawi, on the effect of heat-moisture treatment cooking and sensory quality of starch noodles from locally grown sweetpotato varieties. This study, therefore, aimed at assessing the potential of HMT in producing quality starch noodles. In attempting to do this, important starch noodle characteristics such as cooking quality, swelling capacity and sensory characteristics were determined in samples of eleven sweetpotato varieties.

MATERIALS AND METHODS

Materials

Eleven sweetpotato varieties Kenya, Mugamba, Zondeni, Salera, Semusa, Lunyangwa, LU96/274, LU96/303, LU96/304, LU96/334 and LU96/374 were planted at Kandiyani experimental site in Lilongwe. Six of the varieties (Kenya, Mugamba, Zondeni, Salera, Semusa, Lunyangwa) were released varieties while the other five (LU96/274, LU96/303, LU96/304, LU96/334 and LU96/374) were unreleased but showed great potential of being high yielding. The experimental plots were co-supervised by Southern Africa Root Crops Research Network (SARRNET). Harvesting of all the varieties was carried out four months later and within a 48 hour period. Twenty medium-sized storage roots per variety were randomly selected for starch extraction.

Starch extraction

Starch extraction was carried out within 24 hours of harvesting based on the method of Brabet et al (1998). Freshly harvested sweetpotato tubers were thoroughly washed, peeled and macerated in a heavy duty grater into a bowl of water and filtered through a muslin cloth. The residue was then re-suspended in tap water (1:2 v/v) and filtered in the same way. The two filtrates were pooled and passed through a 250 µm sieve. Starch was allowed to settle for 3 hours at room temperature (20-24°C) and the supernatant was discarded. The starch was then re-suspended in tap water and filtered through a 75 µm sieve and left to settle for 2 hours. This step was repeated three times replacing tap water with deionised water for the two last washings.

Recovered starch was dried in a DV 600 hot air oven (Yamato, Japan) at 40-45°C for 24 hours. Dried starch was then ground in a laboratory blender (Waring, USA) to pass through a 250 µm sieve and stored in sealed polyethylene (Ziploc™) bags at 6°C.

Starch modification

Sweetpotato starch samples were adjusted to 30% moisture by addition of distilled water and equilibrated at 5°C overnight (refrigerated condition). The moisture adjusted samples were placed in foil covered baking pans and heated in a DV600 oven (Yamato, Japan) for 3 hours at 110°C. Modified starch samples were then cooled to room temperature and dried at 50˚C in an oven, equilibrated for 4 hours and sealed in polyethylene bags (Collado et al., 2001).

Starch noodle preparation

Native starch (95%) was mixed with (5%) pregelatinized starch. Pregelatinized starch was prepared by mixing 10 g of native starch with 70 ml of water and heating the starch slurry at 95 °C in a water bath for 5 minutes to form dough. The dough moisture content was then adjusted to 50% and extruded using a hand operated mincer through a modified die (4 mm) directly into hot water (95-96 °C). Extruded noodles were heated for 2 minutes and transferred into cold water (25°C). The noodles were then cooled at 4 °C in a refrigerator for 6 hours and frozen at -5 °C for 8 hours; air dried and packed in polyethylene bags (Collado et al., 2001).

Starch noodle evaluation

Cooking loss and swelling index

Cooking loss was determined by boiling 5 g of cut noodles (2 cm long) for 6 minutes. The samples were then cooled in cold water and drained for 5 minutes and rapidly weighed (W1). The noodles were wiped with filter paper and kept in a petri dish. The cooked product was dried in an oven at 130°C to constant weight (W2). Cooking water was centrifuged at 7500 g in an H26F centrifuge (Kokusan, Japan) for 10 minutes (Mestres et al., 1988). Total cooking losses, which include solid and soluble losses during cooking, were calculated as:

$$\text{Total cooking loss (\%)} = \frac{(5 \times DM - W2) \times 100}{(5 \times DM)}$$

and

$$\text{Swelling index (\%)} = \frac{(W1 - W2) \times 100}{W2}$$

Where DM is the sample dry matter

Sensory evaluation of dry and cooked noodles

Sensory evaluation of dry and cooked noodles was carried by a 10 member descriptive panel that was employed and trained for descriptive analysis. Selection of panelists was based among other factors, on their previous consumption record of pasta-like products. The panelists were trained in three sessions over a two-week period, during which time; they evaluated dry and cooked reference samples to understand terminology that would be used in the actual analysis. In addition, they also discussed the quality attributes and the use of the rating method according to Kim and Wiesenborn (1996). A structured- hedonic scale of 7 points (1 = dislike very much to 7 = like very much) was used. Dry starch noodles were evaluated for colour (lightness), glossiness and hardness while cooked noodles were evaluated for stickiness, firmness and elasticity using the line scaling method (Meilgaard, Caiville and Carr, 1991).

Statistical analysis

Statistical Package for Social Scientists (SPSS, version 15.0) was used for statistical analysis. Differences between samples in each item were tested using analysis of variance (ANOVA) and Duncan's Multiple Range as a post-hoc test when the analysis of variance indicated significant differences in the means. A significance level of $P \leq 0.05$ was used throughout the study.

RESULTS AND DISCUSSION

Effect of HMT on cooking loss of sweetpotato starch noodles

Cooking loss is a measure of the cooking quality for noodles. It is a measure of resistance to disintegration upon prolonged boiling (Galves, Resurreccion and Ware, 1994). Cooking losses showed a significant decrease ($P \leq 0.05$) in all the HMT starch noodles (Figure 1). This was consistent with the results of Purwani et al (2006). HMT has been reported to enhance cross-linking within the starch molecules, hence restricting its swelling capability and release of amylose into the aqueous phase. Occurrence of these strong internal bonds reduces solubility, leading to reduced losses during cooking (Kim et al., 1996). These characteristics may possibly have promoted the gelatinized HMT starches to behave like strong glue around the surface of the noodles.

Several varieties (Mugamba, LU96/303, LU96/304, LU96/334 and LU96/374) showed a highly significant ($P \leq 0.01$) reduction in cooking losses. A two-way analysis of variance showed a significant ($P \leq 0.01$) interaction between variety and treatment on cooking loss. This entailed that HMT impacted differently on the different varieties. The sharp reduction in cooking losses could be attributed to the high level of cross-linking in HMT starches. It is this extensive bonding that prohibited solubilization and amylose leaching into the cooking water, leading to low cooking losses (Chen et al., 2002).

Effect of HMT on swelling index of sweetpotato starch noodles.

Swelling index of the noodles made from modified starches was significantly higher ($P \leq 0.05$) than those from their corresponding native starches (Figure 2). HMT has been found to cause slight expansions of the amorphous regions. This causes disruption and breakage of some hydrogen bonds between the amorphous and crystalline regions, leading to increased water absorption capacity of the starch. Eventually, this leads to a higher swelling index (Adewabole et al., 2005).

However, LU96/374 showed a significant decrease ($P \leq 0.05$) in swelling index after modification. On the other hand, the change in LU96/303 was insignificant. This could be attributed to insufficient disruption of the hydrogen bonding within the starch molecule, which made the amorphous region inaccessible to water during hydration. This showed that the degree of cross-bonding and the strength of inner chemical bonds of the starch were different among the varieties. This finding was supported by significant ($P \leq 0.05$) interactions between variety and treatment for swelling indexes. This implied that different varieties were affected differently by heat-moisture treatment with regard to swelling indexes.

HMT had no significant effect ($P \leq 0.05$) on the molecular order and consequently, on the swelling characteristics of starch from LU96/303. Lin, Wheatley, Chen and Song (2000) also found a similar result, working with three sweetpotato varieties. On the other hand, the decrease shown in LU96/374 could imply a high degree of cross-bonding within the starch molecules. This prohibits relaxation of the crystalline structure and

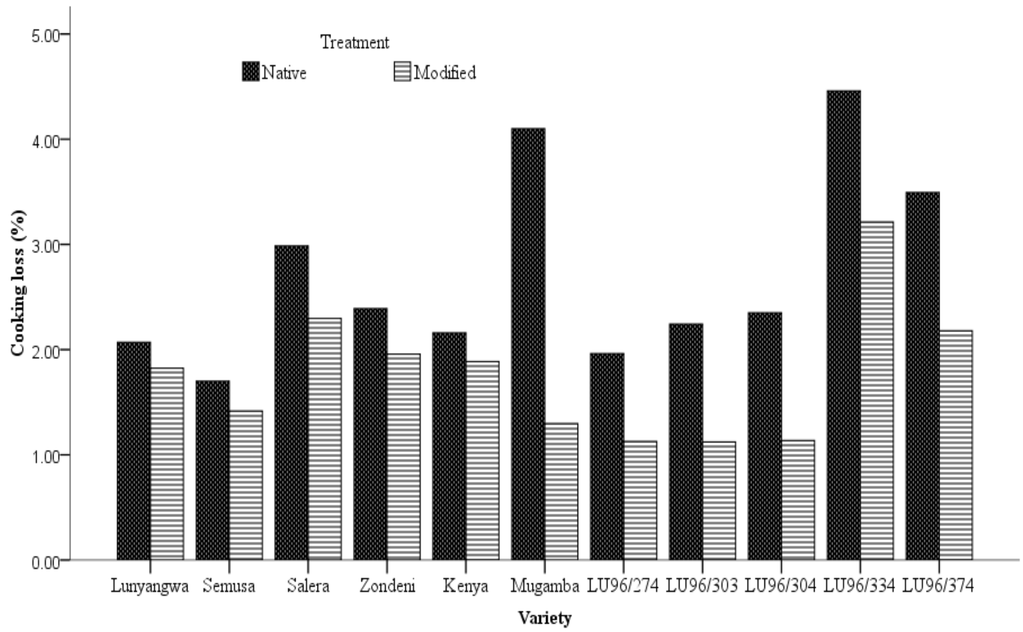

Figure 1. Effect of heat-moisture treatment on cooking loss

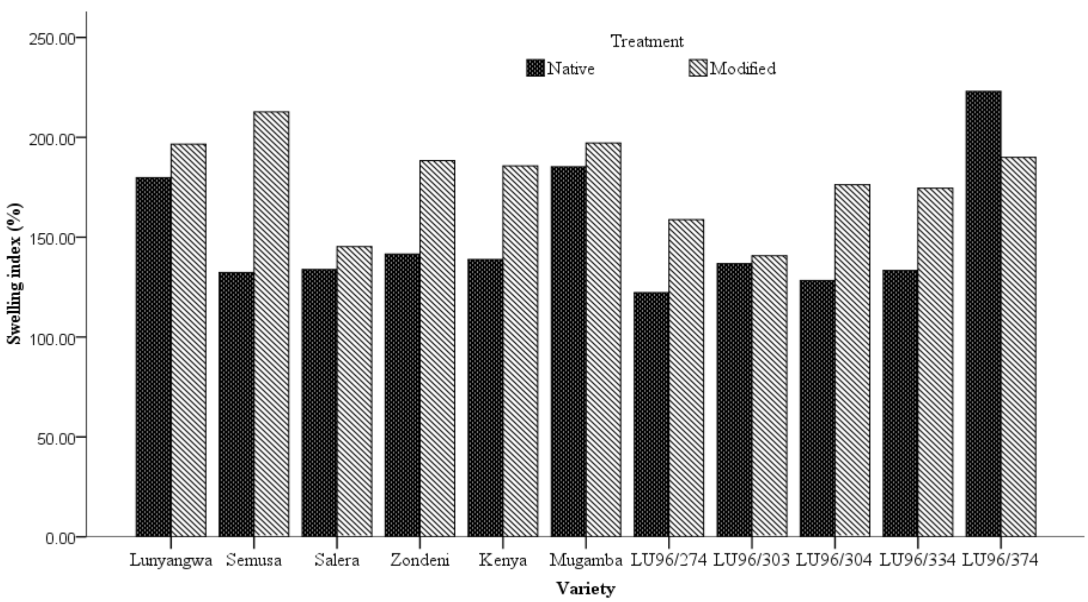

Figure 1. Effect of heat-moisture treatment on swelling index

association of amylose and amylopectin with water through hydrogen bonding (Takizawa, da Silva, Konkel and Demiate, 2004).

Effect of HMT on sensory quality of sweetpotato starch noodles

Except for lightness of the dry noodles, there were significant differences (P≤0.05) in sensory and cooking parameters between noodles made from native and modified starches (Table 1). Noodles made from sweetpotato starch exposed to HMT were significantly (P≤0.05) firmer than those made from native starches Improved firmness is a desirable characteristic for starch noodles. The increase in firmness could be attributed to improved stability in modified starches. Starches with high stability ratio have been found to produce noodles with good firmness and rehydration capacity or cooked

Table 1. Effect of HMT on sensory characteristics of dry sweetpotato starch noodles

Variety	Lightness		Glossiness		Hardness	
	Native	Modified	Native	Modified	Native	Modified
Lunyangwa	4.00±0.50[a]	3.88±0.11[a]	5.00±0.50[c]	2.54±0.21[d]	5.83±0.28[e]	4.87±0.11[f]
Semusa	3.53±0.05[a]	3.45±0.04[a]	4.73±0.25[c]	2.02±0.10[d]	6.83±0.30[e]	5.55±0.12[f]
Salera	5.96±0.20[a]	5.80±0.13[a]	6.00±0.36[c]	3.66±0.03[d]	5.00±0.72[e]	3.98±0.24[f]
Zondeni	5.23±0.40[a]	5.20±0.11[a]	5.16±0.28[c]	2.54±0.09[d]	6.00±0.40[e]	4.95±0.11[f]
Kenya	3.86±0.25[a]	3.62±0.20[a]	6.20±0.26[c]	3.76±0.11[d]	7.00±0.00[e]	5.87±0.22[f]
Mugamba	1.16±0.28[a]	1.70±0.01[a]	4.16±0.28[c]	2.12±0.07[d]	6.66±0.57[e]	5.43±0.11[f]
LU96/274	7.00±000[a]	6.98±0.04 [a]	6.93±0.11[c]	4.01±0.06[d]	5.03±0.21[e]	4.01±0.12[f]
LU96/303	4.16±0.60[a]	4.20±0.33[a]	5.06±0.45[c]	2.87±0.10[d]	5.00±0.20[e]	4.03±0.14[f]
LU96/304	4.20±0.28[a]	4.62±0.21[a]	5.00±0.20[c]	2.55±0.08[d]	5.53±0.55[e]	4.22±0.06[f]
LU96/334	6.03±0.05[a]	6.55±0.10[a]	5.06±0.11[c]	2.06±0.11[d]	5.93±0.11[e]	3.90±0.08[f]
LU96/374	4.33±0.57[a]	4.04±0.30[a]	5.83±0.28[c]	3.01±0.21[d]	5.96±0.05[e]	4.74±0.12[f]

Means followed by the same superscript in a row within the same parameter are not significantly different at p≤0.05

Table 2. Effect of HMT on sensory characteristics of cooked sweetpotato starch noodles

Variety	Stickiness		Firmness		Elasticity	
	Native	Modified	Native	Modified	Native	Modified
Lunyangwa	3.80±0.26[a]	2.91±0.05[b]	3.26±0.11[c]	5.56±0.02[d]	3.90±0.36[e]	3.00±0.54[f]
Semusa	4.80±0.20[a]	3.54±0.11[b]	3.40±0.10[c]	5.88±0.12[d]	5.00±0.26[e]	4.44±0.12[f]
Salera	4.00±0.17[a]	2.88±0.09[b]	3.33±0.11[c]	4.96±0.08[d]	4.90±0.30[e]	3.70±0.12[f]
Zondeni	4.16±0.15[a]	3.08±0.21[b]	3.23±0.32[c]	4.86±0.14[d]	4.00±0.20[e]	3.24±0.08[f]
Kenya	4.03±0.25[a]	3.44±0.08[b]	3.43±0.11[c]	5.40±0.09[d]	5.00±0.36[e]	3.98±0.06[f]
Mugamba	4.10±0.10[a]	3.46±0.12[b]	3.50±0.17[c]	5.62±0.11[d]	5.00±0.20[e]	4.30±0.12[f]
LU96/274	3.90±0.10[a]	2.96±0.07[b]	3.13±0.15[c]	5.02±0.13[d]	5.00±0.34[e]	4.58±0.22[f]
LU96/303	3.90±0.17[a]	2.78±0.06[b]	3.20±0.20[c]	5.22±0.16[d]	3.96±0.05[e]	3.06±0.40[f]
LU96/304	4.00±0.36[a]	2.98±0.11[b]	3.46±0.05[c]	5.44±0.08[d]	4.00±0.00[e]	3.14±0.24[f]
LU96/334	4.00±0.60[a]	2.78±0.14[b]	3.20±0.20[c]	4.78±0.13[d]	4.93±0.20[e]	3.56±0.11[f]
LU96/374	4.03±0.05[a]	3.11±0.08[b]	3.53±0.05[c]	5.60±0.08[d]	3.23±0.21[e]	2.98±0.14[f]

Means followed by the same superscript in a row within the same parameter are not significantly different at p≤0.05

(P≤0.05) firmer than those made from native starches Improved firmness is a desirable characteristic for starch noodles. The increase in firmness could be attributed to improved stability in modified starches. Starches with high stability ratio have been found to produce noodles with good firmness and rehydration capacity or cooked weight (Piyachomkwan et al., 2004). This is because there is high resistance to viscosity breakdown of starch paste as shear is applied.

Noodles made from heat-moisture treated starch also showed a significant decrease (p≤0.05) in stickiness. Reduced stickiness is another important characteristic of starch noodle quality as it facilitates easy separation of the strands. The drop in stickiness could be attributed to the alteration in the pasting behaviour of the treated starches, which showed restricted swelling. HMT may have resulted into formation of strong internal bonds between the polymer chains resulting in low solubility and swelling power. Reduced solubility leads to low release of amylose into the aqueous phase. This eventually leads to a low tendency to re-associate on cooling (Kim et al., 1996).

A significant decrease (P≤0.05) was also observed in hardness of the noodles. This could be attributed insufficient retrogradation as the amount of released amylose is reduced following HMT (Kim et al., 1996). When swollen granules occur between adjacent amylose chains, their association during retrogradation is decreased. Consequently, gels with reduced firmness result, leading to products with reduced hardness (Singh et al., 2005).

CONCLUSION

Results of this research revealed that HMT significantly influence quality of starch noodles. HMT sweetpotato starch noodles had reduced cooking losses with corresponding increase in swelling index. A firmer product resulted after HMT due to increased stability ratio of the starch. Further, noodles from HMT starches showed reduced stickiness and hardness due to formation of strong internal bonds between the starch polymer chains.

However, results on swelling index showed that starch granules in various varieties differ in their response to HMT. LU96/374 showed a significant decrease in swelling index while the change in LU96/303 was insignificant. A significant interaction between variety and starch treatment supported this observation.

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