Effect of Processing Methods on Nutrient Contents of Six Sweet Potato Varieties Grown in Lake Zone of Tanzania

***M.E. Lyimo[1], D. M Gimbi[1] and T. Kihinga[2]**

[1]Department of Food Science and Technology, Sokoine University of Agriculture,
P. O. Box 3006, Morogoro, Tanzania,
[2]Agricultural Research Institute, Ukiriguru, P. O. Box 1433, Mwanza, Tanzania

Abstract

A study was carried out to evaluate the effect of processing methods on nutrient contents of six fresh sweet potato varieties namely Carrot Dar, Japon, Zapallo, Mafuta, Polita and Sekondari commonly grown in three districts (Meatu, Sengerema and Missungwi) located along the lake zone of Tanzania. Fresh samples of sweet potato from these districts were harvested packed in cool box and immediately transported to the Department of Food Science and Technology at Sokoine University of Agriculture, Morogoro. Nutrient content of the samples was evaluated before and after processing, using three different methods namely boiling (moist heat), roasting (dry heat) and sun drying. The results showed that there were significant ($p \leq 0.05$) differences between varieties in protein, fat, reducing sugars, carbohydrates, total carotenoids, calcium, iron and magnesium content. Total carbohydrate between varieties ranged from 23.91 to 41.46 g/100g, total carotenoids (49.321 to 994.02 µg/100g), crude protein (1.44 to 2.50 g/100g), ash (0.87 to 0. 98 g/100g), fat (0.03 to 0.95%) and reducing sugars (102.04 to 145.60 mg/100g). Processing of sweet potato varieties by boiling, roasting and sun drying did not have any significant effect on the carbohydrate, protein, fat, ash, calcium, iron, and magnesium contents. However, significant ($p \leq 0.05$) effect was observed on reducing sugars and total carotenoids, when processed by these methods. Losses of reducing sugars between varieties ranged from 27.04 to 46.49% and total carotenoids (42.88 to 64.94%). The results showed that there is a need to choose processing methods that cause minimum nutrient losses. Also, selection of sweet potato varieties with high nutrient content could compensate likely nutrient losses occurring during processing.

Key words: sweet potato varieties, nutrient content, processing methods

Introduction

Sweet potato (*Ipomoea batatas* Lam) is a household food security crop for many people and as such it makes a significant contribution towards their livelihoods (Tumwegamile *et al.,* 2004). In the past, it was grown as food security crop in rural communities and was often given low priority. Currently, the crop is marketed and consumed in both rural and urban areas (Kapinga *et al.,* 2004). In Tanzania, the crop is gown in almost all zones including Lake Victoria, Western, Southern Highlands, Eastern and Northern Zones. Sweet potato is high in carbohydrates and can produce more edible energy per hectare per day than wheat and rice (Abu *et al.,* 2000). It is one of the sources of energy, vitamins and minerals in the tropics. As with all crops, the nutrient composition of roots and tubers vary from place to place depending on climate, soil, crop variety, maturity stage and storage practices (Jeong *et al.,* 2000).

Like many other foods, roots and tubers are rarely eaten raw. They normally undergo some form of processing and cooking before consumption. The methods of processing and cooking vary from simple boiling to elaborate fermentation, drying, slicing and field sun drying of roots as practiced in some developed countries (Woolfe, 1999). The basic purpose of these methods is to make roots and tubers and their products more palatable and digestible. Also these methods make them safe for human

**Corresponding author: monilyimo@yahoo.com*

Accepted July, 2010 ***Tanzania Journal of Agricultural Sciences (2010) Vol. 10 No. 1, 55-61***

consumption, extend shelf life and provide variety of products, which are more convenient to prepare, cook and consume than the raw sweet potato (Stephen *et al.,* 2005).

So far little information has been reported on the effect of these processing methods on nutrient content in sweet potato in Tanzania. Hence, the objective of this study was to assess the effect of processing methods on nutrients content of different sweet potato varieties commonly grown and consumed in Lake zone of Tanzania.

Materials and methods

A total of 6 varieties of fresh sweet potato namely Carot Dar (orange flesh), Japon (orange flesh), Zapallo (orange flesh), Mafuta (orange flesh), Sekondari (cream flesh) and Polista (white flesh) commonly grown in 3 districts of Lake zone in Tanzania namely Meatu, Sengerema and Missungwi were used in this study

Sample collection and handling

Sweet potato varieties were grown simultaneously in the study areas and harvested at the same time after maturity (about 5 months, average maturity rate for these varieties). Freshly harvested samples were kept in cool boxes (Ndunguru *et al.,* 2000.) and transported immediately to the Department of Food Science laboratory at Sokoine University of Agriculture, Morogoro.

Sample preparation

Samples of fresh sweet potato varieties were washed with clean tap water and divided into four equal lots; (about one kg each). One lot was sun dried, two lots were either boiled (moist heat) or roasted (in oven-(dry heat)) and the fourth lot was treated as control (raw) after the appropriate pre-treatments as follows:

Raw (control): Samples were peeled using a kitchen knife, cut into cubes of about 2.5 cm , washed using distilled water and then ground using mortar and pestle ready for protein, fat, reducing sugars, total carotenoids, moisture and mineral contents analyses.

Sun drying: Fresh sweet potato were peeled, sliced using kitchen knife to slices of about 0.5 cm thickness, then sun dried until moisture content was constant (about three days; day and night drying). The samples were ground using mortar and pestle and analyzed immediately for the same nutrients as for control.

Boiling (moist heat): Fresh sweet potato samples were peeled, washed with distilled water, sliced to pieces of 3-5 cm thick then boiled (moist heat) in clean water until ready to eat (about 30-45 minutes). They were then drained and left to cool at room temperature (22 ± 1ºC) mashed and analyzed immediately for the same parameters as control.

Roasting (dry heat in oven): Fresh whole sweet potato roots were washed with distilled water and placed in a pre-heated oven at 60ºC and baked until ready to eat (about 45- 60 minutes). Samples were left to cool at room temperature 22.±1ºC mashed and analysed immediately for the afore- mentioned parameters.

Laboratory analysis

Proximate analyses of both fresh and processed samples were determined in triplicate according to the procedure described by Association of Official Analytical Chemists (AOAC 1995). Moisture content was determined by drying using air oven (WTC binder, type E 115 RWF 12/5) at 105ºC overnight (method 925.10). Dry matter was calculated from moisture content as percent dry matter = 100 % - [percent moisture, crude protein was determined by micro Kjeldahl (% protein= N x 6.25) (method 925.10), crude fat content was determined using petroleum ether by the soxhlet extraction (method 960.39) and ash content by using muffle furnace (carbolite type RWF 12/5, Sheffield, England) (method. 940.26)]. Carbohydrate content was determined by difference, i.e. 100% - other proximate chemical compositions, using the following formula: Total carbohydrate= 100- (% Crude Protein+% fat+% Ash +% moisture content)

Reducing sugars content was determined by Luff-Schoorl method as described by Egan *et al.,* (1981). Reducing sugars were calculated directly from the table relating titration (T) and sugar content (G).

The amount of mineral content (calcium, iron and magnesium) of fresh and processed samples was

determined in triplicate by using atomic absorption/flame emission spectrophotometer (AA 630-12) (method. 968.08). Absorbances of various cations were read at 422.7, 248.3, and 285.2 nm for calcium, iron, and magnesium, respectively.

Total carotenoid content of sweet potato was determined by extraction method using acetone (Rodriguez-Amaya and Kimura, 2004). Two grams each of sweet potato samples were placed in a mortar and 3 g of hyflosupercel (elite) were added, and then ground in 50 ml cold acetone and filtered with suction through a sintered glass funnel (acetone extract). Then 40 ml of petroleum ether were placed in a 500 ml separatory funnel with teflon stop-cock followed by the acetone extract. Distilled water (300 ml) were then added slowly letting it flow along the walls of the funnel. The two phases were left to separate and the lower phase was discarded, washed 3-4 times with distilled water (200 ml each time) to remove residue acetone. Fifty ml petroleum ether were collected in a volumetric flask, passed through a small funnel containing glass wool and anhydrous sodium sulphate (15g) to remove residual water. Then absorbance of the sample was read at 450 nm in spectrophotometer. Data for nutrient content of all varieties were compiled and analyzed statistically by MSTAT- C statistical program version 2.1 for analysis of variance (ANOVA)

Results and discussion

The nutrient content of six fresh sweet potato varieties is shown in Table 1. There were significant ($p \leq 0.05$) differences between all varieties in nutrient contents except for ash. The protein content between Zapallo and Mafuta also Polista and Sekondari varieties differed significantly ($p<0.05$). Differences in protein content between Carrot Dar and Japon were not significant ($p>0.05$). Highest protein content was recorded in variety Carrot Dar while the lowest was recorded in variety Zapalo. Low protein values of sweet potato observed in this study suggested that it was not a good source of protein. Woolfe (1999) reported similar results and concluded that the limiting nutritional quality of sweet potato was the low protein content which ranged from 1 to 3g/100g on fresh weight basis. The amount of fat content in sweet potato also suggested that it was a poor source of fat (Table 1). Carbohydrate content was high and differed significantly ($p \geq 0.05$) between varieties. These observations support earlier findings reported by Abu *et al.,* (2000) that sweet potato is high in carbohydrates and can produce more edible energy per hectare per day than wheat and rice.

The results of this study also showed that there was significant ($p \leq 0.05$) variation in total carotenoid contents between the six varieties of sweet potato (Table 1). Varieties with deep orange flesh colour like Carrot Dar, Zapallo, Mafuta and Japon had higher contents of total carotenoids while the lowest total carotenoid content was found in cream and white-fleshed varieties, such as Sekondari and Polista. These results compare well with the findings reported by Mulokozi, (2003) and Kapinga *et al.,* (2004) who observed that the amount of total carotenoid contents differed with varieties and the deeper the orange colour the more the carotenoid content.

The results in Table 1 further showed that total carotenoid content in orange fleshed sweet potato varieties was significantly ($p \geq 0.05$) different. This was true for Carrot Dar and Japon and also Carrot Dar and Mafuta, suggesting variation in carotenoid content within the orange fleshed varieties. Similar observations were reported by Xin *et al.,* (2008) who observed that β-carotene in variety Yanshu No. 5 grown in different sites ranged from 53.2 to 84.3 mg kg^{-1} and was unevenly distributed in one sweet potato variety with highest concentration in the core. The results in Table 1 also showed that there was great variation in reducing sugars in the six varieties of sweet potato. This variation could be attributed to, crop variety, cultivation practice, climate, growing season, stage of growth, location, soil, processing and storage practices.

The effect of processing methods on sweet potato varieties in Table 2 showed that boiling, roasting and sun drying had no significant ($p \leq 0.05$) effect on ash, protein, fat, carbohydrate, calcium, iron and magnesium contents. On the other hand, boiling, roasting and sun drying significantly ($p<0.05$) affected, reducing sugars and total carotenoid content. Boiling of the sweet potato caused highest loss in reducing sugar content, while sun drying caused the lowest losses of reducing sugar (Table 2)

Table 1. Nutrient contents of different sweet potato varieties (Dry weight)

Varieties	Nutrients								
	Ash g/100g	Protein g/100g	Fat g/100g	Reducing Sugars mg/100g	Carbohydrate g/100g	Total Carotenoid µg/100g	Calcium g/100g	Iron g/100g	Magnesium
Carrot Dar	0.97	2.50	0.67	103.20	33.45	994.02	29.20	0.67	12.39
Japon	0.97	2.38	0.03	102.04	23.91	165.07	24.40	0.54	12.54
Zapalo	0.87	1.44	0.95	145.60	29.87	176.57	27.06	0.56	12.65
Mafuta	0.98	2.11	0.76	128.81	31.18	177.45	28.65	0.64	12.47
Polista	0.97	2.45	0.14	137.25	41.46	49.32	27.46	0.65	12.84
Sekondari	0.97	1.47	0.16	132.12	33.27	124.83	23.55	0.65	14.09
Mean	0.96	2.06	0.45	124.84	32.19	281.21	26.72	0.62	12.83
CV %	13.67	13.40	1.37	0.09	0.12	1.15	1.25	1.02	11.29
LSD $_{0.05}$	2.16	0.20	0.04	0.08	0.02	2.36	0.25	0.04	1.06
SE±	0.05	0.09	0.02	0.04	0.01	1.14	0.12	0.02	0.51

Leaching of nutrients and Maillard reactions could be the main reasons for reduction in reducing sugar contents (Ejoh *et al.,* 2003). Also the results of this study showed that processing of sweet potato varieties by different methods caused various levels of carotenoids losses (Table 2). Losses of carotenoids during processing of foods have been reported earlier (Ejoh *et al.,* 2003; Rodriguez-Amaya and Kimura, 2004). It has also been reported that drying techniques involving heat, light and open air systems can be damaging to carotenoids as result of oxidation, isomerization and/or free radical formation (Mulokozi and Svanberg 2002).

The effect of combination of variety and processing methods on nutrients that had significant interaction is shown in Table 3. Processing methods in all varieties resulted in lower nutrient content compared to raw (control) suggesting that processing by any of the methods caused nutrient losses. Lower losses of nutrients between processing methods in the six varieties of sweet potato were observed in carbohydrate and iron contents. On the other hand, higher variations were observed in reducing sugars and total carotenoids. Boiling of sweet potato lowered the reducing sugars of variety Zapallo by 47.0% and 34% on variety Mafuta suggesting that

Table 2: Effect of processing methods on nutrient contents of sweet potato varieties (Dry weight)

Processing method	Ash g/100g	Protein g/100g	Fat g/100g	Reducing Sugars mg/100g	Carbohydrate g/100g	Total Carotenoid µg/100g	Calcium g/100g	Iron g/100g	Magnesium
Raw (control)	0.98	2.11	0.46	170.66	32.29	457.32	26.59	0.70	12.35
Moist	0.90	2.05	0.45	91.32	32.16	261.22	26.58	0.59	12.32
Dry heat	0.97	2.05	0.45	112.86	32.15	245.99	26.59	0.59	12.35
Sundrying	0.97	2.02	0.45	124.50	32.15	160.32	26.45	0.60	12.30
Mean	0.96	2.06	0.45	124.84	32.19	281.21	26.72	0.60	12.33
CV %	13.62	13.40	1.37	0.09	0.12	1.15	1.25	1.02	11.29
LSD $_{0.05}$	NS	NS	NS	0.02	0.02	1.92	0.19	0.02	NS
SE±	0.04	0.08	0.01	0.03	0.01	0.93	0.09	0.01	0.42

the later variety can withstand boiling than former variety. Roasting had little effect on reducing sugars in varieties Carrot Dar and Mafuta, causing reductions of 2.26 and 7.4%, respectively compared to 37.67 % reduction observed on variety Zapallo (Table 3). The results of the present study have shown that sun drying of sweet potato caused higher reduction (35.5%) of reducing sugars on variety Zapallo compared to very little reduction (3.8%) observed in Carrot Dar suggesting that this variety can withstand sun drying (with minimal nutrient losses) than the former variety. In general, reducing sugars content in variety Zapallo was highly affected by all processing methods compared to the rest of the varieties. The results in Table 3 also showed that boiling had a greater effect on total carotenoids of the variety Polista causing 53.49% reduction compared to 35.89% on variety Sekondari. Losses of total carotenoids during boiling of sweet potato have been reported earlier by K'asombo *et al.,* (1998), who observed that boiling unpeeled sweet potato for 30 minutes resulted in a 14-59% reduction of total carotenoids content of four sweet potato cultivars. Roasting reduced total carotenoids of variety Zapallo

Table 3: Sweet potato varieties and processing methods with significant interaction (Dry weight)

Variety	Processing methods	Carbohydrate g/100g	Reducing Sugars mg/100g	Total Carotenoid µg/100g	Iron g/100g
Carrot Dar	Raw(Control)	33.50	124.80	1620.00	0.78
	Boiling	33.47	72.02	957.90	0.68
	Roasting	33.47	96.07	865.57	0.60
	Sun drying	33.46	120.00	532.69	0.65
Japon	Raw(Control)	24.54	139.10	247.30	0.61
	Boiling	24.01	78.79	137.70	0.50
	Roasting	24.05	91.21	148.40	0.53
	Sun drying	24.04	99.05	110.90	0.52
Zapalo	Raw(Control)	30.40	208.10	298.30	0.65
	Boiling	29.69	110.40	142.50	0.52
	Roasting	29.68	129.69	149.40	0.53
	Sun drying	29.68	134.20	116.10	0.54
Mafuta	Raw(Control)	31.70	124.00	297.10	0.73
	Boiling	31.02	81.64	157.50	0.62
	Roasting	31.12	114.80	140.00	0.61
	Sun drying	31.24	104.80	113.20	0.63
Polista	Raw(Control)	42.08	189.00	80.30	0.75
	Boiling	41.30	100.00	37.34	0.61
	Roasting	41.37	120.00	41.76	0.63
	Sun drying	41.17	139.20	29.51	0.62
Sekondari	Raw(Control)	33.37	179.00	192.90	0.72
	Boiling	33.30	104.30	124.00	0.62
	Roasting	33.30	115.45	122.90	0.64
	Sun drying	33.30	129.75	59.53	0.64
Mean		32.18	121.76	280.12	0.62
CV %		0.12	0.09	1.15	1.02
LSD $_{0.05}$		0.06	0.17	4.74	0.08
SE±		0.03	0.08	2.29	0.04

by 49.9% compared to 36.29 % reduction on variety Sekondari. Sun drying was the most destructive in total carotenoids causing losses ranging from 55.15 to 69.14% in all varieties (Table 3).

Conclusion

The results of this study have shown that there were significant ($p<0.05$) differences between varieties, in nutrient content except for ash. Processing of sweet potato varieties by boiling, roasting and sun drying caused no significant ($p>0.05$) effect on ash, protein, fat, calcium and magnesium content. On the other hand carbohydrate, iron, reducing sugars and total carotenoids were significantly ($p<0.05$) affected by all processing methods used in this study. Further more, it was observed that losses of nutrient content during processing depended on varieties, some varieties being more tolerant to certain processing methods than others.

Recommandations

The results of the present study have shown that processing sweet potato by either boiling, roasting or sun drying methods led to various levels of nutrient losses in all varieties, suggesting that there is need to select the processing methods that cause minimum nutrient losses. Selection of varieties with high nutrient content for use could compensate for the likely nutrient losses during processing.

References

Abu, A.O., Tewe O. O., Losel D.M. and Onifade A. A. (2000). Changes in lipid, fatty acids and protein composition of sweet potato (Ipomoea batatas) after solid-state fungal fermentation. Biores. Tech. 72: 189 - 192.

AOAC (1995). Official Methods of Analysis. Association of Official Analytical Chemists, Washington, DC. 820pp.

Egan, H., Kirk, K.R. and Sawyer, S. (1981). Pearson's Chemical Analysis of Food (8th Ed). Churchill Livingstone, Edinburgh, London. New York. 233pp.

Ejoh, A.R., Djuikwo, N.V. and Tanya, A.N., (2003). Effect of food preparation techniques on the nutritional profile of four species of Vernonia. [http://www.foodafrica.nri.org] site visited on 20/2/2009.

Jeong, B., Ahn,Y. S. Chung, M. and Lee, J.S. (2000). Characteristic evaluation of sweet potato petiole utilized as vegetable in Korea. In: Twelfth Symposium of the International Society for Tropical Root Crops (ISTRC) on potential of Root Crops for Food and Industries Resources. (Edited by Nakatani, M. and Komaki, K.), 10-16 September 2000, Tsukuba Japan.222-227pp.

Kapinga, R., Agili, S. and Tumegamire, S. (2004). Development of high β-carotene and other Agronomic Traits Through Conventional Breeding with Farmer's Participation, Annual Report. International Potato Center (CIP), Kampala, Uganda. 8pp.

K'osambo ,L.M., Carey, E.E., Misra, A.K., Wilkes,J., Hagenimana, V. (1998). Influence of age, farming site and boiling on provitamin A contents in sweet potato (*Ipomoea batatas (L) Lam*) storage roots. J. Food Composition and Analysis 11, 305-321

Mulokozi, G.I., (2003). Content and In Vitro accessibility of provitamin A carotenoids in some Tanzania vegetables and fruits. Effects of processing and preparation, and influence on vitamin A status. Thesis for Award of PhD at Chalmers University of Technology, Goteborg, Sweden, 165pp.

Mulokozi, G. and Svanberg, U. (2002). Effect of traditional open drying and solar cabinet drying on carotene content and vitamin A activity of green leafy vegetables. Plant Foods for Human Nutr. 60: 230-235.

Ndunguru, G.T, Westby, A., Gidamis, A. Tomlins, K.I. and Rwiza, E. (2000). Losses in sweet potato quality during post harvest handling in Tanzania. In: Proceedings of the 5th Triennial

Congress of the African Potato Association APA conference. (Edited by Adipala, E. Nampala, P and Osiru, M., 29 May to 2 June 2000 Kampala, Uganda, pp. 477 - 480

Prochaska, L.J., Nguyena, X.T., Donata, N. and Piekutowskib, W.N. (2000). Effect of food processing on the thermodynamic and nutritive value of foods: literature and database survey. J. Home 54(2): 254 - 262.

Rodriguez-Amaya, D.B. and Kimura, M. (2004). Harvest Plus Handbook for Carotenoid Analysis Technical Monograph 2. Washington, DC. 20pp.

Stephen C.R, Miang, L., Heenan,S., and Bremer, P.(2005). Evaluation of sweet potato cultivars and heating methods for control of maltose production, viscosity and sensory quality. J. Food Qlty. 28 (2): 191-204.

Tumwegamile, S. Kapinga, R., Zhang, D., Crissman, C. and Agili, S. (2004). Opportunities for promoting orange fleshed sweet potato as a mechanism for combating vitamin A deficiency in Sub-Saharan Africa. Afri. Crop Sci. J. 12 (3): 380-384.

Woolfe, J.A. (1999). Nutritional Aspects of Sweet Potato Roots and Leaves: In: Improvement of Sweet Potato (Ipomoea batatas) in Asia Technical Report. International Potato Centre (CIP), Lima, Peru. 167pp.

Xin, W.C., Liuhua, Y., Guo, Z., Zuyang, L. and Yumin, L. (2008). β-carotene content in sweet potato varieties from China and effect of preparation on β-carotene retention in the Yanshu No. 5. Innov. Foods Sci.and Emerg. Tech. 9 (4): 581-586.