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Characterization of Three Genotypes of Sweet Potato and their Suitability for Jam Making

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ABSTRACT

For a thousand years ago, man by trial and error screened some materials for catering his needs. Now in the era of science and technology the scientist discovered many nutritive crops. A high beta-carotene genotypes of sweet potatoes; TDINUNG NO.64 (dark-orange flesh), CEMSA 74-228 (dark-cream flesh) and ZAPALO (pale-orange flesh) were characterized and processed to jam. Moisture, crude protein, crude fibre, ash, fats, carbohydrates and vitamin A, as well as ascorbic acid, minerals, B group and energy value of genotypes were determined. TDINUNG NO.64 increased in fiber, fats and vitamin C. CEMSA 74-228 contain highest protein, carbohydrates and energy while ZAPALO have higher ash. Moreover, sweet potatoes under study are very rich in vitamin A and containing B-complex greater than many common fruits. The effects of storage at ambient temperature, on microbial growth, TSS, pH, total acidity and total sugars were found to be significant at $p \leq 0.05$ level. As well as, the sweet potato jams had higher acceptability than the market jam especially in term of its color, taste, consistency and overall quality.

Key words: *Ipomoea batatas*, *Bambie*, orange-flesh, biofortification, Vitamin A, processing, developing countries

INTRODUCTION

The sweet potato (*Ipomoea batatas*) is starchy tuberous root is the major economic plant of the crop (Antia *et al.*, 2006), sweet tasting and applications depend on its starch content (Bovell-Benjami, 2007). It probably originated in Mexico and Central America but is now grown widely in Mediterranean-type, subtropical and tropical climatic regions of the world (Zhang *et al.*, 2004).

The Sudanese name for sweet potato is *Bambie*. The sweet potato is a herbaceous perennial vine with alternate heart-shaped. It is white, yellow, orange or purple flesh and its skin may be red, purple or brown and white in color (Zhao *et al.*, 2005). The food ranking system also showed sweet potato to be a strong performer in terms of traditional nutrients. This root vegetable has been used in the traditional system of medicine for Alzheimer's disease because which is rich in beta-carotene (Roy *et al.*, 2008). A very good source of Vitamin C and manganese, as well as a good source of copper, dietary fiber, vitamin B6, potassium and iron. Moreover, poor in content of protein but which is present contains several of essential amino acids like leucine, lysine, phenylalanine, valine, tryptophan and threonine (Hussain *et al.*, 2008). Sweet potatoes and its leaves contain antioxidants; phenolic components; have potential value as chemo-preventative materials for human health (Islam *et al.*, 2009). Both beta-carotene and Vitamin C are very powerful

antioxidants that work in the body to eliminate free radicals. Nestel *et al.* (2006) recorded the biofortification of staple food crops is a new public health approach to control Vitamin A, iron and zinc deficiencies in poor countries. Vitamin A deficiency has been recognized as a widespread problem affected more than 700 million people, especially in developing countries. Beta-carotene is the most available/important source of pro-vitamin A in the diet of most people living in these countries (Sanusi and Adebiyi, 2009). Orange-Fleshed Sweet Potatoes (OFSPs) which are naturally rich in β -carotene, are an excellent food source of pro-vitamin A. These varieties can make a significant contribution to a viable long-term effective and sustainable food-based approach to prevent vitamin A deficiency in developing countries (Hagenimana *et al.*, 1999). Studies of β -carotene during storage and processing of vegetables show no definite trend of nutrient retention but fluctuate among samples analyzed in different laboratories. Reports range from no loss to slight or marked decrease when total carotenoids were measured. The OFSP One of the biofortified crops especially women and preschool children and one of important Millennium Development Goals (SCN, 2004; Nestel *et al.*, 2006).

Sweet potato could be a good source of protein ingredient for food processing as it possesses good solubility and emulsifying properties (Mu *et al.*, 2009). Food preservation prevent deteriorative reactions, extends a food's shelf-life and assures its safety. Thermal processing has most of the characteristics of an ideal food preservation (Chipurura and Muchuweti, 2010).

The preservation of fruit by jam making is a familiar process carried out on a small scale by housewives in many parts of the world. Processing fruits to give a mixture set to a gel and good consistence jam is possible only after perfect preparation (Singh *et al.*, 2009). The principle objectives of this study were determined the proximate composition of sweet potatoes, processed and effected of storage period on stability of products.

MATERIALS AND METHOD

The genotypes of sweet potato; TDINUNG NO.64, CEMSA 74-228 and ZAPALO were obtained from International Potato Center (CIP) and cultivated in Shambat horticultural Station farm, Agricultural Research Corporation (ARC), Sudan during 2010 season. Harvested sweet potatoes were stored at $15^{\circ}\text{C}\pm 2$, 65-70% relative humidity for 7 days. The raw material was washed, peeled and cutted (~2x2 cm); then were immersed in hot water (60°C) for 10 min and then dipped in 1% ascorbic acid solution for 30 min to prevent enzymatic browning of surface (Suliman and Ismail, 2007) which was mixed with water (1:2) and pulped. Sweet potato jam was processed using formula recommended by Singh *et al.* (2009).

Microbiological analyses: According to Kilcast and Subramanian (2000) these products were subjected to microbiological analyses to evaluate its safety and to determine the appropriate shelf life.

Physico-chemical analyses: Total Soluble Solids (TSS), pH-value, total titratable acidity (as citric acid), ascorbic acid and minerals using methods recorded by Ranganna (2001). While the moisture, protein, fats, fiber, ash, reducing sugars and carbohydrates were determined according to the AOAC (2000). The caloric values of the different samples were calculated by summing the values obtained through multiplying the contents of fats, protein and carbohydrates by the coefficients recorded by IMNA (2002).

Vitamin A: Vitamin A was determined according to the method described by AOAC (2000).

B-complex group: A 15 g mostly of sweet potato were extracted with 25 mL of extraction solution (89% water+10% Methyl CN+1% Acetic acid) at 60°C for 15 min cooled then filtered through Whatman No. 1 according to AOAC (2000). An HPLC (model: Shimadzu, Japan, 2004) was used for the determination of thiamine (B1), riboflavin (B2), niacin (B3), pyridoxine (B6) and folic acid. Separation was achieved at ambient temperature on a Phenomenex Luna C₁₈ (150x4.5 mm) analytical column. The flow rate was 0.8 mL min⁻¹ and the absorbance was measured at 280 nm. Detection limits were in the range of 1.6-3.4 ng, per 20 µL injection while linearity held up to 25 ng µL⁻¹. Theobromine (2 ng µL⁻¹) was used as internal standard.

Minerals: The minerals (Ca, Fe, Mg, P, Na K and Zn) were determined according to Ranganna (2001) using atomic absorption chromatography (model: Carbolite-Bam ford S30 2 AU. Sheffield, England). Sodium was determined using fame photometer (model: Instrument shimadzu-AA-6800).

Sensory evaluation: The sensory evaluation was carried out by the ranking method described by Ali and El-Faki (2006).

Statistical analysis: Replicates of each sample were analyzed using Statistical Analysis System (SAS). The Randomized Complete Design (RCD) was adopted for this study. The Analysis of Variance (ANOVA) and least significant difference (LSD at 5%) were used to separate the means according to Musa (2006).

RESULTS AND DISCUSSION

Table 1 shows chemical composition of raw sweet potato genotypes expressed on dry basis. The results showed that no variations in the chemical composition of the raw materials, except slight different in fiber and ash. The moisture percentage of first genotype (TDINUNG NO. 64) was 36.12%, second genotype (CEMSA 74-228) was 36.35% and of third genotype (ZAPALO) was 35.54%. These results are lower than range of 51.80 to 77.10% recorded by Woolfe (1992) and range of 69.20 to 70.80% suggested by Salami *et al.* (2006). These variations may be due to the climatic differences.

The protein content of first, second and third genotypes were 15.09, 17.29 and 12.22%, respectively. The values of proteins are within the range from 13.76 to 18.18% stated by Salami *et al.* (2006). Nevertheless, these values are greater than range from 0.30 to 10.00%

Table 1: Chemical composition of raw sweet potato genotypes

Parameter*	Dry weight basis		
	TDINUNG NO. 64	CEMSA 74-228	ZAPALO
Moisture (%)	36.12	36.35	35.54
C. protein (%)	15.05	17.29	12.22
C. fiber (%)	15.67	9.19	14.31
Ash (%)	10.83	9.90	12.05
Fat (%)	1.63	1.20	1.28
Carbs (%)	56.82	62.42	60.14
Vitamin C (mg/100 g)	65.70	60.08	63.27
Energy (kcal/100 g)	305.98	334.12	305.78

*C: Crude, Carbs: Carbohydrate

reported by Salunkhe and Kadam (1998). This difference in protein content between genotypes implies that it could be possible to breed and produce sweet potato with highly protein content.

Chemical analysis of the sweet potato genotypes showed that the first and third genotypes had substantially greater percentage of crude fiber content (15.67 and 14.31%, respectively), than the second genotype (9.19%). The result of first and third genotype is superior to range 9.77 to 13.02%, whereas, the result of second type is comparable to that range recorded by Salami *et al.* (2006).

As can be seen in Table 1 the content of ash of three genotypes. ZAPALO had higher ash content of 12.05%, than TDINUNG NO. 64 of 10.83% and CEMSA 74-228 of 9.90%. These data are within the range of 9.94-12.86% (Salami *et al.*, 2006). Results show that TDINUNG NO. 64, CEMSA 74-228 and ZAPALO sweet potatoes contain fats 1.63, 1.20 and 1.28%, respectively. The fats content of sweet potato of 1.30%, obtained by Dauthy (2009) in agreement with result obtained by third genotype. The genotypes under investigate containing 56.82, 62.42 and 60.14% carbohydrates content, respectively. Dauthy (1995) suggested inferior content (27.30%) than those obtained in this study. All the findings of the proximate analyses obtained in this study were highest than results of 21 Caribbean sweet potato genotypes recorded by Adebisolo *et al.* (2009).

The contents of Vitamin C of three genotypes (65.70, 60.08 and 63.27 mg/100 g, respectively) are richer than range of fourteen sweet potato cultivars of 9.50 to 25.00 mg/100 g stated by Woolfe (1992). These genotypes containing a large amount of energy for human body, equal to 305.98, 334.12 and 305.78 k cal/100 g for TDINUNG NO. 64, CEMSA 74-228 and ZAPALO, respectively. These findings of energy value were higher than those reported by Salunkhe and Kadam (1998) and which might be attributed to differences between carbohydrates, protein and fat values.

Table 2 shows the vitamin A and contents of B-complex group of fresh sweet potatoes under study. Vitamin A content of TDINUNG NO. 64, CEMSA 74-228 and ZAPALO were 225.27, 148.65 and 217.83 µg/100 g retinol equivalent, respectively. The findings of all genotypes within the range of 100-1600 µg/100 g RE obtained by Low *et al.* (2007). Beta-carotene-rich orange-fleshed sweet potato is an excellent source of pro-vitamin A. in developing countries; sweet potato is a secondary staple food and may play a role in controlling Vitamin A deficiency (Jaarsveld *et al.*, 2005).

TDINUNG NO. 64, CEMSA 74-228 and ZAPALO sweet potato genotypes are containing 1.45, 0.16 and 1.08 mg/100 g of B1; 0.37, 0.10 and 0.30 mg/100 g of B2; 12.44, 5.43 and 10.25 mg/100 g of B3; 1.58, 0.22 and 1.29 mg/100 g of B6 and lastly 0.19, 0.01 and 0.07 mg/100 g of folic acid, respectively. These results are agreement with results of OFSPs recorded by Suliman and Ismail (2007).

Moreover, the minerals profiles of sweet potatoes were presented in Table 3. From the tabulated data it is obvious that the genotypes are rich in many minerals. CEMSA 74-228 has highest levels of iron, magnesium, phosphorus, sodium and potassium of 0.64, 21.60, 44.63, 15.72 and 352.00 mg/100 g, respectively. While TDINUNG NO. 64 have highest level of zinc of 0.32 mg/100 g.

Table 2: Vitamins A and B-complex content of the fresh sweet potato genotypes

Parameter	TDINUNG NO. 64	CEMSA 74-228	ZAPALO
A (µg/100 g RE)	225.27	148.65	217.83
B-complex (mg/100 g)			
B1	1.45	0.16	1.08
B2	0.37	0.10	0.30
B3	12.44	5.43	10.25
B6	1.58	0.22	1.29
Folic acid	0.19	0.01	0.07

The samples of products investigated were free from bacterial or fungal contamination during 12 months ambient storage. The physico-chemical characteristics of three genotypes jams at zero time (initial) were within the range recommended range for jam manufacture by CODEX (2006, 2002).

The significant difference ($p \leq 0.05$) of chemical and physical-chemical properties of jams during storage is as shown in figures below. There is little significant difference ($p \leq 0.05$) in TSS% was observed during storage period, from 69.00 to 68.50%, 70.00 to 69.00% and 68.00 to 68.50% for TDINUNG NO. 64, CEMSA 74-228 and ZAPALO, respectively (Fig. 1). These results were in agreement with the findings of Yildiz *et al.* (2011).

The jams processed from sweet potato genotypes showed an increase in pH throughout storage period (Fig. 2). The initial values were 2.67, 2.61 and 2.67; the final values were 2.95, 2.83 and 2.80. Consequently, the total titeratable acidity decreased toward the end of storage time for three types of jam, when initial (0.51, 0.63 and 0.53%, respectively) and final (0.44, 0.55 and 0.41%, respectively) times were compared. The relationship between total titeratable acidity behavior and storage time was illustrated in Fig. 3. This losses were agrees with losses recorded for some fruit jams during storage (Khan, 1989).

After 12 months storage (Fig. 4), the total sugars of jams were significantly ($p \leq 0.05$) decreased from 67.54 to 66.81% (first jam), 66.63 to 64.51% (second jam) and from 68.70 to 67.00% (third jam). The loss of total sugars may be explained by non enzymatic browning reactions. Yousif and Alghamdi (2000) reported the same behavior during stored jam from some Saudi date cultivars.

Table 3: Minerals content (mg/100 g) of sweet potato genotypes

Mineral	TDINUNG NO. 64	CEMSA 74-228	ZAPALO
Ca	32.35	23.10	29.24
Fe	0.37	0.64	0.25
Mg	9.26	21.60	9.15
P	25.00	44.63	26.13
Na	10.50	15.72	14.95
K	198.50	352.00	207.00
Zn	0.32	0.18	0.26

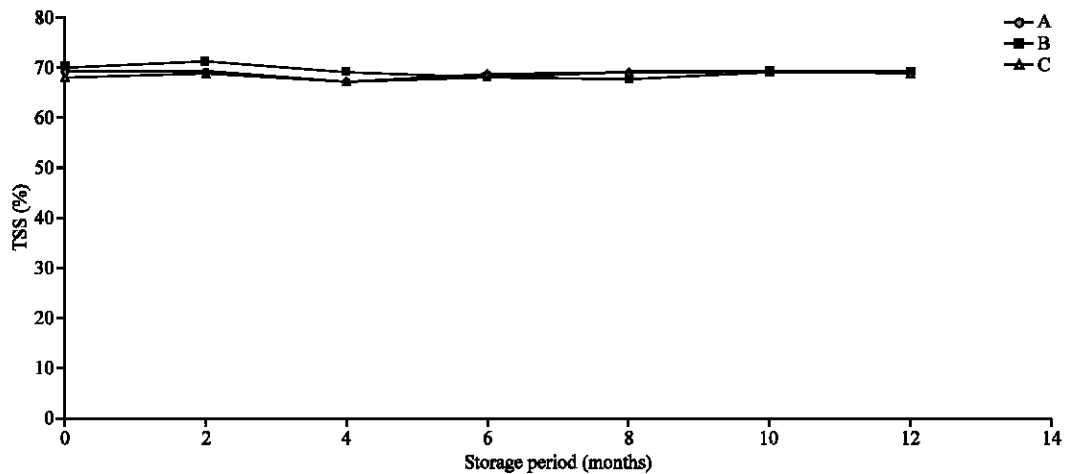


Fig. 1: Effects of storage period on total soluble solids of sweet potato jams. Where: A: TDINUNG No. 64, B: CEMSA 74-228 and C: ZAPALO

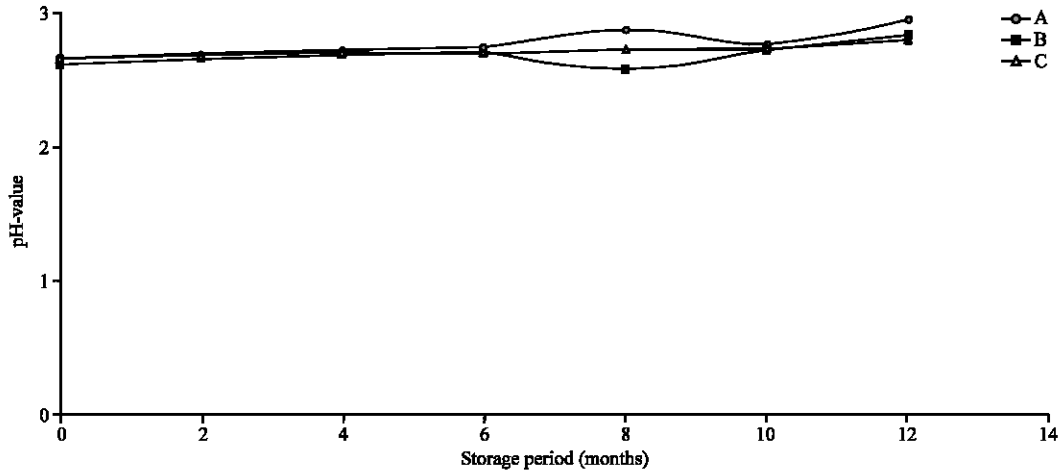


Fig. 2: Effects of storage period on pH-value of sweet potato jams. Where: A: TDINUNG No. 64, B: CEMSA 74-228 and C: ZAPALO

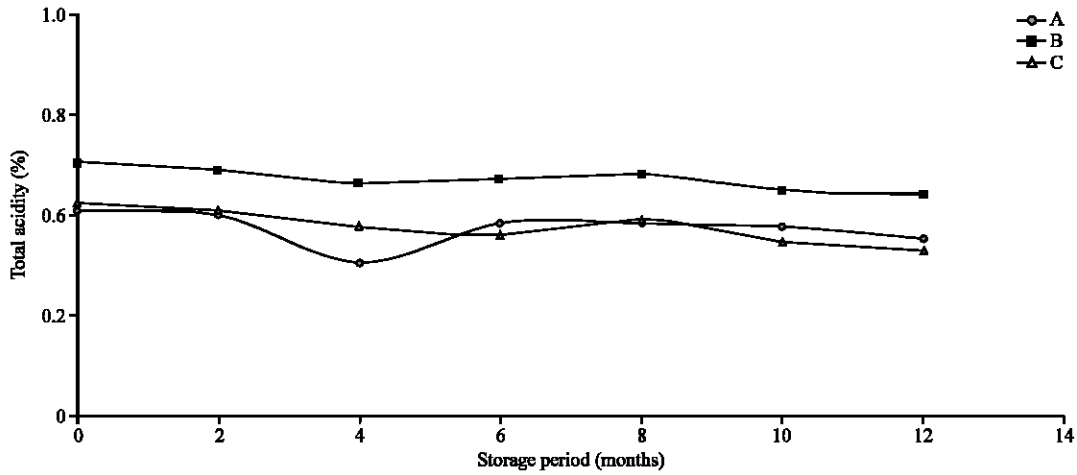


Fig. 3: Effects of storage period on total acidity of sweet potato jams. Where: A: TDINUNG No. 64, B: CEMSA 74-228 and C: ZAPALO

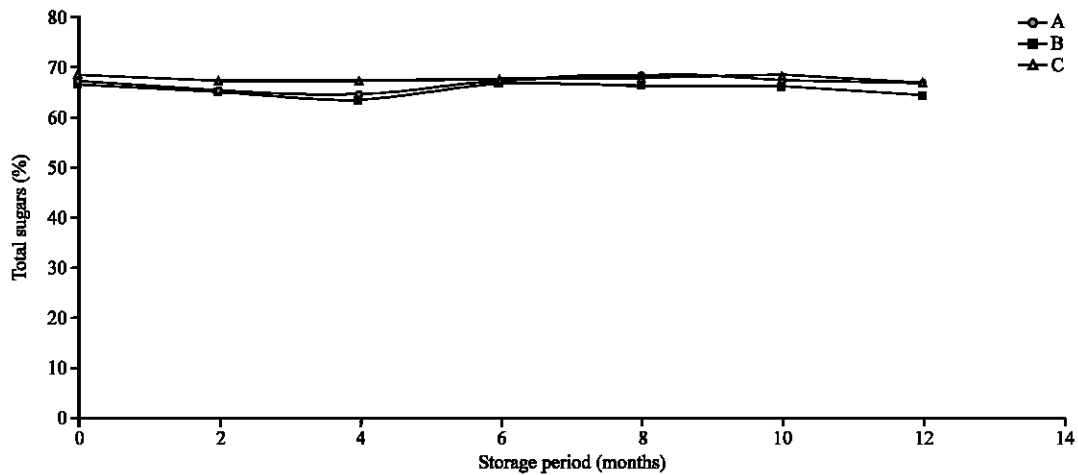


Fig. 4: Effects of storage period on total sugars of sweet potato jams. Where: A: TDINUNG No. 64, B: CEMSA 74-228 and C: ZAPALO

Table 4: Sensory evaluation quality of sweet potato jams

Properties	TDINUNG NO. 64	CEMSA 74-228	ZAPALO	Control
Color	62 ^a	45 ^{ab}	53 ^a	40 ^b
Flavor	51 ^b	45 ^d	49 ^c	55 ^a
Taste	57 ^a	50 ^b	51 ^b	42 ^c
Consistency	60 ^a	54 ^b	46 ^c	40 ^d
Overall quality	59 ^a	49 ^c	51 ^b	41 ^d

Values having different superscript letters in columns and rows are significantly different ($p \leq 0.05$)

Furthermore, Table 4 shows results of sensory evaluation quality of sweet potato jam compared to jam obtained from market (control). The panelists were preferred sweet potato jam processed from TDINUNG NO. 64, followed ZAPALO jam, followed CEMSA 74-228 jam and lastly the control jam (market sample). These jams had a good natural color appearance, with evident significant ($p \leq 0.05$) differences in flavor, taste and consistency between the control jam and sweet potato jams. TDINUNG NO. 64 recorded highest values of color (62 score), taste (57 score) and consistency (60 score); while the control recorded the highest value of flavor (55 score) and lowest values of color, taste, consistency and overall quality of 40, 42, 40 and 41 scores, respectively.

CONCLUSION

It can be concluded that orange-fleshed sweet potatoes can play a remarkable role in the human diet since it contains an excellent amount of vitamin A, a good source of carbohydrates, Vitamin C and B high. Also, support the body with many minerals. On the other hand, like other fruits jam, sweet potatoes observed best quality nutritious jam and were found most beneficial by securing microbial safety, physico-chemical stability and highest score during 12 months storage at ambient temperature.

REFERENCES

- AOAC, 2000. Official Methods of Analysis. 17th Edn., Association of Official Agriculture Chemist, Washington DC., USA.
- Adebisolo, J.A., K.O. Falade, O.J. Akingbala and P. Titus, 2009. Physico-chemical properties of twenty-one Caribbean sweet potato cultivars. *Int. J. Food Sci. Technol.*, 44: 1696-1704.
- Ali, M.A. and A.E. El-Faki, 2006. A comparison between a traditional and an advanced decortication method on the nutrients of sorghum (*Sorghum bicolor* L. Moench) grains. *J. Food Sci. Technol.*, 1: 31-43.
- Antia, B.S., E.J. Akpan, P.A. Okon and I.U. Umoren, 2006. Nutritive and anti-nutritive evaluation of sweet potatoes (*Ipomoea batatas*) leaves. *Pak. J. Nutr.*, 5: 166-168.
- Bovell-Benjami, A.C., 2007. Sweet potato: A review of its past, present and future role in human nutrition. *Adv. Food Nutr. Res.*, 52: 1-59.
- CODEX, 2002. Committee on Processed Fruits and Vegetables. CODEX, USA.
- CODEX, 2006. General Standard for Jams and Jellies. Vol. 13, CODEX, Geneva, Swetherland.
- Chipurura, B. and M. Muchuweti, 2010. Effect of irradiation and high pressure processing technologies on the bioactive compounds and antioxidant capacities of vegetables. *Asian J. Clin. Nutr.*, 2: 190-199.
- Dauthy, M.E., 1995. Sweet potato. Agricultural Services Bulletin, No. 119. Agriculture and Consumer Protection. Food and Agricultural Organization of the United Nations. Rome, Italy.

- Dauthy, M.E., 2009. Quality for Keeps: Food Preservation _ Fruitful Canning, Fruit and vegetable processing. Chapters 5,8, University of Missouri, MU Extension Publishes, USA.
- Hagenimana, V., M.A. Oyunga, J. Low, S.M. Njoroge, S.T. Gichuki and J. Kabira, 1999. The Effects of Women Farmers Adoption of Orange-Fleshed Sweet Potatoes: Raising Vitamin A Intake in Kenya. International Center for Research on Women, Washington, DC.
- Hussain, I., A. Zeb, I. Shakir and A.S. Shah, 2008. Combine effect of potassium sorbate and sodium benzoate on individual and blended juices of apricot and apple fruits grown in Azad Jammu and Kashmir. *Pak. J. Nutr.*, 7: 181-185.
- IMNA, 2002. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids. The National Academies Press, Washington, DC. USA.
- Islam, I., A.U. Shaikh and I.M. Shahidul, 2009. Antioxidative and antimutagenic potentials of phytochemicals from *Ipomoea batatas* (L.) Lam. *Int. J. Cancer Res.*, 5: 83-94.
- Jaarsveld, P.J., S.A. Tanumihardjo, P.N.C.J. Lombard and A.J.S. Benadç, 2005. Carotene-rich orange-fleshed sweet potato improves the vitamin a status of primary school children assessed with the modified-relative-dose-response test 1-3. *Am. J. Clin. Nutr.*, 81: 1080-1087.
- Khan, A., 1989. Post-harvest losses during processing and preservation of fruits and vegetables. Ph. D. Thesis, Institute of Chemistry, University of Punjab, Lahore, Pakistan.
- Kilcast, D. and P. Subramanian, 2000. The Stability and Shelf-Life of Foods. Woodhead Publishing, Cambridge, England.
- Low, J.W., M. Arimond, N. Osman, B. Cunguara, F. Zano and D. Tschirley, 2007. A Food-based Approach introducing orange-fleshed sweet potatoes increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique. *J. Nutr.*, 137: 1320-1327.
- Mu, T.H., S.S. Tan and Y.L. Yue, 2009. The amino acid composition, solubility and emulsifying properties of sweet potato protein. *Food Chem.*, 112: 1002-1005.
- Musa, S.K., 2006. Effect of storage temperature and coating on some mango cultivars grown in Sudan. *J. Food Sci. Technol.*, 1: 16-24.
- Nestel, P., H.E. Bouis, J.V. Meenakshi and W. Pfeiffer, 2006. Symposium: Food fortification in developing countries bio fortification of staple food crops. *J. Nutr.*, 136: 1064-1067.
- Ranganna, S., 2001. Proximate Analysis, Color Measurement and Sensory Evaluation. Tata McGraw Hill Co. Ltd., New Delhi, India.
- Roy, C., T.K. Ghosh and D. Guha, 2008. Dose dependent activity of *Benincasa hispida* on colchicine induced experimental rat model of alzheimer`s disease. *Int. J. Pharmacol.*, 4: 237-244.
- SCN, 2004. United nation system standing committee on nutrition. 5th Report on the World Nutrition Situation. Nutrition for Improved Development Outcome. SCN, Geneva.
- Salami, A.E., I.O.A. Adeleye and O.A. Olorunnisomo, 2006. Improvement in yield and chemical composition of sweet potato for livestock feeding through tillage and fertilizer application. *Agric. J.*, 1: 206-210.
- Salunkhe, D.K. and S.S. Kadam, 1998. Handbook of Vegetable Science and Technology: Production, Composition, Storage and Processing. Marcel Dekker Inc., New York, pp: 533-538.
- Sanusi, R.A. and A.E. Adebisi, 2009. Beta carotene content of commonly consumed foods and soups in Nigeria. *Pak. J. Nutr.*, 8: 1512-1516.
- Singh, S., S. Jain, S.P. Singh and D. Singh, 2009. Quality changes in fruit jams from combinations of different fruit pulps. *J. Food Proc. Preserv.*, 33: 41-57.

- Suliman, A.M.A. and I.A. Ismail, 2007. Newly developed products from high beta-carotene sweet potato. *J. Food Sci. Technol.*, 2: 144-157.
- Woolfe, J.A., 1992. *Sweet Potato: An Untapped Food Resource*. Cambridge University Press, Cambridge, MA., pp: 643.
- Yildiz, S., O. Gokkurt, S. Ileri and Z.A. Akbas, 2011. The stability of strawberry jam during storage. <http://web.itu.edu.tr/~klicmer/gid416e/JAM.ppt>.
- Yousif, A.K. and A.S. Alghamdi, 2000. Suitability of some Saudi date cultivars for making. *J. King Saud Univ.*, 12: 41-50.
- Zhang, D., G. Rossel, A. Kriegner and R. Hijmans, 2004. AFLP assessment of diversity in sweetpotato from Latin America and the Pacific region: Its implications of the dispersal of the crop. *Genet. Resour. Crop Evol.*, 51: 115-120.
- Zhao, G., J. Kan, Z. Li and Z. Chen, 2005. Characterization and immunostimulatory activity of an (1->6)- α -D-glucan from the root of *Ipomoea batatas*. *Int. Immunopharmacol.*, 5: 1436-1445.