NUTRITIONAL AND SENSORY QUALITY OF ORANGE-FLESHED SWEET POTATO VARIETIES

Bao, Badi M.[1] and **Fweja,** Leonard W.T.[2]

[1,2] Department of Food and Nutrition, Faculty of Science, Technology and Environmental Studies, The Open University of Tanzania, P.O Box 23409, Dar Es Salaam, Tanzania
Email address: lfweja@yahoo.com

Abstract
Sweet potatoes (Ipomea batatas) are vital nutritional staple crop in Tanzania with great nutritional potential. The aim of the study was to evaluate the nutritional and sensory quality of orange-fleshed sweet potato (OFSP) alongside white-fleshed sweet potatoes (WFSP) varieties. Two cultivars of both OFSP (Mataya and Kiegea) and WFSP (Sinia and Vumilia) were studied. Proximate composition was established and sensory quality evaluated using a seven point hedonic scale. The variations in all proximate parameters were significant ($P < 0.05$) between Kiegea and other cultivars excluding fibre contents. Carbohydrate content varied significantly ($P < 0.05$) between varieties and between cultivars of the same variety. Kiegea (an OFSP variety) was higher in rank in most of the proximate parameters excluding carbohydrate content. The sensory quality results indicate that the OFSP varieties ranked higher in terms of colour and aroma (as first and second) with Kiegea ranking first. Greater texture scores were recorded in WFSP varieties. The general acceptability was highest for Vumilia and lowest for Sinia cultivar in the subsequent ascending order: Sinia < Mataya < Kiegea <Vumilia. The differences in the general acceptability was likewise significant ($P < 0.05$) between Sinia and other cultivars but were insignificant ($P \geq 0.05$) among the first three higher ranked cultivars. The results recorded significant variations ($P < 0.05$) in all four organoleptic characteristics between OFSP and WFSP varieties but were insignificant ($P \geq 0.05$) between OFSP cultivars. The results signify the nutritional potential of OFSP varieties and their acceptance by the consumers.

Keywords: Orange fleshed sweet potato varieties, white fleshed sweet potato varieties, proximate analysis and sensory quality

Received: 27.01.2020 Reviewed: 20.03.2020 Accepted: 28.04.2020

INTRODUCTION

Sweet potato (*Ipomea batatas*) is among the most extensively grown root crops in sub-Saharan Africa, covering about 2.9 million hectares with a projected production of 12.6 million tons of roots in 2007 (Low *et al.,* 2009). Sweet potato plays a huge role as a food security crop that is constantly managed for reliable supply, not essentially for maximum yields (Kapinga *et al.,* 2007). According to Low *et al* (2017) among food crops, sweet potato has the uppermost edible energy per hectare per day and it is a chief staple crop (>80 kg/capita/year production) in heavily populated Rwanda, Burundi, Malawi, and parts of Uganda. In other areas of East and Southern Africa, it is a secondary staple (15-60 kg/capita/year), while in West Africa, sweet potato roots are regularly eaten as a snack or breakfast food (< 10 kg/capita/year). The crop is an essential food-in various African countries especially in sub Saharan area as a provider of vitamin A. It is a vital survival crop grown in nearly all agro ecological zones of Tanzania. In most areas of Tanzania sweet potato has gained importance owing to its adaptability to marginal conditions such as drought, wet conditions, low soil fertility, and is placed high as food security crop once local chief crops like maize and rice are limited or fail (Helen Keller International, 2012). Of the two main categories of sweet potatoes, that is, white fleshed sweet potatoes (WFSP) and orange-fleshed sweet potatoes (OFSP), the latter (OFSP) is considered as a very appropriate variety for food-based approach (Low *et al.,* 2007) due to its richness in carotenoids, a pro-vitamin A (Helen Keller International, 2012). β-carotene is the principal pro-vitamin A carotenoid and the major carotenoid in OFSP

(Takahata *et al.*, 1993). Eating OFSP can offer viable vitamin A, which is important in averting nyctalopia (night blindness) (Ndirigue, 2004) specifically among susceptible individuals (pregnant women and children). In view of its nutritional potential (the OFSP), the International Potato Centre (CIP) in partnership with the National Agricultural Research System reinforced research on sweet potatoes in Tanzania, which resulted in the development of genotypes, some of which have been bred and released. The eight sweet potato varieties that were released between 2002 and 2010, include Mataya, Kiegea, Ukerewe, Vumilia, Mavuno, Sinia, Juhudi and Simama (Helen Keller International, 2012).Other varieties, which were lately released (Kapinga *et al*., 2010) are Ejumula, Kakamega and Naspot 90. According to MAFC (2010), the OFSP varieties (Mataya and Kiegea) were released for use in Tanzania in 2010. Although Mataya and Kiegea varieties are characterized in terms of dry matter content and yield (12-15t/ha) as being moderate, and in terms of tolerance to Sweet Potato Virus Disease (SPVD), nonetheless, tiny if any is known regarding their nutrient content and sensory quality. Available data (Nicanuru, 2016) indicates the effect of pretreatments and drying on nutrient content of four OFSP varieties, that is Ejumula, Kabode, Karoti dar and Jewel. Mustafa (2017) on the other hand, compared the contribution of OFSP (Kabode and Mataya) varieties against non-OFSP varieties (Polista and Naspot 1) for improved nutrition without examining their sensory quality. In this regard, the objective of the current study was to evaluate the nutritional and sensory quality of OFSP varieties (Mataya & Kiegea) against white fleshed sweet potato (WFSP) varieties (Sinia and Vumilia).

MATERIALS AND METHODS

Description of the study area

This study was done in Kibaha district, one of the six districts of the Coast region, in Tanzania. The district occupies an area of approximately 1,812 km^2 with a population of 198,697 people based on the 2012 census. It is situated within latitude -6.7813° S and longitude 38.9929° E. Kibaha district exhibits a distinctive tropical climate with a rainfall fluctuating from 800 mm to 1000 mm and an average temperature of 28°C per annum. It demonstrates a bimodal rainfall pattern, with a short rainy season experienced from October to December and a long rainy season between March and June. Distinctive of coastal areas, Kibaha district has hot and humid weather conditions, with an average day temperature of 30°C.

Experimental design and field layout

The present pilot study was experimented by means of a randomized block design at the National Root Crops Research Institute (NRCRI) as described by Badi and Fweja (2020). The sweet potatoes vine cuttings for the pilot were propagated in a field multiplication block. Each clone was planted in an experimental plot sized 6.0×4.0 m in randomized block design with three replications. The spacing between and within the ridges were 100 and 30 cm correspondingly. The experimental field was not enriched with any fertilizer and weeding and cultivation were executed as per the institute guidance. All the sweet potato varieties were reaped from the same experimental field, the usual cultural practices such as early planting and delaying harvest hold were observed.

Pre-preparation of potato root samples

Four sweet potato cultivars, namely Kiegea, Mataya (which are OFSP varieties) and Sinia and Vumilia (WFSP varieties) were used in this study. These cultivars were planted in early March 2018 and the consignments of the roots were harvested in Mid-June 2018. Only sound potato roots free of diseases or physical damage were chosen for data collection. The roots were thoroughly washed with tap water and dried with paper toweling. The roots were then transported immediately to the International Institute of Tropical Agriculture (IITA) for laboratory analysis.

Proximate Composition of OFSP and WFSP

The cleaned sweet potatoes were skinned, sliced into small portions with knife. These processes were done hastily to escape enzymatic degradation. Grated samples were packed as 1 kg samples in plastic bags, sealed, coded and frozen at -20°C until analysis. Crude protein, crude fat, moisture content and ash content were quantified by AOAC (1995) techniques. The carbohydrate content was determined by difference (Carbohydrate = 100 - (%fat + % protein + % moisture + % ash). Dry matter was computed based on moisture content according to Egan et al. (1981). All experimental processes were done at the IITA laboratory.

Sensory analysis

Twenty (20) randomly drawn users of sweet potatoes at Maili moja ward market were trained to be panelist to analyse specific sensory characteristics (aroma, colour, texture and overall acceptability) in boiled OFSP (Mataya & Kiegea) and WFSP (Sinia and Vumilia) varieties. A 7-point Hedonic scale was employed for sensory analysis (Binbridge *et al.*, 1996). The scale ranges from 6 to 0 where, 6 indicates like extremely, 5 indicate like very much, 4 indicate like much, 3 indicate neither like nor dislike, 2 indicate dislike much, 1 indicate dislike very much and 0 indicate dislike extremely. The sweet potato pieces for sensory analysis were steamed at 100°C for about 20 min and presented to the panelists within 15 min after steaming at a temperature between 50 and 65°C on plates coded with a random three digit number.

Data analysis

SPSS (version 12.0 SPSS Inc, IL, USA) was used in the analysis of data. The analysis was accomplished using descriptive statistics and values presented as mean, standard deviation and percentage. Inferential statistics was done using ANOVA at the 5% level of least significance to determine any dissimilarities in the mean values between different sweet potato cultivars and the particular dissimilarities between pairs of means were separated by using Duncan's Multiple Range Test.

RESULTS AND DISCUSSIONS

The results for proximate composition of both OFSP (Mataya & Kiegea) varieties and WFSP (Sinia & Vumilia) varieties are summarised in Table 1. The moisture content varied significantly ($p< 0.05$) between OFSP and WFSP varieties. Significant variations ($p< 0.05$) were also observed between WFSP cultivars (Sinia and Vumilia) but were insignificant ($p \geq 0.05$) between OFSP cultivars (Kiegera and Mataya). The moisture contents recorded for both OFSP and WFSP varieties are however lower than those reported in previous studies (Wenkam, 1983) for fresh sweet potatoes (77.8%). Mustafa (2017) recorded the moisture content that varied between 61.07 -78.86% for OFSP cultivars (Kabode and Mataya) and WFSP cultivars (Naspot 1 and Polista). In the current study the moisture content ranged from62.56±0.02 - 72.10±0.25%.

Table 1: Proximate composition of Fresh OFSP and WFSP varieties

Variety		Proximate parameters					
		Moisture (%)	Protein (N×6.25) g	Fibres (g/100g)	Ash (g)	Fat (g)	Carbohydrate (g/100g)
OFSP	Kiegea	72.10±0.25^{a}	0.91±0.02^{a}	0.13±0.05^{a}	0.44±0.02^{a}	0.25±0.02^{a}	26.27±0.46^{a}
	Mataya	71.68±0.46^{a}	0.81±0.02^{b}	0.15±0.01^{a}	0.41±0.02^{b}	0.19±0.05^{b}	27.31±0.50^{b}
WFSP	Sinia	62.56±0.02^{b}	0.80±0.01^{b}	0.12±0.01^{a}	0.41±0.01^{b}	0.21±0.01^{b}	35.87±0.03^{c}
	Vumilia	64.33±0.03^{c}	0.81±0.01^{b}	0.12±0.01^{a}	0.39±0.02^{b}	0.20±0.01^{b}	34.12±0.01^{d}

Values are means of triplicate experiments and values for the same nutrient in the same column with different superscript letters are significantly different at $P < 0.05$

The variations in the moisture content among sweet potato varieties can be due to the differences in genetic composition, agro-ecological zones and agro-cultural practices. However, comparing with other roots and tubers, sweet potatoes have higher moisture contents and thus low dry matter content. The normal dry matter content of sweet potatoes is around 30%, but differs widely depending on variety, geographic area, climate, and amount of light, soil and cultivation practices. It has been reported (Woolfe, 1992) that the application of fertilizer significantly reduces the moisture content in sweet potatoes. However in the present study no fertilizer was applied, which implies the interplay of other factors. The low moisture content signifies high dry matter content and, thus, more carbohydrates and, consequently, higher energy content (Table 1).

Fat content results show significant variations ($p < 0.05$) between OFSP varieties (Mataya and Kiegea) and also between Kiegea cultivar and WFSP varieties. However the differences within WFSP varieties (Sinia and Vumilia) were insignificant ($P < 0.05$). Like other roots and tubers, sweet potato is well recognized for its low-fat content. The results of fat contents were similar to those reported in other studies (Ishida *et al.*, 2000) which documented 0.2% to 0.33% fat contents. However the current values (0.19 – 0.25%) were lower than those reported by Mustafa (2017) that varied from 0.29 to 9.66%.

Protein contents similarly demonstrated significant differences ($p<0.05$) between OFSP varieties (Mataya and Kiegea), but were insignificant ($P \geq 0.05$) between WFSP varieties (Vumilia and Sinia). Significant differences ($p < 0.05$) were also observed between OFSP varieties (Kiegea in particular) and WFSP varieties (Vumilia and Sinia). Nevertheless, the protein contents of the OFSP varieties (Mataya and Kiegea) were lower than those reported in previous studies (Senanayake *et al.*, 2013). Senanayake *et al.* (2013) recorded between 1.2 and 3.3% protein contents on dry weight basis in five varieties of sweet potato. Other literature (FAO, 2001) have indicated sweet potato to contain about 1.6% protein content. The deviation of the current results (0.80 – 0.91%) from available literature data could be due to genetical variations between varieties or clones

The crude ash content results between OFSP varieties (Mataya and Kiegea) recorded significant variations ($p < 0.05$), however the differences were insignificant ($P \geq 0.05$) between the WFSP varieties (Sinia and Vumilia). Furthermore, only crude ash content for Kiegea cultivar (an OFSP variety) varied significantly ($p < 0.05$) with WFSP varieties (Sinia and Vumilia) but the variations were insignificant for Mataya (OFSP variety). The documented crude ash contents in the present study which range from 0.39±0.02 to 0.44±0.02% compares well with those reported for fresh sweet potato tubers by Ingabire and Vasanthakaalam (2011) which varied from between 0.40% to 0.44%. Mustafa (2017) reported the crude ash content of 0.69 - 1.50% which is higher than those reported in the present study.

The crude fibre contents results showed no significant ($p<0.05$) difference between OFSP and WFSP varieties. The current results on crude fibre content which ranged from 0.12±0.01 to 0.15±0.01 compares well with those obtained by Ingabire and Vasanthakaalam (2011) for Rwandan varieties that range from 0.11% to 0.14%. Nonetheless the present results on crude fibre content were lower than those reported by Senanayake et al. (2013) which varied from 2.1 to 13.6 % on dry matter basis. Mustafa (2017) similarly recorded much higher crude fibre contents (4.02 -9.09%) than those documented in the present study. This difference may be attributed to genetical and cultivar differences and / or environmental conditions. Dietary fibre is indicated to reduce the incidences of colon cancer, diabetes, heart diseases and certain digestive diseases (Ingabire and Vasanthakaalam, 2011).

Carbohydrate content varied from 26.27±0.46 to 35.87±0.03% and registered significant variations ($p<0.05$) between varieties (OFSP and WFSP) and between cultivars of the same variety. A previous study (Wenkam, 1983) indicated fresh sweet potato had 27% carbohydrate content whereas FAO (2001) reported 28% carbohydrate content for fresh samples. Those earlier results compare well with the results of the present study in particular OFSP varieties but are lower than those recorded for WFSP varieties. On the other hand, the current result indicates higher carbohydrate content than reported earlier by Mustafa (2017) varying from 8.72 to 23.56%. The observed differences could be attributed to the variety and maturity stage of the same (Mustafa, 2017).

Sensory quality of WFSP and OFSP varieties

The results in Table 2 shows the sensory evaluation results for WFSP varieties (Vumilia and Sinia) and OFSP varieties (Kiegea and Mataya) which was done by using a 7 point hedonic scale method.

Sensory evaluation of the OFSP varieties was conducted alongside the WFSP varieties (Table 2) in order to evaluate their acceptability. Four attributes were evaluated including colour, texture, aroma and the overall acceptability. The results indicate that OFSP varieties (Kiegea and Mataya) ranked higher in terms of colour and aroma with Kiegea variety leading in either cases. OFSP varieties (Kiegea and Mataya) developed a deep orange colour in the course of boiling which could possibly explain its superiority in colour. However, in terms of texture the OFSP varieties (Kiegea and Mataya) ranked lower with Kiegea cultivar ranking last. On the other hand, the WFSP varieties (Sinia and vumilia) ranked first and second respectively in terms of texture. The predominance of WFSP varieties in texture score over OFSP varieties could be associated with low moisture content and high starch content (Table 1). According to Amare (2016) the texture of a potato differs during thermal processing because of the breakdown of the reinforcing cellular martial. In his work using two temperature regimes (95°C and 96°C) and three potato cultivars (Salome, Ditta and Asterix) gave an impression that an optimal temperature time combination for specific cultivar provides better quality in terms of hardness, mealiness and total appearance which was the case for Salome potatoes compared to Ditta and Asterix cultivars at 95°C.

Table 2: Sensory quality of WFSP and OFSP varieties

Attribute	Varieties		Mean±SD	Rank	p-value
Color	OFSP	Kiegea	$5.35^a±0.75$	1	0.00
		Mataya	$5.30^a±0.57$	2	
	WFSP	Sinia	$1.45^b±1.19$	4	
		Vumilia	$3.30^c±1.17$	3	
Texture	OFSP	Kiegea	$2.85^a±1.09$	4	0.00
		Mataya	$3.25^a±1.25$	3	
	WFSP	Sinia	$4.75^b±0.97$	1	
		Vumilia	$4.60^b±1.14$	2	
Aroma	OFSP	Kiegea	$3.30^a±0.92$	1	0.00
		Mataya	$2.90^a±0.97$	2	
	WFSP	Sinia	$1.70^b±1.03$	3	
		Vumilia	$2.40^b±0.88$	4	
Overall acceptability	OFSP	Kiegea	$4.05^a±1.00$	2	0.00
		Mataya	$3.65^a±1.14$	3	
	WFSP	Sinia	$2.65^b±1.14$	4	
		Vumilia	$4.15^a±0.81$	1	

The three cultivars had no significant differences in the dry matter and the ash contents implying the textural difference could be due to other factors. Nonetheless other studies have indicated a correlation between dry matter content, sensory perceived texture characteristics and the starch content (Van Dijk, *et al.*, 2002). Romanoa *et al.* (2018) also reported that dry matter, gelatinization of starch and removal of moisture influences sensory attributes in particular textural properties. The orange colour which developed in OFSP varieties (Kiegea and Mataya) during boiling could explain their high score in colour evaluation. In all four sensory attributes the results indicate significant differences ($P < 0.05$) between OFSP and WFSP varieties but the differences were insignificant ($P \geq 0.05$) between OFSP cultivars. In terms of overall acceptability, Vumilia (WFSP variety) ranked first and Sinia (OFSP variety) ranked last. Generally the ranking was in the following descending order: Vumilia > Kiegea > Mataya > Sinia. The differences in the overall acceptability was similarly significant ($P < 0.05$) between Sinia and other cultivars but were insignificant ($P \geq 0.05$) between the first three leading varieties (Vumilia, Kiegea and Mataya). According to van Oirschot et al. (2003) the differences between sweet potato cultivars in sensory characteristics are mainly determined by textural components. Vumilia had the highest textural score among the four cultivars. The findings by Oyunga *et al.* (2015) on sensory evaluation of OFSP varieties (Kabode and Vita) against a local variety indicated that the overall acceptability of the local variety was higher than that of OFSP varieties. In the present study one of the two local WFSP varieties (Vumilia) had the highest overall acceptability score while the other had the lowest overall acceptability score. The findings of previous studies (Kapinga *et al.*, 2003) described firmness as an indicator of high dry matter content which is a preferred sweet potato root quality. This could partly explain the overall acceptability of Vumilia variety which had 34.12±0.01 g/100g carbohydrate content compared to 26.27±0.46 g/100g and 27.31±0.50 g/100g of Kiegea and Mataya respectively but was lower than Sinia which had 35.87±0.03 g/100g carbohydrate content suggesting an interplay of other factors as well. The OFSP cultivars have often been rated poorly regarding finger-feel firmness (Leksrisompong *et al.*, 2012) probably due to their generally, low dry matter (20 to 24%) contents (Tomlins *et al.*, 2012; Vimala *et al.*, 2013). OFSP varieties (Kiegea and Mataya) ranked second and third respectively, in the present study in terms of overall acceptability. This implies the potential of OFSP varieties and possible acceptability due to their superior colour and aroma as well as richness in β-carotene, a precursor for vitamin A.

CONCLUSIONS

This study aimed at evaluating the nutritional and sensory quality of released orange fleshed sweet potato varieties. The proximate compositions results showed significantly difference ($p<0.05$) between varieties in moisture content, fat, protein, crude ash content, dry matter content, and carbohydrates except fibre contents. The observed difference could be due to genitical variations, geographic area, climate, and amount of light, soil and cultivation practices

The sensory analysis indicates significant differences ($p< 0.05$) in all attributes between OFSP varieties (Kiegea and Mataya) and WFSP varieties (Vumilia and Sinia) but were insignificant ($P \geq 0.05$) between OFSP cultivars. OFSP varieties were superior in both colour and aroma whereas WFSP varieties were superior in texture. In terms of overall acceptability WFSP varieties, Vumilia ranked first and Sinia ranked last. The overall ranking was in the following descending order: Vumilia > Kiegea >Mataya > Sinia. The differences in the overall acceptability was similarly significant ($P < 0.05$) between Sinia and the other three varieties but was insignificant ($P \geq 0.05$) among the first three leading varieties (Vumilia, Kiegea and Mataya). The results generally signify the nutritional potential of

OFSP varieties and their acceptance by the consumers.

Acknowledgements
The authors acknowledges for the support provided by the National Root Crops Research Institute (NRCRI) in the field experiment and the International Institute of Tropical Agriculture (IITA) for provision of laboratory facilities for laboratory analysis.

REFERENCES

[1]. Amare, A. (2016). Analysis of sensory and texture properties of three potato cultivars boiled to different thermal center temperatures. Lund Institute of Technology, Department of Food Technology, Engineering and Nutrition, LTH, Lund University Lund, Sweden
[2]. A.O.A.C., (1995). Official Methods of Analysis, 16th ed. Association of official analytical chemists. Washington, D.C., U.S.A.
[3]. Badi M. B and Fweja, L. W.T (2020). Evaluation of the Potential of Freshly Bred Orange-Fleshed Sweet Potato Varieties in Combating Vitamin A Deficiency. Tanzania Journal of Science, 46(1): 1-8, 2020
[4]. Bainbridge Z, Tomlins K, Willings K, Westby, A. (1996). Methods for assessing quality characteristics of non-grain starch staple. Part 4 advanced methods. National Resources Institute. University of Greenwich, UK ISBN 0-85954-400-1:43-79.
[5]. Egan, H, Kirk, K.R., Sawyer, S. (1981). Pearson's Chemical Analysis of Food, 8th ed. Churchill Livingstone Edinburgh, London. New York. 591pp.
[6]. F.A.O, (2001). Improving nutrition through home gardening: Nutrition Programmes Service Food and Nutrition Division. Rome: FAO.
[7]. Helen Keller International (HKI) (2012). Orange-fleshed Sweet Potato: Situation Analysis and Needs Assessment: Tanzania Report, Dar es Salaam: Helen Keller International Tanzania
[8]. Ingabire, M.R., Vasanthakaalam, H. (2011). Comparison of the Nutrient composition of four sweet potato varietiescultivated in Rwanda. American Journal of Food and Nutrition, 1: 34 - 38.
[9]. Ishida, H, Suzuno, H, Sugiyama, N, Innami, S, Tadokoro, T, Maekawa, A. (2000). Nutritive evaluation on chemical components of leaves stalks and stems of sweet potatoes (*Ipomoea batatas poir*.). Food Chemistry, 68: 359 - 367
[10]. Kapinga, R, Lemaga, B, Ewell, P, Zhang, D, Tumwegamiire, S, Agili S, Nsumba, J. (2010). Increased promotion and evaluation of high β carotene sweetpotato as part of the food based approaches to combat Vitamin A deficiency in sub-Saharan Africa (SSA). International Potato Center (CIP) and PRAPACE.
[11]. Kapinga, R, Jeremiah, S, Rwiza, E, Rees, D. (2003). Farmer criteria for selection of sweet potato varieties. Sweet potato postharvest assessment: Experiences from East Africa. Chapman, pp. 9-21
[12]. Kapinga, R, Zhang, D, Lemaga, B, Andrade, M, Mwanga, R, Laurie, S, Ndoho P, Kanju, E. (2007). Sweet potato crop improvement in sub-Saharan Africa and future challenges. Proceedings of the 13th ISTRC Symposium. Pp. 82 - 94
[13]. Leksrisompong, P, Whitson, M, Truong, V. D, Drake, M. (2012). Sensory attributes and consumer acceptance of sweet potato cultivars with varying colours. J. Sensory Stud. 27(1): 59 - 69
[14]. Low, J, Ball, A, Magezi, S, Njoku, J, Mwanga, R, Andrade, M, Tomlins, K, Dove, R, van Mourik, T. (2017). Sweet Potato Development and Delivery in Sub-Saharan Africa. African Journal of Food Agriculture and Nutrition Development. 17(2): 11955-11972
[15]. Low, J, Arimond, M, Osman, N. (2007). A food-based approach introducing orange-fleshed sweet potatoes increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique. The Journal of Nutrition. 137(5):1320 - 1327.

[16]. Low, J, Lynam, J, Lemaga, B, Crissman, C, Barker, I, Thiele, G, Namanda, S, Wheatley, C, Andrade, M. (2009). Sweet potato in Sub-Saharan Africa. In. Loebenstein G, Thottappilly G editors. The Sweet potato. Springer. Pp 359 – 389.

[17]. Ministry of Agriculture Food Security and Cooperatives (MAFC) (2010). Annual Performance Report for 2009/10 Financial Year. Dar Es Salaam, Tanzania: Monitoring & Evaluation and Statistics Section, Ministry of Agriculture Food Security and Cooperatives.

[18]. Mustafa, S. M, (2017). Orange Fleshed Sweet Potato Consumption for Improved Nutrition in Gairo. A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree Of Master of Science in Human Nutrition of the Sokoine University Of Agriculture. Morogoro, Tanzania.

[19]. Ndirigue, J. (2004). Adaptability and acceptability of orange and yellow fleshed sweet potato genotypes in Rwanda. BSc (Agr) Hons IFA Yagambi, DRC.

[20]. Nicanuru, C. (2016). Effect of Pretreatments and Drying On Nutrient Content of Orange Fleshed Sweet Potato Tubers and Cowpea Leaves Used in Maswa District, Tanzania. A Dissertation submitted in partial fulfillment for the degree of Master of Science in Food Science and Technology of the Jomo Kenyatta University of Agriculture and Technology

[21]. Oyunga-Ogubi M. A, Loechl C, Quedraogo H, Low, J. (2015). Sensory evaluation and consumer acceptability of orange-fleshed sweet potato by pregnant women and children1-2 years in Western Kenya. Kenya Agriculture Research Institute, International Potato Centre-Nairobi, CIP: 185 – 191.

[22]. Romanoa, A, D'Amelia, V, Gallo, V, Palomba, S, Carputo, D, Masia, P. (2018). Relationships between composition, microstructure and cooking performances of six potato varieties. Food Research International 114 (2018) 10–19

[23]. Senanayake, S. A, Ranaweera, K. K. D. S, Gunaratne, A, Bamunuarachchi, A. (2013). Comparative analysis ofnutritional quality of five different cultivars of sweet potatoes (Ipomea batatas (L) Lam) in Sri Lanka. Journal of. Food Science and Nutrition, 1: 284–291.

[24]. Takahata, Y, Noda, T, Nagata, T. (1993). Varietal differences in chemical composition of the sweet potato storage root. Acta Horticulture, 343:77–80.

[25]. Tomlins, K. I, Owori, C, Bechoff, A, Menya, G, Westby, A. (2012). Relationship among the carotenoid content, dry matter content and sensory attributes of sweet potato. Food Chemistry, 31(1):14-21.

[26]. van Dijk, C, Fischer, M, Holm, J, Beekhuizen, J, Stolle-Smits, T, Boeriu, C. (2002). Texture of Cooked Potatoes (*Solanum tuberosum*). 1. Relationships between Dry Matter Content, Sensory-Perceived Texture, and Near-Infrared Spectroscopy. Journal of Agriculture and Food Chemistry, 50 (18): 5082-5088

[27]. van Oirschot, Q, E. A, Rees, D, Aked, J. (2003). Sensory characteristics of five sweet potato cultivars and their changes during storage under tropical conditions. Food Quality and Preference 14 (2003) 673–680

[28]. Vimala, B, Nambisan, B, Hariprakash, B. (2013). *Variability of Carotenoids and Dry Matter Content in Orange-fleshed Sweet Potato (Ipomoea batatas (L.) Lam.) During Storage*. Journal of Root Crops 37(2):182.

[29]. Wenkam, N. S. (1983). Foods of Hawaii and the Pacific Basin. *Vegetables and vegetable products: Raw, processed, and prepared. In Volume 1:* Composition; University of Hawaii: Honolulu, USA.

[30]. Woolfe, J. A. (1992). *Sweetpotato: An untapped food resource*. Cambridge University Press. Cambridge, UK.