PHYSICOCHEMICAL AND SENSORY PROPERTIES OF JAMS PRODUCED FROM FOUR MANGO VARIETIES IN BENUE STATE, NORTH CENTRAL NIGERIA

Ojo M. O.[1], Balogun A. A. [2] and Jime J. A.[3]
[1] Federal University of Technology Minna P.M.B. 65 Minna, Niger state
[2] Federal University of Agriculture Makurdi. P.M.B. 2373 Makurdi, Benue State
[3] University of Mkar, Mkar P.M.B. 017, Gboko, Benue State
Corresponding author's email: ojo@futminna.edu.ng
Phone number: 08065747751
ABSTRACT

ABSTRACT
The study investigated the physicochemical and sensory properties of jams prepared from four popular mango fruits varieties (Julie, Peter, Dabsha and Hindi) in Benue State. A commercial mango jam was used as control. The physicochemical and sensory properties of the mango jams were determined using standard methods. Results revealed that the total soluble solids, titratable acidity and pH of the jams differed significantly. Jams produced from the Julie, Peter, Dabsha, Hindi mango varieties had higher total soluble solids compared with the commercial jam. The ash, vitamin A and C content of the jams ranged from 0.13 to 0.34 mg/100 g, 89.10 to 129.90 µg/100g and 12.12 to 24.07 mg/100g, respectively. The vitamin A contents of the prepared jams were significantly higher than the commercial mango jam. The prepared jams also had higher sensory attributes compared to the commercial mango jam. However, Dabsha mango jam was the most acceptable among the prepared jams.

Key words: Mango jam, mango varieties, physicochemical and sensory properties

INTRODUCTION

Mango is a fleshy juicy stone fruit with a characteristic yellowish-red colour (Venkateswarlu and Reddy, 2014). Mango originated from the Indian subcontinent and reached East Africa by 10th Century. Mango belongs to the genus *Mangifera*, consisting of numerous tropical fruiting trees in the flowering plant family *Anacardiaceae* in the order of *Sapindales*. Mango (*Mangifera indica)*is one of the most important commercial fruit trees grown in over 90 tropics and subtropics countries (FAO, 2009). Mango has over 1000 varieties and of these, only 100 varieties with similar properties and peculiarity are traded and grown for consumption both in fresh and processed form worldwide (Bally *et al.,* 2011).

Mango is the most popular fruit in many countries among millions of people in the world and at the same time it occupies a prominent place among the best fruits of the world (Bally *et al.,* 2009) especially in the tropic where it is considered to be the choicest of all indigenous fruits. Mangoes are a highly nutritious fruits containing carbohydrates (16.20-17.18 g/100g), proteins (0.36-0.40% g/100g), fats (0.33-0.53g/100g), Ash (0.34-0.52g/100g). Vitamins A and C has been found prominent with values ranging from 54-58µg and 9.79-186.00mg/100g respectively (Maldonado *et al*., 2019; USDA, 2018). Significant amount vitamin B1 (0.01-0.04 mg/100g), vitamin B2 (0.02 – 0.07mg/100g) and phenolic compounds are also present (Maldonado *et al*., 2019). The diversity of mango is so huge not only because of their number and variety but the distinct taste and features. Mango is one of the most widely cultivated fruit and according to Sauco (2017) world mango production has increased considerably and constantly: $15{,}700\times10^3$ tons in 1990, $25{,}040\times10^3$ tons in 2000, $30{,}880\times10^3$ tons in 2006 and $42{,}140\times10^3$ tons in 2012. However, this increase in production has been accompanied by large postharvest losses of 45% worldwide which has been attributed to poor utilization and limited value addition. To increase the availability of this fruit throughout the year, the surplus production must be processed into a variety of value-added products (Gathambiri, 2009).
Mango crop requires very low investment once they grow making them an important cash crop. Mango is grown in many parts of the western and southwestern parts of Nigeria and with Benue State topping the list with exotic varieties (Olaniyan, 2004; Avav and Uza 2002). Mango is one of the second potential fruit crop produced in Benue state next to orange, the production of mangoes in Benue State has earned Nigeria its 8th position on the chart of mango producers in the world (Ubwa *et al*., 2014).

Gboko with five districts namely, Mbatyav, Mbatierev, Mbayion, Ipav and Yandev is popular in mango fruit production (Ajayi and Nyishir, 2006). The local Government originally had Mango production covering over 70% of the total acreage allotted for fruit production with varieties of mango found such as *opioro* (known as the German mango in Benue), *peter*, *hindi*, *Julie, dabsha,* others are *kerosene mango* (so called because of its characteristic kerosene like odour*)* and *broken* (Ajayi and Nyishir, 2006). Mangoes produced in Nigeria are consumed as fresh fruits while the rest (approximately 50%) are lost due to lack of

processing industries, inadequate facilities for storage and transportation thus exacerbating the problem of postharvest (Okoruwa, 2018). The potentials in mangoes has been underdeveloped because the food processing industry in Nigeria is in its infant stage, and production of horticultural crops is much less developed than the production of food grains in the country hence less utilization of the available fruits.

Processing is considered as improving the value of raw produce and an extension of storage life (Okoth *et al.,* 2013) and one of the alternatives and profitable methods of using mangoes would be in processing mango for jam production. Jam preparation is one of the ancient methods and it is the best suited technique for preservation of perishable fruits (Bekele *et al*., 2020). Jam is a semi solid food and the production involves the disruption of the fruit tissue followed by heating with added water and sugar to activate its pectin before being put into containers (Mohammad *et al*., 2017). Mango is one of the most cherished fruits, not only in flavor and taste (Hussain *et al.,* 2005) but also for its nutritional value therefore giving its jam a suitable/acceptable taste and flavor. Mango jam is and also a good source of vitamin A and C, rich in carbohydrates, minerals potassium, and phosphorus (WHO, 2003). The suitability of mango variety for jam production is generally screened on the basis of juiciness, wholesomeness and its availability all year round.

Several researchers (Muhammad *et al*., 2012; Abdelazim *et al*., 2010; Bekele *et al*., 2020; Muhammad, 2013) have reported on quality of some mango jams in some regions of the world and composite mango jam from mango, pineapple and pawpaw has also been evaluated (Ogunbande *et al*., 2013). However, information on the production process and physicochemical properties of these mango jam varieties in Benue state are not available. Therefore, this study explores production of mango jam towards value addition of these varieties of mango with reduction of the major problem of post-harvest losses especially during the glut season. Mango jam production from varieties of mango available in Benue state could present jams with distinct flavor as each variety has a unique flavor attributed to it. This information would be important to small scale entrepreneur/processor and as such providing possible employment for the teeming population.

METHODOLOGY

Source of materials and sample preparation: Mangoes varieties used for this study were *Julie*, *Peter*, *Dabsha* and *Hindi* mango. Orange fruits and sugar was procured from Gboko main market, Benue State. A commercial mango jam used as control was sourced from the Shoprite superstore in Nsukka town, Enugu State.

Extraction of pectin: Pectin used in this study was extracted from orange rind using the method described by Girma and Worku (2016). Matured oranges were properly washed and peeled and the pith was peeled off from the back and cut into narrow strips. 100 ml of lemon juice was added to the chopped pith and allowed to sit for 1h; 700 ml of distilled water was then added to the mixture of the pith and lemon juice and allowed to simmer for 10 mins. The mixture was poured into a strainer lined with cheesecloth and allowed to drain for 12h and the pectin was collected. Flow chart for pectin extraction is as shown in Figure 1.

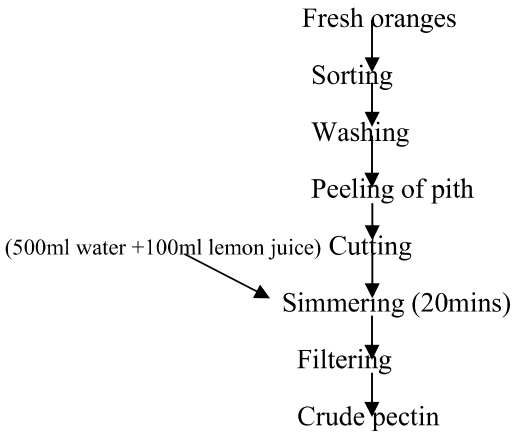

Figure 1: Extraction of pectin from orange pith
Source: Girma and Worku (2016)

Pulp and jam yield determination: Yield capacity was determined as the percentage pulp recovered after removal of skin and the seed from a weighed kilogram of mango fruits varieties.
Yield(%)= (pulp weight/Xg) x100 ……(1)
Xg= weight of whole mango fruit

Mango jam production: The method described by Bastin (2004) was adopted with slight modification by using seven hundred grams (700g) each of the matured and ripe selected varieties of mangoes. The mangoes were sorted, washed, peeled, and the core removed, the pulp was diced into smaller sizes followed by blending using a whirl blender (model) and boiled in 600ml distilled water for 10 min to soften the fruit pulp. Sugar (500 g) was added after 10min to the boiled pulp while mixing and 2 ml of the prepared pectin solution was added followed by the addition of 33g citric acid. The mixture was stirred continuously until a stable gel was formed and poured directly into an already sterilized jar and allowed to cool in cold water. The flow chart for the production of mango jams is as shown in Figure 2

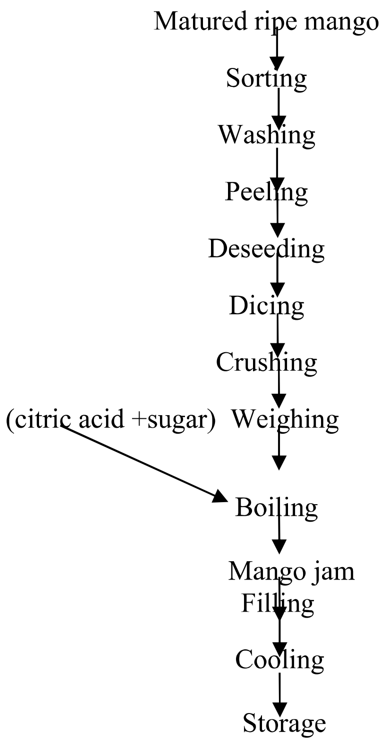

Figure 2: Production of mango jam
Source: Bastin (2004)

Determination of physicochemical properties

Determination of Total Soluble Solids (TSS), Total Titratable Acidity (TTA) and pH: Total soluble solids of the various mango jam sample determined using the Atago hand held Abbe refractometer (Rx 5000, Atago, Tokyo, Japan). The refractometer was maintained at 20 °C and calibrated with distilled water, this method is based on the principle that refractive index increases with increase in solid content. Two drops quantity of each sample was placed on the prism-plate of the refractometer and the reading appearing on the screen was directly recorded as total soluble solids (°Brix). Titratable acidity (TA) was determined according to the method described by AOAC (2012). Ten grams (10g) of the sample was weighed and diluted with 250ml of distilled water. 25ml of the diluents was taken and titrated with standardized solution of 0.1N Sodium hydroxide (NaOH) using 0.3 ml phenolphthalein as an indicator until a pink end point is attained which persists for about 30 seconds and the corresponding burette reading taken. The TA was calculated using the formula:

TA(%)= (ml of NaOH) × (N of NaoH) ×mil equivalent of A × 100/Weight of sample used ……………………………………………(2).

The pH was determined using a glass electrode pH meter (Model; HANNA instruments 8521) at ambient temperature. Five grams (5g) of the various mango jam samples were weighed each into 10 ml of distilled water and allowed to stand for 30minutes in 40 °C water bath. The samples were removed and filtered using filter paper and the pH was determined. The pH meter was standardized and the pH was measured by inserting directly the electrodes into 10ml beaker containing the sample, the value was read from the pH meter to know the level of alkalinity or acidity of the mango jams products. The pH meter was rinsed immediately after use before proceeding to the next sample.

Determination of Ash, Minerals and Vitamins: Ash and vitamin C content of the various jam samples was determined using the method as described by AOAC (2012) and Vitamin A was analysed by determining the beta carotene content using the method described by Ranganna (1999) and the conversion factor by (FAO/WHO) was used to evaluate the Vitamin A content

Sensory evaluation: Sensory evaluation was carried out using the method as described by Iwe (2002). Twenty (20) trained sensory panelists consisting of students from the Department of Food Science and Technology, University of Mkar, Mkar Benue State. All evaluation sessions were held in the food sensory laboratory of the University. The mango jam samples from the various mango varieties were stored at 5°C and were taken out 2 h before serving. Appearance, flavor, mouth feel, degree of spread ability and overall acceptability sensory parameters of mango jam samples were evaluated using nine point hedonic scale (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely). The panelists were briefed how to use sensory evaluation forms and terminologies of sensory attributes. All samples were presented in 50 ml cups coded with random, two-digit number to the panelists at room temperature under normal lightning conditions. Sliced bread pieces were used as carrier since jam is normally consumed with bread with spoons for scooping and spreading. Sensory Appearance, flavor, mouth feel, degree of spread ability, and overall acceptability Drinking water was provided for oral rinsing. The average values of the sensory scores were used in the analysis Mango jam was compared with a commercialized mango jam (Danish jam, made in Poland) as the reference jam.

Statistical Analysis: Data obtained were subjected to analysis of variance (ANOVA) and differences among means were compared using Duncan multiple range test at 5% probability level. All computations were made by statistical software SPSS (version 20).

RESULTS AND DISCUSSIONS

The pulp yield of the various mango samples is as presented in Table 1. The pulp yield ranged from 55.30 – 66.70% with *Dabsha Mango* yielded the highest while and *Hindi* the lowest. These variations could have been due to growing conditions and varietal difference as some of these varieties have larger seeds which may influence the percentage yield. High pulp ratio will be of economic benefit in the production of jam among other factors such as seed ratio, firmness, maturity and fibre absence (Pleguezuelo *et al.,* 2012). The pulp content of these mango varieties are slightly lower than the values reported by Bekele *et al*. (2020) on pulp contents of Ethiopians mangoes which ranged from 65.44-78.14% while it falls within the range of 62.01, 66.23 and 68.23 % reported by Ubwa *et al*. (2014) for *Julie, Hindi* and local mango pulps of Benue state respectively. The, total titrable acidity total soluble solids and pH of the various mango jam samples is as presented in Table 1.

Table 1: Pulp yield and the physicochemical properties of the various mango jam

Sample	Pulp yield (%)	TSS (brix°)	TTA (%)	pH
SJ	ND	29.00^{d}±1.41	0.29^{a}±0.01	3.10^{e}±0.00
HMJ	60.78± 3.10	65.50^{c}±0.70	0.20^{b}±0.02	3.70^{a}±0.00
JMJ	62.30± 2.87	66.50^{c}±2.12	0.16^{c}±0.02	3.31^{b}±0.01
PMJ	64.80± 1.65	79.00^{a}±1.41	0.35^{a}±0.15	3.21^{d}±0.02
DMJ	66.70± 2.05	72.50^{b}±2.12	0.20^{bc}±0.01	3.40^{c}±0.02

Values with different superscript within same column are significantly (P≤0.05) different.
TSS= Total soluble solids , TTA= Total titratable acid , SJ=Commercial control, HMJ=*Hindi* mango jam JMJ=*Julie* mango jam, PMJ=*Peter* mango jam and DMJ=*Dabsha* mango jam

The TSS ranged from 29.00 to 79.00 brix° with the control mango jam sample (SJ) having the lowest and sample while PMJ had the highest value. There was a significant ($p<0.05$) difference among the samples' TSS and all the mango jam produced had higher TSS than the control. High TSS in food products is a positive index of gelling (Ogunbande *et al*., 2013). TSS also indicates the possibility sweetness invariably sweeter jams were produced from the Benue mango varieties compared with the commercial jam (SJ). High sugar content is more advantageous as the moisture would not be available as free water. Sugar acts as preservative by binding with the free water**.** Also, the bound water may not readily available for microbial growth and this leads to prolonged shelf life of jams (Bekele *et al*., 2020). The TSS values falls within the range of 60-65% or greater recommended by Codex alimentarius for standard soluble solids of jams and marmalade (FAO, 1981).

The TTA which ranged from 0.16 to 0.35% for the various mango jam samples is an indicator of the amount of organic acids present in the mango jams sample. JMJ had the lowest of 0.16% while PMJ had the highest value of 0.35%. Acid facilitates release of trapped pectin inside the fruit cells during heating of fruit with sugar, the addition of lemon juice lowers the acidity of the jam mixture and the total acid in the jam is also influenced by the acidity of the pulp. TTA influences the microorganism growth and proliferation, also influences the sensory attributes, preservation of the products and overall final quality of jam. The variation in the TTA value may be due to the level or degree of maturity and ripening of the mango varieties (Bekele *et al*., 2020; Nelson, 2014). The data reported are within the range (0.35, 0.37 and 0.34%) reported by Mohammed (2013) on jams from mango varieties in Darfur region India and 0.23-0.83 % reported by Bekele *et al*. (2020) on some Ethiopian mango jams. The pH is the natural logarithm of the hydrogen ion concentration of a substance. It is an important factor to obtain optimum gel condition in jam making. Hydrogen ion influences the rates of growth of bacteria, yeasts and molds. The pH values ranged from 3.10 – 3.70 with the control (3.10) being more acidic than the other mango jam varieties. This could be attributed to variation in acidity of the mango pulps. This pH range compare favorably with the Ethiopian mango jams with pH ranging from 3.33 – 4.75 (Bekele *et al*., 2020). According to Kordylas (1990) and FAO (2009), standard jam pH recommendation ranges from 3.00-3.50. Therefore, all the mango jam samples fall within the range of standard jams except HMJ which shows a slightly higher value.

The ash, vitamin A and C content of the various mango jam samples is as presented in Table 2. Ash, Vitamins A and C result of the various mango jams is as presented in Table 2. Ash content of food materials gives an indication of the mineral composition of the food sample which is very important in the biochemical functions of the body. The ash content of the various mango jam samples ranged from 0.13 to 0. 34%, while the vitamin A and C ranged from 89.10 – 129.90 µg/100g and 12.12 – 24.07 mg/100g respectively. There was significant ($p<0.05$)

Table 2: Ash, vitamins A and C contents of jam produced from selected varieties of mango

Jam Samples	Ash (%)	Vitamin A (µg/100g)	Vitamin C (mg/100g)
SJ	0.13^{b}± 0.01	89.1^{c}±0.04	24.07^{a}±0.10
HMJ	0.34^{a}±0.02	89.3^{c}±0.08	16.10^{c}±0.14
JMJ	0.33^{a}±0.03	129.90^{a}±0.07	12.12^{d}±0.17
PMJ	0.30^{c}±0.02	102.8^{b}±0.02	18.15^{b}±0.21
DMJ	0.33^{a}±0.04	92.8^{d}±0.03	16.10^{c}±0.14

Values with different superscript within same column are significantly (P≤0.05) different.
SJ=Commercial control HMJ=*Hindi* mango jam, JMJ=*Julie* mango jam PMJ=*Peter* mango jam
DMJ=*Dabsha* mango jam

difference among the mango jam samples vitamin contents. Vitamin A and C are dominant in mango fruits, USDA (2018) reported vitamin A and C content to be 92.8 and 39 -54µg respectively for whole mango fruits. Varietal differences could have played a role in the variations in the vitamin compositions and response to the heat process by the Vitamins. According to Onimawo and Akubor (2012) vitamin A is destroyed when heated in the presence of oxygen. Vitamin C content is also affected by the stage of ripening, it is higher in less ripe mango fruit compared with fully ripe mango (Matheyambath *et al*., 2016). These mango jams varieties can serve as source of micronutrient vitamin A (from beta carotene).

Sensory attributes of mango jam samples: The mean sensory scores for the various mango jams samples is as presented in Table 3. Mango jams produced from the local varieties were rated higher in appearance, flavor, mouthfeel spreadability, and were more acceptable than the commercial mango jam used as control. Appearance gives the visual assessment which is the first impression and a key feature in the choice of consumer for products preference, purchase and final use (Abid *et al*., 2018). The mean sensory score for appearance ranged from 5.55 – 8.45, while flavor which is a combination of taste and aroma ranged from 5.70 – 8.60 with the mango varieties having higher scores than the commercial mango jam. This could be as result of sweetness as detected in the TSS content values and also the distinctive aroma of these varieties of mangoes. Mean sensory scores for mouthfeel and spreadability ranged from 5.80 to 8.40 and 6.10 to 8.30 respectively with mango sample DMJ the most acceptable with the mean score of 8.70. DMJ was the most acceptable probably due of to its bright colour, distinctive flavor of the original fruit, intermediate consistency, and texture fulfilling the quality of a good jam (Rababah, 2014). All the mango jam samples were generally accepted at confidence limit of 5%.

CONCLUSION AND RECOMMENDATION

This study demonstrated that acceptable and standard mango jams can be produced from the *Dabsha*, *Hindi*, *Julie* and *Peter* mango varieties found in Benue State. All the mango varieties had an appreciable pulp yield and the total soluble content was higher than the commercial jam. Jams produced from these varieties were found to meet up with the standard jam requirements. Sensory evaluation rated the varieties of Benue mango jam higher than the commercial mango jam with *Dabsha* variety mango jam as the most acceptable. Further studies are recommended on the storage stability of the prepared mango jams.

Table 3: Mean sensory scores of jam produced from selected varieties of mango

Samples	Appearance	Flavor	Mouth feel	Spraedability	Overall Acceptability
SJ	5.55^{c}±1.03	5.70^{b}±1.41	5.80^{c}±1.23	6.10^{c}±1.25	6.60^{c}±0.75
HMJ	7.45^{b}±0.94	8.05^{a}±0.75	7.60^{b}±0.59	7.90^{ab}±0.91	8.05^{a}±0.75
JMJ	8.15^{a}±0.81	8.00^{a}±1.21	8.00^{ab}±1.21	8.15^{a}±0.87	8.40^{ab}±0.68
PMJ	8.20^{a}±0.77	8.05^{a}±0.94	7.85^{ab}±0.81	7.35^{b}±0.98	8.05^{b}±0.75
DMJ	8.45^{a}±0.76	8.60^{a}±0.59	8.40^{a}±0.68	8.30^{a}±0.80	8.70^{a}±0.47

Values with different superscript within same column are significantly (P≤0.05) different.
SJ=Commercial control, HMJ=Hindi mango jam, JMJ=Julie mango jam,
PMJ=Peter mango jam, DMJ=Dabsha mango jam

REFERENCES

Abdelazim, A.M.**N.,** Khalid, A.M., Gammam, A.A.O. (2010). Suitability of some Sudanese mango varieties for jam making. American Journal of Scientific and industrial Research. 2153 -649x

Abid, M., Yaich, H., Hidouri H., Attia, H. and Ayadi, M. A. (2018). Effect of substituted gelling agents from pomegranate peel on colour, textural and sensory properties of pomegranate jam," Food Chemistry, 239, pp. 1047–1054.

Ajayi, A.R. and Nshir, S.A. (2006). Mango variety production, marketing and consumption preference among households in Benue state nigeria. Proceedings of thr 23rd Annual conference of the horticultural society of Nigeria pp. 337-343.

AOAC. (2012). Association of Official Analytical Chemists. Official Methods of Analysis. 17thEdition, Washington DC, USA

Avav, T. and Uza, D.V. (2002). Agriculture. In Pigionerre, A.L. (Ed) Africa Atlases,Nigeria Les Ed. J.A. Paris pp 92-95

Bally I.S.E. (2011). Advances in research and development of mango industry. Review in Brasilian. Fruti, 33 (1).

Bally, I., Lu, P. and Johnson, H. (2009). Mango breeding in Jain, S.M and Priyadarshan P.M (eds), reeding plantation tree \crops: Tropical Species Springer Science; Business Media.

Bastin, S. (2004). The science of jam and jelly making. Cooperative extension service. University of Kentucky. College of Agriculture.

Bekele M., Satheesh, N. and Jemal, S. (2020). Screening of Ethiopian mango cultivars for suitability for preparing jam and determination of pectin, sugar, and acid effects on physico-chemical and sensory properties of mango jam. Scientific African

FAO (2009). Utilization of tropical foods: fruit and leaves. Food and nutrition paper, via delle terme dicaracalla, 00100 Rome, Italy.

FAO (1981). Codex standard for jam jellies and marmalade. Retrieved from http://www.fao.org/input/download/standards/11254/CXS_296e.pdf 23rd February 2020.

Girma, E. and Worku, T. (2016). Extraction and Characterization of Pectin From Selected Fruit Peel Waste. International Journal of Scientific and Research Publications, 6(2), ISSN 2250-3153.

Gathambiri C.W., Muchui, M. N., Njuguna, J. K., Wepukhulu, S B., Kiiru, S. N., Wanjala, S. N. and Kariuki, D. N, (2006) Evaluation of postharvest characteristic of mango fruit: 10thKARI Biennial Scientific Proceedings.

Hussain, I.N.G. Sabeen, R.K. , Muhammed, T.M., Khan M. and Ifithar, S. (2005). Varietal suitability and storage stability of mango squash. International Journal of Agriculture and Biology, 7 : 1038-1039.

Iwe, M.O. (2002). Handbook of sensory methods and analysis. 1st ed. Rejoint communication services Ltd., Enugu, Nigeria.

Kordyias, J.M., 1990. Processing and preservation of tropical and subtropical food. Journal of Agriculture and Food Technology, 13: 28-40.

Maldonado, M E., Yahia E.M. Bedoya R., Landázuri , P.,A guillón, J., Restrepo, B and Ospina J.C. (2019). Chemical Composition of Mango (*Mangifera indica* L.) Fruit: Nutritional and Phytochemical Compounds. Frontiers in plant science 1664-462X

Matheyambath A. C., Subramanian J., Paliyath G. (2016). "Mangoes reference module in food science," in Encyclopedia of food and health. Eds. Paul B. C., Told F. F. (Switzerland: Elsevier;), 641–645.

Mohammed Naeem, M.N., Hameed, A, Nourman S., Samina, K. and Muhammad, A. (2012). Storage studies of jam prepared from different mango varieties. Pakistan Journal of Nutrition 11(7), 653-659.

Mohammed Naeem, M.N., Mohd Fairulnizal M.N., Norhayati, M.K., Zaiton, A. A.,Norliza, H. and Rusidah, S. (2017). The nutritional composition of fruit jams in the Malaysian Market, Journal of the Saudi Society of Agricultural Sciences . 16(1), pp 89-96.

Mohammed A.Y. A (2013). Physico-chemical characteristics of different types of mango (*Mangifera Indica* L.) fruits grown in drafur regions and its use in jam processing. Science International. 1(5), 144-147.

Ogunbande, B.J., Girgih, A.T., Oni, K. and Ojo, M.O (2013). Evaluation of the physicochemical, microbiological and sensory attributes of composite jam from pawpaw, mango and pineapple pulps. Journal of Medical and Biological sciences, 3(2), 17-23.

Okoruwa, A. (2018). Nigeria records 50% postharvest losses (guardian news, May 21st). Retrieved from https://guardian.ng/features/agro-care/nigeria-records-50-post-harvest-losses/

Okoth, E.M., Sila, D.N., Onyango, C.A., Owino, W.. O., Musembi, S.. M. and Mathooko, F.M. 10 (2013), "Evaluation of physical and sensory quality attributes of three mango varieties at three 11 stages of ripeness , grown in lower eastern province of Kenya - part 1", Journal of Animal and Plant Sciences, 17 (3), pp. 2608–2618.

Olaniyan, A. O. (2004). General information about mango and citrus production in Nigeria. paper presented at the Mashav International Training on Mango and citrus orchards training and management held at Maizube Farms Minna, Niger state. 22nd Nov – 3rd Dec. 2004.

Onimawo, I.A. and Akubor, P.I. (2012). Food chemistry (Integrated approach with biochemical background). 2nd Edn. Joytal printing press Ibadan Nigeria.

Nelson S. (2014). Food Analysis. Springer Science & Business Media. Retrieved from https://fac.ksu.edu.sa/sites/default/files/1_determination_of_total_acidity_of_food.pdf 21/05/20

Pleguezuelo, C.R.R., Zuazo, V. H., Fernández, J. L. and Tarifa, and Franco, T. D. (2012), "Physico-chemical Quality Parameters of Mango (*Mangifera indica L.*) Fruits Grown in a Mediterranean Subtropical Climate (SE Spain)", Journal of Agricultural Science and Technology, 14, pp. 365–374.

Rababah, T. M., Al-U'Datt, M. and Al-Mahasneh M. (2014). Effect of Jam processing and storage on phytochemicals and physiochemical properties of cherry at different temperatures. Journal of Food Processing and Preservation, 38(1) pp. 247–254.

Ranganna, S. (1999). Handbook of analysis and quality control for fruit and vegetable products and Ed., Tata Mc-Graw Hill publishing company Ltd, New Delhi.

Saúco, V.G. (2017). Trends in world mango production and marketing. Acta Horticulture. 1183, 351-364.

Ubwa, S. T. , Ishu, M. O., Offem, J. O., Tyohemba, R. L. and G. O.Igbum (2014). Proximate composition and some physical attributes of three mango (*Mangifera indica L.*) fruit varieties International Journal of Agronomy and Agricultural Research (IJAAR) 4(2), pp. 21-29.

United States Department of Agriculture, Agricultural Research Service (2018). USDA National Nutrient Database for Standard Reference, Released 1 April, Nutrient Data Laboratory Home Page .

Venkateswarlu, K. and Reddy, P.S.K. (2014), "Mango : Carotenoids", International Journal of Pharmamedix India, 2 (2), pp. 741–44.

WHO (2003). Diet, nutrition and the prevention of chronic diseases. World Health Technical report Series