

## Uses, Constraints and Quality Characteristics of Juice Developed from a Wild Fruit- Baobab

<sup>1</sup>Amina Ahmed and <sup>2</sup>Bendantunguka P. M. Tiisekwa

<sup>1</sup>Mbeya University of Science and Technology

P.O Box 131-Mbeya, Tanzania

<sup>2</sup>Sokoine University of Agriculture

P.O Box 3000 Morogoro, Tanzania

Email: <sup>1</sup>mimomed88@gmail.com, <sup>2</sup>btiisekwa@yahoo.co.uk

### Abstract

*The investigation studied the uses, constraints and quality characteristics of juice developed from a wild fruit, Baobab. Desk review, observation and informal interviews with vendors, processors and consumers using open-ended questionnaire were conducted in Morogoro, Mbeya and Dodoma regions. Stepwise process was followed to develop baobab juice formulations with varied amount of pulp and sugar, colour and spice extracts and analyzed for titratable acidity, and sensory properties using 9-points hedonic scale. It was found that the pulp, leaf and bulk from the baobab tree are traditionally used as food and natural remedy for number of disease including malaria, anemia, vomiting, diarrhea and skin problems. Limited baobab products, mainly candy and ice cream were found in the local and super markets. Constraints to consumption of baobab and its products were limited processing knowledge and poor hygiene, and sensory qualities of the available products. The baobab pulp and sugar levels, colour and type of spice extract had significant effect on Total Titratable Acidity, Total Soluble Solids and sensory scores of the formulations. The titratable acidity ranged from 0.175 to 0.427% citric acid while Total Soluble Solids from 13 to 15° Brix. The final formulation scored high for sensory attributes of color, consistency, flavour, sweetness and overall acceptability. Therefore, juice prepared from baobab would increase the consumption of baobab fruit; hence promote uses of this valuable wild fruit for food and nutrition purpose.*

**Keywords:** Baobab, juice, product development, wild fruit

---

## 1.0. Introduction

Currently, there is a global drive to promote consumption of wild and traditional fruits and vegetables to create dietary diversity that ensures both food and nutrition security. On the other hand, most of wild and traditional plants including baobab are characterized with lower water requirements, adaptation to poor quality soils as well as higher resistance to pests and diseases (Meldrum et al., 2018; Sauberlich, 1994). In the recent past, baobab pulp has gained popularity in American, Asian and European countries (Sidibe and Williams, 2002) due to its high nutritional and bioactive content (Tembo, 2016). However, its potential is still unlocked in many countries of Africa including Tanzania.

Baobab, *Adansonia digitata* is member of the Bombacaceae family mostly found in South Africa, Botswana, Namibia, Mozambique, Malawi and Zimbabwe but can also be found in most semiarid parts of African countries including Tanzania (Tembo, 2016; Sidibe & Williams, 2002; Sauberlich, 1994). Almost all parts of baobab plant are used for either food or medicinal purposes due to high content of both nutrients and health promoting phytochemicals (Tembo, 2016). For instance, the baobab leaf and pulp are rich in carbohydrate, lipids, terpenoids, flavonoids, sterols, vitamins, and essential amino acids (Braca et al., 2018; Tembo, 2016; Kamatou et al., 2011). These make baobab one of the traditional fruits rich in high nutritional and functional qualities (Aluko, 2017; Sidibe & Williams, 2002; Ndabikunze et al., 2011). Baobab fruit is very rich in vitamin C (Tembo, 2016) that reported to enhance immunity, lower incidence of cataract development and coronary disease (Sauberlich, 1994). For instance, the vitamin C content in dried pulp range from 107.8 to 465.8 mg/100g (Tembo, 2016; Jackson, 2015) compared to 83 mg/100g (dry weight basis) of fresh paprika (Daood, 2015). Moreover, calcium content of baobab leaves range between 307 and 2640 mg/100 g of dry weight (Chadare & Linnemann, 2009). Due to high level of antioxidants, dietary fibres, vitamins and minerals, baobab pulp has a potential to be used as one of the ingredient for the development of beverages (Kamatou et al., 2011). However, less has been done on product development.

Product development plays an important role in value addition of cultivated and non-cultivated crops. It is a stepwise process involving number of test batch with adjusted quantities prepared and revised until the correct proportions for an optimal formula are determined (Supekar, 2018; Morris & Brady, 2004). To align with, the food industry has been successful and continuously finds alternative ingredients for formulating products that are nutritionally modified versions and deliver better nutrition (Ahmed & Bajwa, 2019). Consumer demand for such functional products is also increasing daily. The demand for food and beverages with nutritional additives and improved sensory properties has vastly attracted the consumers' attention in the recent past (Vocke et al., 2017; Okello et al., 2015). Natural juices are among good example of such beverages due to their increased bioavailability of nutrients and health promoting components also known as phytonutrients (Henning et al., 2017). Number of fruits including mangoes, passions, grapes, pineapples etc. have been used in domestic and food industries to prepare juice and beverages in Tanzania. However, juice preparations from baobab pulp are rarely to find in the markets. Therefore, this study investigated to find out the uses, constraints for consumption of baobab fruit in Tanzania as well as developing baobab juice and assessing its physicochemical and sensory qualities.

## **2.0. Methodology**

### **2.1. Baseline Study**

Information on uses and consumption constraints of baobab was gathered by way of desk review using Google search engine to find out available baobab products in online stores and researches. Observation technique was used to find out the available baobab products in the markets and food stores. Moreover, informal and short interviews with vendors, processors and consumers were conducted in three regions namely Morogoro, Dodoma and Mbeya with a guide of an open ended questionnaire (Annex 1). Two major markets Mawenzi and Municipal markets in Morogoro Municipality; SIDO market in Mbeya City; and Majengo and Mpwapa markets in Dodoma.

### **2.2. Juice Formulation**

Baobab pulp was purchased from the local market and baobab juice formulation was prepared at Sokoine University of Agriculture, in Morogoro, Tanzania. Baobab juice was developed as per product development steps suggested by (Supekar, 2018 & Earle et al., 2017). In the initial stage of product development, a commercial baobab drink from Malawi was used as reference for descriptive sensory evaluation. However, the consistency and colour of the reference baobab drink was not accepted by panel. Therefore, from number of trials, three formulations with baobab pulp level of 4%, 6% and 8% with brix level 13%, 14% and 15%, respectively were prepared.

In the first experiment, baobab pulp was dissolved in portable water and the mixture strained through 0.5 mm sieve and heated to 70°C for 5 minutes. Brix level of each formulation was raised to 13%, 14% and 15% and formulations were then chilled to 6°C for 24 hours prior to sensory evaluation. In the second experiment, one formulation with the highest sensory scores was selected and added with 50mls of 0.8% of vanilla and cardamom extracts. The spice extracts were prepared by soaking 0.8% mixture of ground spice in warm portable water in air tighten container for 10 minutes and then strained. In the third experiment, the formulation with highest sensory scores was added with 0.002% yellow and pink food colour and assessed its acceptability. In fourth experiment, the formulation with highest sensory score from previous experiment was reformulated and evaluated for its sensory properties.

### **2.3. Analysis of Physicochemical Properties**

TSS of the juice formulations was measured using a hand refractometer at 22°C, and expressed as °Brix. Total acidity was analyzed as per AOAC (2000) methods using 0.1M sodium hydroxide (NaOH) with phenolphthalein indicator, and the results were expressed as percentage of citric acid (ml/100ml of juice).

### **2.4. Sensory Evaluation**

The samples of baobab juice formulations were evaluated by a semi-trained panel of judges for the sensory attributes of color, flavor, consistency, sweetness and overall acceptability on nine point's hedonic scale where 1 indicated liked extremely and 9 disliked extremely (Poste et al., 1991).

### **2.5. Statistical Analysis**

The data were analyzed by analysis of variance (ANOVA) using SPSS 16.1 software and the mean difference compared using least significance difference (LSD) and Pearson correlation at  $p \leq 0.05$ .

### 3.0. Results and Discussion

#### 3.1. Uses and Consumption Constraints of Baobab and Baobab Products

In Tanzania, baobab (*Adansonia digitata*) also known as *ubuyu* is among the wild cultivated fruit variety mostly found in Dodoma, Singida, Morogoro and Iringa regions. It was reported by respondents that, the pulp, leaf and bulk from the baobab tree are traditionally used as food and natural remedy for boosting immunity of people living with HIV/AIDS and treating number of diseases including malaria, anemia, diarrhea and nausea. The medicinal properties of baobab pulp, leaves bulk have been related with presence of phytochemicals such as alkaloids, antioxidants and vitamins that possess antimicrobial activities against range of virus and bacterial (Salihu & Ali, 2019; Samatha et al., 2017; Vimalanathan & Hudson, 2009; Anani et al., 2000).

Raw baobabs found in the markets were mainly in form of pulp with seeds or as seedless powder. Few vendors were selling baobab fruits pods because some customers want that way; it is safe and easier to transport the baobab fruit in its pod. In addition to that, colour of the baobab is maintained within its pod. The colour of the baobab pulp found in the market ranged from white to off cream. The reason for colour variation was associated to specie types and storage conditions (Chadare, 2010). The baobab pulp is traditionally white irrespective of variety, and gradually changes to off cream once the pod is cracked. This could be attributed to the chemical changes such as oxidation due to storage conditions, relative humidity, and presence of oxygen, light, catalysts, type and properties of package (Tembo, 2016; Chadare, 2010; Ana & Lia, 1997).

Main baobab products found in the market were home-made candies with seeds, baobab sweet bars and ice cream. Baobab candies and bars were the mainly products sold in the main markets at both wholesale and retail price. Baobab candies and ice creams were available at retail price mainly in households, streets, schools, shops and some mini supermarkets. The superior baobab candies preferred by consumers were the one from Zanzibar known as “*Ubuyu wa Zanzibar*” which has vast flavour of aromatic compounds from added spices.

In view of the consumers’ point, the process to extract baobab pulp from seed is tedious. However, most of the consumers claimed to opt seedy pulp because the seedless pulp normally contains contaminants such as sand and insect debris which are difficult to separate. The same reasons were mentioned by individuals who opt not to use baobab pulp and its products at all. From our observation, the contaminants in baobab pulp could be introduced after cracking the pod which normally take place on the ground and poor handling of pulp in jute bags and open containers. Therefore, proper handling practices along the value chain would ensure the baobab pulp quality and consequently increase its acceptance across number of consumers.

According to the processors’ point of view, aged baobab with off cream colour is mostly preferable due to its cheaper price, absorbs syrup (mixture of sugar, colour and flavour) faster and distribute evenly across the pulp, and results in product with smooth texture. On the other hand, the fresh pulp requires more sugar, results in product with uneven flavour distributions and harsh texture and mouthfeel that can wound mouth. The homemade baobab ice creams were commonly sold in schools. Moreover, homemade baobab sauces to accompany starchy food were found to be used by fast food vendors specifically in Morogoro town. Some food vendors reported to add baobab pulp into tamarind juice to increase its viscosity. However, the survey did not found any branded baobab juice in the markets. Therefore, the baobab juice was formulated and assed to its acceptability.

### 3.2. Physicochemical Properties of Baobab Juice Formulations

Raw baobab juice was inconsistent due to sedimentation. Heating resulted into change of colour to deep brown and increased consistency of the juice formulations. The increase of consistency of the formulations showed a positive relationship with the heating of juice up to 70 °C and hold to that temperature for 5 minutes. The increase in consistency could be due to pectin-gel formation upon heating. The pectin content in baobab pulp is higher compared to that of bananas, apricots, peaches and apples (Ndabinkunze et al., 2011; Sauberlich, 1994). For instance, Ndabinkunze et al. (2011) prepared jam by replacing commercial pectin with baobab pulp and found that pulp acidity had influence on the pectin-gel formation. Similarly, Abdalla et al. (2010) used gum Arabic in five different sequential concentrations (1, 1.5, 2, 2.5 and 3%) to prevent pulp sedimentation.

The predominant acid naturally occurring in baobab fruit is citric acid. However, other organic acids include malic and succinic acids are also present in small amounts (Tembo, 2016; Phytotrade, 2008). The content of citric acid in raw baobab pulp usually ranges from 2.7 to 3.2% by weight of fruit pulp (Phytotrade, 2008). The Total Titratable Acidity (TTA) of the juice formulations ranged from 0.175 to 0.427% citric acid (Table 1). The TTA of juice formulations differed significantly at  $p > 0.05$ . The increase of acidity among the formulations showed a positive relationship with the increase of baobab pulp content. Abdalla et al., (2010) reported a range from 0.026 to 0.027% for a drink prepared containing about 2.6% baobab pulp with several level of guar gum. Akubor (2017) prepared baobab juice for wine preparation and reported TTA of 0.68%. The difference in titratable acidity is due to difference in pulp amount used to prepare the juices. Acids of the fruit have an influence on the taste, flavour, pH, colour, and microbial stability of the juice (Akubor, 2017; Amerine & Joslyn, 1970). TSS-TTA ratio ranged from 32.59 to 85.77. Sugar and acid ratio content play an important role in adjusting flavour of the food (Ndabinkunze et al., 2011; Birkhed, 1984).

Table 1

#### *Physicochemical of Baobab Juice Formulations*

Formulation	Baobab pulp level (%)	Initial Total soluble solids (°B)	Final Total soluble solids (°B)	Total titratable acidity (%)	TSS-TTA ratio
F1	4	3.5	13	0.198 <sup>a</sup> ± 0.000	65.52 <sup>a</sup> ± 0.00
F2	4	3.5	14	0.188 <sup>a</sup> ± 0.003	74.59 <sup>b</sup> ± 1.44
F3	4	3.5	15	0.175 <sup>b</sup> ± 0.003	85.77 <sup>c</sup> ± 1.79
F4	6	4.0	13	0.264 <sup>c</sup> ± 0.004	49.15 <sup>d</sup> ± 0.68
F5	6	4.0	14	0.271 <sup>c</sup> ± 0.134	51.76 <sup>e</sup> ± 2.60
F6	6	4.0	15	0.258 <sup>c</sup> ± 0.003	58.11 <sup>f</sup> ± 0.83
F7	8	7.0	13	0.399 <sup>d</sup> ± 0.003	32.59 <sup>g</sup> ± 0.30
F8	8	7.0	14	0.374 <sup>e</sup> ± 0.008	37.51 <sup>h</sup> ± 0.75
F9	8	7.0	15	0.427 <sup>f</sup> ± 0.010	35.17 <sup>i</sup> ± 0.81

Values are mean ± SD, values with different superscript in a row differ significantly at  $p > 0.05$

### 3.3. Sensory Quality of Baobab Juice

Baobab juice has brown-yellowish to brown colour which deepens upon increase of baobab pulp level and heating (Plate 1). In general, the overall acceptability sensory scores of the baobab juice for consistency were highest in formulations with 6% baobab pulp, followed by 4% and 8% (Annex 2). On the other hand, the highest overall acceptability score was highest

in formulations with 13°B, followed by 14°B and 15°B (Annex 2). The reason for lowest score for overall acceptability of the 8% baobab pulp formulations could be due to lower TSS-TTA ratio (Table 1). Abdalla et al., (2010) prepared drink containing about 2.6% baobab pulp with several level of guar gum and found high sensory acceptability of the formulations.

Table 2

*Effect of Pulp and Brix Levels on Sensory Scores of Baobab Juices*

Formulation	Consistency	Sweetness	Overall Acceptability
F1	2.93 <sup>ac</sup> ± 1.16	2.21 <sup>a</sup> ± 0.77	2.48 <sup>a</sup> ± 1.12
F2	3.14 <sup>ac</sup> ± 1.13	2.24 <sup>a</sup> ± 0.79	2.76 <sup>a</sup> ± 0.87
F3	2.52 <sup>abc</sup> ± 1.15	2.00 <sup>a</sup> ± 0.71	2.14 <sup>a</sup> ± 0.95
F4	2.69 <sup>abc</sup> ± 1.56	2.34 <sup>a</sup> ± 0.81	2.28 <sup>a</sup> ± 0.88
F5	2.41 <sup>ab</sup> ± 1.27	2.14 <sup>a</sup> ± 0.95	2.14 <sup>a</sup> ± 0.92
F6	2.14 <sup>b</sup> ± 2.36	2.10 <sup>a</sup> ± 0.90	2.24 <sup>a</sup> ± 1.27
F7	2.66 <sup>abc</sup> ± 1.18	4.14 <sup>bc</sup> ± 1.77	3.90 <sup>b</sup> ± 2.27
F8	3.21 <sup>c</sup> ± 1.72	4.17 <sup>b</sup> ± 1.81	3.72 <sup>b</sup> ± 2.36
F9	2.83 <sup>abc</sup> ± 2.21	3.48 <sup>c</sup> ± 2.03	4.10 <sup>b</sup> ± 2.19

Values are mean ± SD, values with different superscript in a row differ significantly at p > 0.05

Specifically, the sensory scores for overall acceptability were highest in formulation F5 followed by F3 and F6 (Table 2). The scores for these attributes ranged from liked moderately (3) and liked very much (2). Therefore, formulation F5 was further redeveloped to get the optimal formulation.

Colour is considered as the most important sensory parameter, which can influence consumers' expectations on the likely taste and flavour of the food and drinks (Spence, 2015). Panelists suggested that the natural colour of baobab juice was strange, hence could affect the acceptance of the juice. Similarly, Abdalla et al. (2010) found that the color intensity of beverages had negative effect on sensory score of baobab beverages. Therefore, addition of colour increased panel acceptability significantly (Table 3). Juice with yellow colour had the highest acceptability sensory score (1.77) followed by pink (3.07) and control (3.86).

Table 1

*Effect of Colour and Flavour on Sensory Scores the Baobab Juice*

Colour	Control	Yellow	Pink
	3.86 <sup>a</sup>	1.77 <sup>b</sup>	3.07 <sup>a</sup>
Flavor	Control	Vanilla	Cardamom
	2.80 <sup>a</sup>	2.10 <sup>b</sup>	2.30 <sup>ab</sup>

Means within the same row superscripted by different letters are significantly different at P < 0.05

On the other hand, juice formulation flavored with vanilla extract had highest acceptability sensory score (2.10) followed by cardamom (2.30) and control (2.80). Similarly, in market survey we found that the available baobab candies and ice creams were added with vast colour and flavour and spices to suit consumer preference. Similarly, Abdalla et al. (2010) found that the addition of three drops of baobab oil improved the flavour acceptability of baobab drink. Therefore, formulation with yellow colour and vanilla was reformulated and its overall acceptability evaluated.

Table 4

*Pearson Correlation of Sensory Scores of the Final Formulation*

	Colour	Consistency	Flavour	Sweetness	Overall acceptability
Colour	1.00	0.95*	0.90*	0.88*	0.88*
Consistency	0.95*	1.00	0.90*	0.91*	0.88*
Flavour	0.90*	0.90*	1.00	0.87*	0.93*
Sweetness	0.87*	0.91*	0.86*	1.00	0.82*
Mean	2.70±1.39	2.53±1.19	1.93±0.87	1.67±0.71	1.97±0.81

*Pearson correlation with superscripted by \* are significantly at P<0.05*

The sensory scores for color, consistency, flavour, sweetness and overall acceptability of the final formulation ranged from liked very much (2) to liked moderately (3) (Table 4). The Pearson correlation suggested that flavor had the most influence on overall acceptability of the baobab juice (Table 4). Normally, spices contain volatile compounds which impart favorable taste and aroma when added in food. Thus, cardamom and vanilla extracts have been used as a flavoring agent in alcoholic and non-alcoholic beverages, frozen desserts, candies, baked goods, puddings, condiments, relishes, gravies, meat and meat products (Mahady et al., 2005; Rakshit & Ramalingam, 2010).

#### 4.0. Conclusion

There should be developed a standard and proper handling practices along the value chain of baobab from harvesting to marketing that ensure the pulp quality so as to increase consumer acceptance. Sensory scores indicated that good quality juice with high acceptability could be manufactured from baobab pulp. Moreover, addition of colour and flavour could increase the acceptability of the baobab juice; hence influence dietary diversity through use of this wild and underutilized fruit. The formulation of baobab juice could be adapted by household and food processors to contributing to both food and nutrition security, and income generation.

#### Acknowledgments

The authors wish to thank Mr. Tumaini Marango, Ms. Mwanaidi Salim, the respondents and sensory panel for dedicating their time towards this study.

#### References

- Abdalla, A. A., Yagoup, N. H., & Mudawi, H. A. (2010). Production and Quality Evaluation of Baobab (*Adansonia Digitata*) Beverages. *Journal of Applied Sciences Research*, 6(6), 729-741.
- Ahmed, A., & Bajwa, U. (2019). Composition, texture and microstructure appraisal of paneer coagulated with sour fruit juices. *Journal of food science and technology*, 56(1), 253-261. <https://doi.org/10.1007/s13197-018-3484-4>
- Akubor, P. I. (2017). Characterization of Fruit Wines from Baobab (*Adansonia digitata*), Pineapple (*Ananas sativus*) and Carrot (*Daucus carota*) Tropical Fruits. *Asian Journal of Biotechnology and Bioresource Technology*, 1(3), 1-10. DOI: 10.9734/AJB2T/2017/35643

- Aluko, A. (2017). *Probiotic Viability and Storage Stability of Yoghurt Enriched with Baobab Pulp (Adansonia digitata)*. Jomo Kenyatta University of Agriculture and Technology.
- Amerine, M. A., & Joslyn, M. A. (1970). *Table wines: the technology of their production*. 2<sup>nd</sup> ed. California: University of California Press. 997 pages.
- Ana, M. R., & Lia, N. G. (1997). Influence of system composition on ascorbic acid destruction at processing temperatures. *Journal of Science of Food Agric.*, 74, pp. 369–378.
- Anani, K., Hudson, J. B., de Souza, C., Akpagana, K., Tower, G. H. N., Arnason, J. T., & Gbeassor, M. (2000). *Investigation of medicinal plants of Togo for antiviral and antimicrobial activities, pharmaceutical Biology*, 38(1), pp. 40-45. DOI: [10.1076/1388-0209\(200001\)3811-BFT040](https://doi.org/10.1076/1388-0209(200001)3811-BFT040)
- AOAC, (2000). *Official method of analysis*, 17<sup>th</sup> ed., Washington DC: Association of Official Analytical Chemists,
- Birkhed, D. (1984). *Sugar content, acidity and effect on plaque ph of fruit juices, fruit drinks, carbonated beverages and sport drinks*, *Caries Res.*, 18, pp. 120–127. DOI:10.1159/000260759
- Braca, A., Sinisgalli, C., De Leo, M., Muscatello, B., Cioni, P. L., Milella, L., Ostuni, A., Giani, S., & Sanogo, R. (2018). Phytochemical Profile, Antioxidant and Antidiabetic Activities of *Adansonia digitata* L. (Baobab) from Mali, as a Source of Health-Promoting Compounds”, *Molecules*, 23(23), pp. 1-18. DOI: 10.3390/molecules23123104.
- Chadare, F. J. (2010). Baobab (*Adansonia digitata* L.) foods from Benin: composition, processing and quality PhD. Wageningen University.
- Chadare, F. J., & Linnemann, A. R. (2009). Baobab Food Products: A review on their composition and nutritional value. *Critical Reviews in Food Science and Nutrition*, 49, pp. 254-274. Faculty of Agronomic Sciences, University of Abomey-Calavi, Cotonou, Benin
- Daood, H. G., Palotás, G., Palotás, G., Somogyi, G., Pék, Z., & Helyes, L. (2014). Carotenoid and antioxidant content of ground paprika from indoor-cultivated traditional varieties and new hybrids of spice red peppers. *Food Research International*, 65, pp. 231 – 237. doi = <https://doi.org/10.1016/j.foodres.2014.04.048>
- Earle, M., Earle, R., & Anderson, A. (2017). *Food product development*, New Zealand Institute of Food Science and Technology. [Online]. Available at: <http://www.nzifst.org.nz/foodproductdevelopment/Chapter-3-2-1.htm> [Accessed 10 April 2019].
- Henning, S. M., Yang, J., Shao, P., Lee, R., Huang, J., Ly, A., Hsu, M., Lu, Q., Thames, G., Heber, D., & Zhaoping, L. (2017). *Health benefit of vegetable/ fruit juice-based diet: Role of microbiome*. *Scientific Reports*. DOI: 10.1038/s41598-017-02200-6.
- Jackson, S. (2015). Baobab: The Tree of Life — An Ethnopharmacological Review. American Botanical Council. [Online] Available at: <http://cms.herbalgram.org/herbalgram/issue108/hg108-feat-baobab.html?ts=1585904863&signature=aa6e87b05f5d2a854ed2c43eb59ec798> [Accessed 10 April 2019].
- Kamatou, G. P. P., Vermaak, I., & Viljoen, A. M. (2011). An Updated Review of *Adansonia digitata*: A Commercially Important African Tree. *South African Journal of Botany*, 77(4), pp. 908–919.
- Mahady, G. B. (2005). Medicinal plants for the prevention and treatment of bacterial infections: Current Pharmaceutical Design. *Journal of Phytotherapy Research*, 11, pp. 2405 -2427.
- Meldrum, G., Padulosi, S., Lochetti, G., Robitaille, R., & Diulgheroff, S. (2018). Issues and

- Prospects for the Sustainable Use and Conservation of Cultivated Vegetable Diversity for More Nutrition-Sensitive Agriculture. *Agriculture*, 8(7), pp. 112.
- Morris, J. R., & Brady, P. L. (2004). Adding value to enhance profits research report 974. University of Arkansas. Faye Heville: System's division of Agriculture.
- Ndabikunze, B. K., Masambu, B. N., Tiisekwa, B. P. M., & Issa-Zacharia, A. (2011). The production of jam from indigenous fruits using baobab (*Adansonia digitata* L.) powder as a substitute for commercial pectin. *Afri. J. Food Sci.*, 5, 168-175.
- Okello, J. J., Hutchinson, M. J., Mwang'ombe, A., Ambuko, J., Olubayo, & Mwakangalu, M. (2015). Consumer demand for value-added products of African indigenous vegetables in coastal Kenya: The case of sundried and frozen cowpea leaves. *Journal of Agriculture, Food Systems, and Community Development*, 6(1), 189–207.  
<http://dx.doi.org/10.5304/jafscd.2015.061.004>
- Phytotrade Africa (2008). "Baobab Dried Fruit Pulp – An application for Novel Foods Approval in the EU as a food ingredient", [Online]. Pp. 1- 43. Available at: [https://acnfp.food.gov.uk/sites/default/files/mnt/drupal\\_data/sources/files/multimedia/pdfs/baobabapplicationfinal.pdf](https://acnfp.food.gov.uk/sites/default/files/mnt/drupal_data/sources/files/multimedia/pdfs/baobabapplicationfinal.pdf). [Accessed 10 December 2018].
- Poste, L. M., Mackie, D. A., Buller, G., & Larmond, E. (1991). Laboratory methods for sensory analysis of food. Ottawa: Research Branch Agriculture Canada Publication.
- Rakshit, M., & Ramalingam, C. (2010). Health Benefits of Spices with Special Reference to Antimicrobial Activity and Bio Active Components. *Journal of Experimental Sciences*, 1(7), pp. 12 -18.
- Salihu, A. M., & Ali, M. (2019). Antibacterial Activity of Leaf and Stem Bark Extracts of *Adansonia digitata* against *Escherichia Coli* and *Salmonella typhi* Grown in Potiskum, Yobe State Nigeria". *International Journal of Research in Business Studies and Management*, 2(2), pp. 1-7.
- Samatha, T., Shama, N., Chandrakala, G., Thirupathi, K., & RamaSwamy N. (2017). Antibacterial Activity of *Adansonia digitata* L: A Globally Endangered Tree. *International Journal of Pharmacognosy and Phytochemical Research*, 9(11), 1410-1413. doi:10.25258/phyto.v9i11.11183
- Sauberlich, H. E. (1994). Pharmacology of vitamin C. *Annual Review of Nutrition*, 1(4), 371-391.
- Sidibe, M., & Williams, J. T. (2002). Baobab (*Adansonia digitata*). The International Centre for Underutilised Crops, Southampton, UK.
- Spence, C. (2015). On the psychological impact of food colour. *Flavour*, 4(2), pp. 1-16. DOI: doi.org/10.1186/s13411-015-0031-3.
- Supekar, P. (2018). Food Product Development Process – Product Development Stages. Discover food tech. <https://discoverfoodtech.com/food-product-development-process/> [Accessed 10 January 2019].
- Tembo, D. T. (2016). Optimisation of Baobab (*Adansonia digitata*) fruit processing and handling techniques for increased human nutrition and commercialization in Malawi. The University of Leeds.
- Vimalanathan, S., & Hudson, J. B. (2009). Multiple inflammatory and antiviral activities in *Adansonia digitata* (Baobab) leaves, fruits and seeds. *Journal of Medicinal Plants Research*, 3(8), pp. 576-582.
- Vocke, R. Fricker, R. Williams, B. S., & Dimitrova, D. (2017). *The rise of wellcare: A new market at the nexus of health, food, and beauty* [Online]. Available: <https://www.strategyand.pwc.com/report/rise-of-wellcare> [Accessed 10 December 2018].