

BINDURA UNIVERSITY OF SCIENCE EDUCATION

DEVELOPMENT OF *ZIZIPHUS MAURITIANA* L. FRUITS (MASAWU) NON-ALCOHOLIC BEVERAGES AND ASSESSMENT OF THEIR ACCEPTABILITY



DEPARTMENT NATURAL RESOURCES

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APPROVAL FORM

The undersigned certified that they have supervised and recommended to Bindura University of Science Education for acceptance of dissertation entitled "**DEVELOPMENT OF ZIZIPHUS MAURITIANA L. FRUITS (MASAWU) NON-ALCOHOLIC BEVERAGES AND ASSESSMENT OF THEIR ACCEPTABILITY**" submitted in partial fulfilment of the requirements of the bachelor of environmental science honours degree in natural resources management.

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A handwritten signature in blue ink, consisting of a circular initial followed by a long horizontal stroke and a large, stylized letter 'J'.

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DEDICATION

I would like to dedicate this project to my loved ones.

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First and foremost, I would like to thank Prof Nyakudya and Dr Mureva, for their guidance, support, and patience throughout this process. They provided me with invaluable advice during my research writing and been vital to help me finish this dissertation. I am very grateful to my family and friends for all their encouragement and motivation over the years. I thank my mother for providing me with love and comic relief when I needed it the most.

ABSTRACT

The global fruit juice value market is increasing driven by the fact that soft drinks, such as colas and flavoured sodas, are becoming less popular due to their high sugar content, artificial colouring, phosphoric acid, artificial sweeteners, and caffeine, all of which have harmful effects on the human body.

This study's main objective was to develop improved *Z. mauritiana* fruits synthetic preservatives-free non-alcoholic beverages and to determine the consumers' preferred product among the masawu non-alcoholic beverages. The study involved the formulation of four different non-alcoholic beverages using masawu as the main ingredient, including a tamarind and sugar. The four beverages were prepared using a simple method, before beginning any treatment, the fruits were rinsed with distilled water. After cleaning, the fruits were oven dried for 72 hours at a temperature of 72 degrees Celsius to remove any moisture in the fruits and kept in a dry container to minimise moisture absorption. A July motion dehuller was used to separate the seed from the pulp and the pulp was used for making the non-alcoholic beverage. After dehulling the pulp was sieved through ISI Mesh No. 1 (1 mm). One litre of water with different mixtures of ingredients was boiled for 15 to 20 minutes. Sugar was then added as a sweetener. After the mixture had settled, it was strained and served

The four prototypes were created by combining varying ratios of masawu and tamarind. To enhance the sensory quality of the blends, white sugar was added to the other two blends as a sweetener. White sugar was used because it does not change the colour of the beverages. Four different non-alcoholic beverages were formulated namely Masawu+Sugar, Masawu+Tamarind+Sugar, Masawu Only and Masawu+Tamarind. The sensory evaluation of these beverages was conducted using a 9-point hedonic scale to determine the overall acceptability, taste, flavour, appearance, and texture of each beverage and 51 people who voluntarily wanted to participate were part of this sensory evaluation test. The results showed that Masawu+Sugar and Masawu+Tamarind+Sugar were well-accepted, and they were deemed overall acceptable by 86.3% and 96.1% of the participants respectively. Masawu Only and Masawu+Tamarind had lower acceptance rates among participants at 41.2% and 29.4%, respectively. The study concluded that masawu is a good raw material for the production of non-alcoholic beverages. The study recommends optimisation of Masawu+Sugar and Masawu+Tamarind+Sugar non-alcoholic beverages before

commercialisation. Further studies on shelf life and proximate analysis of the formulated blends are recommended to guide storage ability, nutritional profile, and packaging guidelines.

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CHAPTER 1: INTRODUCTION

1.1 Background to the Study

The global fruit juice market value reached US\$141 billion in 2021 and is expected to reach US\$182 billion by 2027 (Technavio, 2022). This increase is driven by the fact that soft drinks, such as colas and flavoured sodas, are becoming less popular due to their high sugar content, artificial colouring, phosphoric acid, artificial sweeteners, and caffeine, all of which have harmful effects on the human body (Blocher *et al.*, 2021). Consumers changing lifestyles and eating habits have increased the consumption of economical, healthy, and rapid sources of nutrition, such as packaged fruit juices, which has fuelled the market's expansion. As a result, many people are switching from fizzy drinks to natural fruit beverages. In response to this shift in the market, manufacturers are developing a wide range of tastes and producing preservative and sugar-free fruit juices (beverages) to broaden the consumer base (Kar & Peru, 2020). In Zimbabwe, most of the fruit beverages are made from exotic fruit trees, including *Mangifera indica* L., *Citrus sinensis* L., *Ananas comosus* L., *Citrus limon* L., *Citrus paradise* Macfad. and *Psidium guajava* L. However, Zimbabwe has a wide range of indigenous fruit trees, such as *Adansonia digitata* L., *Sclerocarya birrea* A. Rich., and *Uapaca kirkiana* Müel Arg., which have the potential to produce a variety of value-added products.

An example of a non-alcoholic beverage widely consumed in Zimbabwe is gununzvi, made from *Ziziphus mauritiana* L. fruits (masawu). Gununzvi is especially popular in the Zambezi Valley in northern Zimbabwe, where people have been consuming it for generations (Bongo *et al.*, 2017; Musemwa *et al.*, 2017; Katanha, 2018). These beverages are known for their thirst-quenching, refreshing, stimulating, and nourishing properties (Bongo *et al.*, 2017). Gununzvi is known for its thirst-quenching, refreshing, invigorating, and nutritional properties (Bongo *et al.*, 2017). In times of crop failure, people in the Zambezi Valley drink gununzvi, making it a fall-back food and drink (Bongo *et al.*, 2017). *Ziziphus mauritiana* is a tree native to India and other parts of Asia but has been introduced to many parts of Africa, including Zimbabwe, and has naturalised in the Zambezi Valley in northern Zimbabwe. The fruit of this tree is rich in nutrients and has been used for centuries in traditional medicine to treat a range of ailments, including diarrhoea, dysentery, and respiratory infections

(Musemwa *et al.*, 2017). In addition to its medicinal properties, the fruit is also a popular ingredient in many non-alcoholic beverages, including gununzvi.

Gununzvi is typically prepared by boiling the Masawu fruits until they become soft. The fruits are then mashed to extract the juice, mixed with water and sometimes sugar to taste. The resulting drink is refreshing, sweet, and slightly tangy, with a pleasant aroma (Bongo *et al.*, 2017; Musemwa *et al.*, 2017). The beverage is usually consumed cold and is a popular choice during hot and dry seasons.

The nutritional value of a 100 g serving of masawu contains 61 calories, 14.3 g of carbohydrates and 1.6 g of protein value (USDA, 2019). It is high in Vitamin C, containing about 71% of the daily recommended intake, which is more than oranges (69%) (USDA, 2019). Masawu also has more Vitamin A (10% DV (daily value) than apples (3% DV) and bananas (2% DV) (USDA, 2019). However, it contains less Vitamin A than pineapples (58% DV) (USDA, 2019). In terms of minerals, masawu are an excellent source of potassium (K), magnesium (Mg), copper (Cu), iron (Fe) and manganese (Mn). The fruits contain more K (9% DV) and Cu (11% DV) than oranges (6% and 4% DV, respectively) (USDA, 2019). Masawu also has more Fe (4% DV) than bananas (2% DV) but less than pineapples (7% DV) (USDA, 2019).

While masawu contains various vitamins and minerals, its nutritional content is comparable to other popular fruits like oranges, apples, bananas, and pineapples. As with these other fruits, Masawu fruit can be part of a healthy diet and help reduce the risk of disease. However, the acceptability of fruit beverages made from wild fruits among consumers is influenced by various factors, including taste, aroma, appearance, and nutritional value. Developing fruit beverages using wild fruits presents an opportunity to promote sustainable use of natural resources, generate income, and improve the nutritional security status of African communities. Acceptability of beverages made from wild fruits among consumers is important because it determines their success in the market. Consumers' preferences for taste, aroma, and appearance vary depending on cultural, social, and economic factors, and these preferences can influence the demand for fruit juices made from wild fruits (Mabhaudhi *et al.*, 2014). Non-alcoholic beverages play an essential role in the daily lives of Zimbabwean people, not only as a source of nourishment but also as an expression of cultural identity. There is a need to develop and conduct a sensory evaluation of fruit beverages to commercialise them.

1.2 Problem Statement

Sweetened and carbonated drinks, such as colas or sodas, have been related to ailments such as type 2 diabetes, obesity, and heart disease, and they increase the risk of dental decay, osteoporosis, and renal disease (Hamad, 2019). These drinks affect many physiological systems, including the circulatory, digestive, reproductive, and central nervous systems. Consequently, non-alcoholic beverages without or with minimal additives offer consumers a healthier alternative. While masawu non-alcoholic beverages may still contain a high amount of natural sugar, they have a higher nutritional value than fizzy drinks, less sugar, and no or limited carbonation.

1.3 Main Objective:

To develop improved *Z. mauritiana* fruits synthetic preservatives-free non-alcoholic beverages.

1.4 Specific Objectives:

1.4.1. To develop four prototypes of pure masawu non-alcoholic beverages.

1.4.2. To determine the consumers' preferred product among the four prototypes of masawu non-alcoholic beverages.

1.5 Justification:

Results from the study will help produce a commercial masawu non-alcoholic beverage that will assist the institution by generating revenue from the juice. Also, the commercialisation of indigenous fruit products has the potential to improve the socio-economic status of rural communities by creating jobs, increasing family income, providing a non-seasonal supply of safe and high-quality non-alcoholic beverages, fostering environmental rehabilitation, and domestication of fruit trees (Bongo *et al.*, 2017). According to (Nyanga, 2012), masawu are good sources of nutrients such as carbohydrates, protein, and essential micronutrients such as Ca, K, phosphorus, Cu, Fe, zinc, and vitamin C.

1.6 Limitations of the Study

The current research did not analyse the nutritional composition of non-alcoholic beverages, which restricts how applicable the findings are for health and diet reasons. The study did not establish the shelf life of the created drinks, which limits how valid the results are for commercial purposes. Future research could include a comprehensive shelf-life analysis of

the developed beverages, such as evaluating microbial development, pH level, acidity, and other elements that may impact the stability and safety of the beverages. The sample size used for this study was 51 participants, which can be adequate because the researcher was comparing a smaller set of samples. However, a smaller sample size may be more likely to get non-representative results. Many published studies have sample sizes of 100 to 200 or more to gain more statistical power. For example, Stone *et al.* (2012) had 208 participants in their study comparing sensory attributes of Cabernet Sauvignon wines.

1.7 Statement on Ethics

The researcher obtained informed consent from the participants, which involved providing them with sufficient information about the study and any potential risks and benefits so they could make informed choices about participating. The researcher also ensured participants' privacy was protected during the entire examination. This was achieved by not sharing the confidential details of participants with anyone. Furthermore, the researcher made sure developing and producing the non-alcoholic beverages were safe and that high-quality ingredients were used. This was achieved by working in a food-friendly environment and paying attention to hygiene.

CHAPTER 2: LITERATURE REVIEW

2.1 Indigenous (African) Fruits Non-alcoholic Beverages Production Protocol

Uacapa kirkiana (sugar plum), *Strychnos spinosa* Lam (monkey orange), *Annona senegalensis* Pers. (wild custard apple), and *A. digitata* are underutilised African fruits with potential for processing into non-alcoholic beverages. *Uacapa kirkiana* fruit is acidic and often used to make non-alcoholic beverages in Angola (Silva *et al.*, 2018). Monkey orange is high in vitamin C and carotenoids and is traditionally used in jams, non-alcoholic beverages and wines in West Africa (Glew *et al.*, 2006). *Annona senegalensis* contains citric acid and sugar and is used in non-alcoholic beverages, jams, and alcoholic drinks in West Africa (Adepoju & Adeniji, 2012). Baobab fruit pulp has a citrusy flavour, high antioxidant capacity and vitamin C; it is used for non-alcoholic beverages, mixers in cocktails and carbonated drinks in Africa (Chadare *et al.*, 2009).

Silva *et al.* (2018) reported making *U. kirkiana* non-alcoholic beverage by following the below steps. The fruit was washed peeled, and seeds were removed manually. The pulp was then blended until smooth. The blended pulp was mixed with sugar and citric acid to taste. The mixture was heated at a boiling point for 5 minutes to reduce the microbial count. The hot juice was then filtered and bottled. The juice was pasteurised by heating it to 85°C for 20 seconds and then rapidly cooled. The pasteurised juice was stored at room temperature for three weeks.

Turk *et al.* (2003) described the preparation of a non-alcoholic beverage from *Strychnos spinosa* Lam. as outlined hereunder. The fruit was washed and peeled, and the seeds were removed manually. The pulp was then blended until smooth. The blended pulp was mixed with sugar and citric acid to taste. The mixture was heated at the boiling point for 5 minutes to reduce the microbial count. The hot juice was then filtered and bottled. The juice was hot filled at 85°C, and the bottles were sealed. The pasteurised juice was stored at room temperature for six weeks.

Chadare *et al.* (2010) described the production of *A. digitata* non-alcoholic beverage as outlined below. The fruit was washed and peeled, and the seeds were removed manually. The pulp was then blended until smooth. To taste, the blended pulp was mixed with sugar, pineapple, and mango. The mixture was heated at the boiling point for 5 minutes to reduce the microbial count. The hot juice was then filtered and bottled. The juice was pasteurised by

heating it to a temperature of 90°C for 15 minutes and then rapidly cooled. The pasteurised juice was stored at room temperature.

Uacapa kirkiana is native to West and Central Africa. The fruit is commonly used to make non-alcoholic beverages, which are rich in vitamin C and have a tart taste. For *U. kirkiana*, a study in Angola produced a non-alcoholic beverage containing 73% fruit pulp, 24% sugar, and 0.3% citric acid that was pasteurised and had a shelf life of 3 weeks (Silva *et al.*, 2018). For monkey orange, a study in Ghana developed a juice with 60% monkey orange pulp, 1% citric acid, and 39% sugar that was hot-filled at 85°C and had a shelf life of 6 weeks (Turk *et al.*, 2003). For baobab, a study in Benin produced a non-alcoholic beverage with 10% baobab pulp, 7% pineapple, 7% mango and sugar to taste that was pasteurised at 90°C for 15 minutes (Chadare *et al.*, 2010).

Uacapa kirkiana and monkey orange non-alcoholic beverage were reported to be high in vitamin C (38 and 59 mg/100g, respectively) and the baobab non-alcoholic beverage high in vitamin C (338 to 692 mg/100g) and polyphenols (831 mg GAE/L) indicating potential health benefits (Chadare *et al.*, 2010; Silva *et al.*, 2018; Turk *et al.*, 2003). Further refinements to flavours, sweetness, acidity, and pasteurisation parameters may improve product quality and shelf life to reach commercial potential.

2. 2 Sensory Evaluation of Non-Alcoholic Beverages

Prototype evaluation showed that *Uacapa* spp and *S. spinosa* non-alcoholic beverages had high acceptability, and baobab non-alcoholic beverages had moderately high acceptability according to colour, aroma, taste and overall acceptability (Chadare *et al.*, 2010; Silva *et al.*, 2018; Turk *et al.*, 2003).

A study conducted in Nigeria found that *U. kirkiana* beverage was highly acceptable among consumers, with 80% of the participants indicating that they would repurchase the non-alcoholic beverage (Owoyale *et al.*, 2016).

Baobab is a fruit widely distributed in Africa and commonly used to make non-alcoholic beverages. The fruit contains vitamin C, calcium (Ca), and antioxidants. A study conducted in Senegal found that baobab non-alcoholic beverages were highly acceptable among consumers, with 80% of the participants indicating that they liked the taste of the juice (Lebbie *et al.*, 1994).

Monkey oranges are native to Southern Africa. The fruit is commonly used to make juice, which is rich in vitamin C and has a sweet taste. A study conducted in South Africa found that monkey orange juice was highly acceptable among consumers, with 70% of the participants indicating that they would buy the juice again (Mabhaudhi *et al.*, 2014).

Annona senegalensis is a fruit that is native to West Africa and is commonly used to make juice. The fruit is rich in vitamin C and has a sweet taste. A study conducted in Burkina Faso found that *A. senegalensis* juice was highly acceptable among consumers, with 83% of the participants indicating that they liked the taste of the juice (Kaboré *et al.*, 2015).

In conclusion non-alcoholic beverages made from indigenous are highly acceptable among consumers and have the potential to contribute to the improvement of nutrition and income in many communities in Africa.

CHAPTER 3: MATERIALS AND METHODS

3.1 Study Area

The masawu non-alcoholic beverages were produced at the Bindura University of Science Education (BUSE) Environmental Science Laboratory Food Section at Astra Campus between January and March 2023. Participants in the sensory evaluation exercise were drawn from students and staff at Astra Campus.

3.2 Production of Non-alcoholic Beverages

3.2.1 Collection of raw materials

Mature, dry, sour, and sweet masawu were purchased from communities in Muzarabani District in the Zambezi Valley (16°20'S, 31°21'E, <400 m above sea level). The fruits were carried to the laboratory in sack bags. The fruits were stored in a room that fluctuated between 20 and 22 °C depending on the weather outside between January and March 2023.

3.2.2 Preparation of Non-Alcoholic Beverages

Mature and undamaged fruits were selected and used to make non-alcoholic beverages. Before beginning any treatment, the fruits were rinsed with distilled water. After cleaning, the fruits were oven-dried for 72 hours at a temperature of 72 degrees Celsius to remove any moisture in the fruits and kept in a dry container to minimise moisture absorption. A July motion dehuller was used to separate the seed from the pulp and the pulp was used for making the non-alcoholic beverage. After dehulling the pulp was sieved through ISI Mesh No. 1 (1 mm). One litre of water with different ingredients was boiled for 15 to 20 minutes. Sugar is then added as a sweetener. After the mixture had settled, it was strained and served Chilled. Different formulations of non-alcoholic beverages were produced through an iterative trial and error process until they were trimmed to four prototypes (mixtures) Table 1. The four prototypes were created by combining varying ratios of masawu and tamarind. To enhance the sensory quality of the blends, white sugar was added to the other two blends as a sweetener. White sugar was used because it does not change the colour of the beverages.

Table 1. Composition of masawu non-alcoholic beverage blends

Identity	Main Ingredients	Proportions (grams) per 1000 ml water
A	Masawu powder, water, sugar	130g masawu powder, 60g sugar
B	Masawu powder, water, tamarind fruit, sugar	130g masawu powder, 60g sugar, 80g tamarind
C	Masawu powder, water	130g masawu
D	Masawu powder, tamarind fruit	130g masawu, 80g tamarind

The summarised stages in the production of masawu non-alcoholic beverages are indicated in Figure 1.

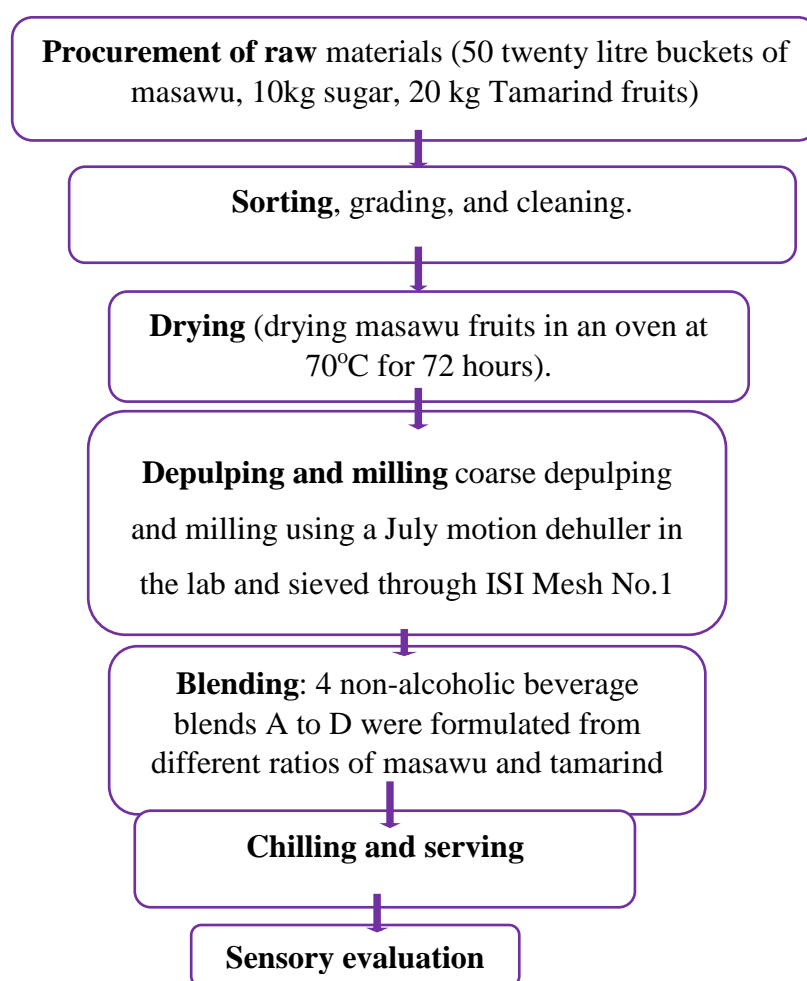


Figure 3.1. Masawu non-alcoholic beverage development chart

3.3 Sensory Evaluation of Non-Alcoholic Beverages

The research design used in this research was a repeated measured experiment. Several trials were done during the development of the prototypes. Initially, eight prototypes were made, and a few people volunteered to taste them and recommended the four prototypes, which were then used for sensory evaluation on fifty-one participants who volunteered to test and tested four prototypes of non-alcoholic beverages. The beverage formulations were tested for sensory acceptability, and the two best performed. The beverages A, B, and C The participants were given questionnaires to complete, and they tried the non-alcoholic beverages randomly. Participants rated the beverages using the Hedonic scale according to (Stone *et al.*, 2012), which has ratings from 1 extremely dislike to 9 extremely like. Participants evaluated four characteristics, namely flavour, which is a sensory impression that the beverage produces in the mouth and nose; taste, which is a sensation produced when taste buds on our tongue come into contact with specific molecules, such as those that are sweet, sour, salty, bitter and savoury; appearance, which refers to visual characteristics of a beverage such as colour and transparency; texture, which refers to the feel of the beverages that can be felt by the mouth and tongue such as its hardness, softness, smoothness and creaminess. Finally, participants rated the beverages in terms of overall acceptability.

3.4 Data Analysis Methods

All analyses were conducted using the Statistical Package for Social Sciences (SPSS) Version 20. Freidman's ANOVA was used for sensory evaluation and quality parameters to determine whether differences between mean ranks were significant, and means were separated using post hoc tests for Friedman's ANOVA. Descriptive statistics was also used to describe the data used and determine the number of experiment participants' ratings and the number of females and males who participated. Also, determine the number of people in each age category. Binary Logistic Regression was used to determine whether the rating of the non-alcoholic beverage characteristics (appearance, texture, taste, flavour) and overall acceptability of the beverages was significantly affected by gender and age.

3.5 Ethical Considerations

Food production and consumption ethics were observed according to (Korthals, 2007). Food is an intrinsic good for consumers. Some food has not only monetary value but cultural, social, and ethical value as well because it has an inherent role to play in individuals experiencing life according to their ideas of what constitutes a good life. Clear guidelines regarding product ingredients and relevant product information were followed to avoid

conflicting and potentially untrustworthy information being presented to consumers. Consent was sought from individuals who participated in sensory taste and evaluation.

CHAPTER 4: RESULTS

4.1 Demographic Data of Participants

Most of the participants in the sensory evaluation (45.1%) were between 18 and 25 years of age (Table 2). The majority (62.7%) of the participants were male. Gender and age did not affect ($P>0.05$) the rating of the characteristics and overall acceptability of non-alcoholic beverages.

Table 4.1. Demographic data of participants

Demographic characteristic		Frequency (%)
Age	18-25	23 (45.1)
	26-35	10 (19.6)
	36-45	7 (13.7)
	46-55	10 (19.6)
	>55	1 (2.0)
Gender	Male	32 (62.7)
	Female	19 (37.3)



Figure 4.1 Masawu non-alcoholic beverage development chart

4.2 Sensory evaluation of non-alcoholic beverages

Participants' ranking of the masawu non-alcoholic beverages based on individual attributes (taste, appearance, flavour, and texture) followed the same order: Masawu+Tamarind+Sugar > Masawu+Sugar > Masawu Only \approx Masawu+Tamarind Only (Table 3).

Concerning overall acceptability, Masawu+Tamarind+Sugar had the highest rank, and Masawu+Tamarind only had the lowest ($P<0.05$).

Table 4.2. Friedman Test ranks for attributes of masawu non-alcoholic beverages

Beverage	¹ Mean Ranks				
	Taste	Appearance	Flavour	Texture	Overall acceptability
Masawu+Sugar	2.99 ^a	2.72 ^a	3.03 ^a	2.83 ^a	2.98 ^a
Masawu+Tamarind+ Sugar	3.65 ^b	2.99 ^b	3.54 ^b	3.20 ^b	3.46 ^b
Masawu Only	1.73 ^c	2.16 ^c	1.74 ^c	2.01 ^c	1.94 ^c
Masawu+Tamarind Only	1.63 ^c	2.13 ^c	1.70 ^c	1.96 ^c	1.62 ^d

¹Key: Mean ranks in the same column with different superscripts are significantly different (p<0.05).

4.3 Participants' Scores for Attributes (Taste, Flavour, Appearance and Texture) of Masawu Non-Alcoholic Beverages

All (100%) and 86.3% of the participants indicated that they at least "liked slightly" Masawu+Tamarind+Sugar and Masawu+Sugar non-alcoholic beverages respectively (Table 4.3.). Only about a quarter of the participants at least "liked slightly" the other two non-alcoholic beverages (Masawu Only and Masawu+Tamarind Only). Most participants (54.9%) indicated they at least "Like very much" Masawu+Tamarind+Sugar.

Table 2.3. Sensory evaluation taste of non-alcoholic beverages made from different formulations as tested by participants.

Masawu Non-Alcoholic Beverage Composition	Taste Rating Score (%)								
	Extremely dislike	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely
Masawu+Sugar	2.0	0.0	0.0	3.9	7.8	23.5	29.4	27.5	5.9
Masawu+Tamarind+Sugar	0.0	0.0	0.0	0.0	0.0	13.7	31.4	33.3	21.6
Masawu Only	5.9	13.7	11.8	27.5	15.7	11.8	7.8	5.9	0.0
Masawu+Tamarind Only	9.4	15.7	11.8	21.6	15.7	15.7	7.8	2.0	0.0

The majority of the participants rated the appearance of all beverages positively, with ratings at "Like slightly" and above as follows: Masawu+Sugar (93.6%), Masawu+Tamarind+Sugar (92.1%), Masawu Only (72.5%), and Masawu+Tamarind Only (62.7%) (Table 5).

Table 4.3. Sensory evaluation of the appearance of juices made from different formulations as tested by participants

Masawu Non-Alcoholic Beverage Composition	Appearance Rating Score (%)								
	Extremely dislike	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely
Masawu+Sugar	0.0	0.0	0.0	2.0	3.9	5.4	49.0	23.5	15.7
Masawu+Tamarind+Sugar	0.0	0.0	0.0	3.9	3.9	9.8	15.7	43.1	23.5
Masawu Only	3.9	5.9	0.0	5.9	11.8	13.7	29.4	13.7	15.7
Masawu+Tamarind	5.9	7.8	3.9	9.8	9.8	7.8	15.7	25.5	13.7

Similar to appearance, the majority of the participants rated the texture of all beverages positively with ratings at "Like slightly" and above as follows: Masawu+Sugar (88.2%), Masawu+Tamarind+Sugar (90.2%), Masawu Only (64.7%), and Masawu+Tamarind Only (60.8%) (Table 6).

Table 4.4. Sensory evaluation texture of juices made from different formulations as tested by participants.

Masawu Non-Alcoholic Beverage Composition	Texture Rating Score ([Frequency (%)])								
	Extremely dislike	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely
Masawu+Sugar	2.0	0.0	3.9	0.0	5.9	17.6	35.3	25.5	9.8
Masawu+Tamarind+Sugar	0.0	0.0	3.9	3.9	2.0	3.9	9.8	54.9	21.6
Masawu Only	3.9	7.8	3.9	9.8	9.8	19.6	31.4	7.8	5.9
Masawu+Tamarind	3.9	5.9	5.9	13.7	9.5	15.7	25.5	9.8	9.8

Ninety six percent and 76.5% of the participants indicated that they at least "liked slightly" Masawu+Tamarind+Sugar and Masawu+Sugar non-alcoholic beverages respectively (Table 7). Less than half of the participants at least "liked slightly" the other two beverages (Masawu Only and Masawu+Tamarind Only). About half of the participants (50.3%) indicated they at least "Like very much" Masawu+Tamarind+Sugar.

Table 4.5. Sensory evaluation of flavour of juices made from different formulations as tested by participants

Beverage	Flavour Rating Score ([Frequency (%)]								
	Extremely dislike	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely
Masawu+Sugar	0.0	0.0	0.0	7.8	15.7	11.8	21.6	29.4	13.7
Masawu+Tamarind+Sugar	0.0	0.0	0.0	2.0	2.0	11.8	23.5	37.3	23.5
Masawu Only	9.8	3.8	9.8	23.5	15.7	21.6	9.8	5.9	0
Masawu+Tamarind	7.8	9.8	11.8	11.8	13.7	27.5	11.8	3.9	2.0

Participants indicated that only two beverages, Masawu+Sugar (86.3%) and Masawu+Tamarind+Sugar (96.1%) were well accepted (Table 8).

Table 4.6. Overall acceptability of non-alcoholic beverages

Description	Acceptability (%)	
	Yes	No
Masawu+Sugar	86.3	13.7
Masawu+Tamarind+Sugar	96.1	3.9
Masawu Only	41.2	58.8
Masawu+Tamarind	29.4	70.6

CHAPTER 5: DISCUSSION

5.1 Demographic Data of Participants

The study shows that most of the participants in the sensory evaluation were young adults between the ages of 18 to 25 year old, accounting for 45.1% of the total participants. This is because they were more willing to participate in the study. According to this study, age and gender did not affect the ranking. However, in similar studies conducted by (Chadare *et al.*, 2009), they found that gender significantly affected the sensory acceptance of the beverages, but age did not. The study also conducted by (Turk *et al.*, 2003) found that gender also significantly affected the preference for beverages, but age did not.

5.2 Sensory Evaluation Non-Alcoholic Beverages

The sensory evaluation results for the taste, flavour, appearance, and texture of non-alcoholic beverages made from different formulations showed that Masawu+Tamarind+Sugar and Masawu+Sugar were the most liked beverages among the participants. The findings of this study are consistent with previous studies that evaluated the sensory properties and consumer acceptability of indigenous fruit-based beverages. (Chadare *et al.* 2009) found that the addition of sugar and citric acid improved the sensory attributes of baobab fruit pulp, including taste, aroma, colour, and overall acceptability. Addition of sugar, citric acid and natural fruit flavourings significantly enhanced the sensory quality, aroma and sweetness of beverages made from *U. kirkiana* fruit (Silva *et al.*, 2018; Owoyale *et al.*, 2016). Turk *et al.* (2003) showed that adding lemon and sugar to *Hibiscus sabdariffa* beverage increased overall liking and acceptability compared to *Hibiscus sabdariffa* alone. This study demonstrated that supplementing masawu beverages with tamarind and sugar improved its taste, flavour, texture, and acceptance. These additives likely enhanced the sweetness, tartness and mouth feel of the masawu beverage, leading to greater liking by participants.

Regarding appearance, most participants rated all beverages positively, with Masawu+Sugar and Masawu+Tamarind+Sugar receiving the highest ratings. Similarly, most participants ordered the texture of all beverages positively, with Masawu+Sugar and Masawu+Tamarind+Sugar receiving the highest ratings. These results suggest that the addition of tamarind and sugar did not negatively affect the appearance and texture of the beverages and may have even improved them.

Regarding flavour, Masawu+Tamarind+Sugar received the highest rating, with the majority of participants (50.3%) indicating that they at least "Like very much" the flavour.

Masawu+Sugar was also well-liked in terms of flavour, with 76.5% of participants indicating that they at least "liked slightly" its flavour.

Similar studies by Chadare *et al.* (2009) and Turk *et al.* (2003) evaluated the sensory properties of *A. digitata* and *S. spinosa* beverages, respectively. Chadare *et al.* (2009) found that the majority of the participants (63%) rated the beverage as either "like moderately" or "like very much". And flavour about 59% of the participants rated that they either "like moderately" or "like very much". appearance about 77% of participants rated either "like moderately" or "like very much". They did not evaluate texture.

Turk *et al.* (2003) also found out that the majority of the participants rated taste 93% as either "like moderately" or "like very much". About 92% of the participants rated the appearance of the beverages as either "like moderately" or "like very much". Also, 95% of the participants rated the flavour as "like slightly" or "like very moderately". They also did not evaluate texture.

The results highlight that natural sweeteners and flavourings can increase the palatability and consumer appeal of indigenous vegetables and fruits. (Kaboré *et al.*, 2015) demonstrated that adding sugar, honey and natural fruit juices resulted in baobab and tamarind beverages with superior sensory properties, including taste, aroma, visual aspect, and overall appreciation. As in this study, sugar and fruit beverages were found to complement the tartness of tamarind and improve its acceptability. Previous research strongly supports the findings of this study that supplementing masawu fruit beverage with tamarind and sugar enhanced its sensory attributes and overall acceptability. Addition of sugar is good as it improves the taste of the beverages however sugar is not good for people with diabetes and also sweetened beverages if consumed in excess, they cause dental decay and other diseases that why the researcher developed both sweetened and zero sugar beverages

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

Four masawu non-alcoholic beverage blends were produced namely Masawu+Sugar, Masawu+Tamarind+Sugar, Masawu Only and Masawu+Tamarind Only. Sensory evaluation revealed that masawu juice is acceptable to consumers. The most preferred blend in terms of taste, flavour, texture and appearance was Masawu+Tamarind+Sugar with an overall acceptance of 96.1% followed by Masawu+Sugar with overall acceptance of 86.3%. These two have potential for commercial production.

The tart taste of tamarind greatly contributed to the flavour and taste of the Masawu+Tamarind+Sugar and Masawu+Sugar formulations, which were the most accepted. In summary, the masawu juice formulations were developed using locally available, low-cost fruits commonly eaten in Zimbabwe's Dande, Muzarabani and Mbire districts. The non-alcoholic blends could potentially be used as affordable complementary non-alcoholic beverages to address health issues from excess soda consumption and in place of expensive commercial beverages.

6.2 Recommendations

Based on the findings, masawu can be recommended as a key ingredient for making non-alcoholic beverages. Masawu+Sugar and Masawu+Tamarind+Sugar blends are recommended for further development into commercial products. While this study evaluated the sensory qualities of juice blends made with masawu, the shelf-life and proximate analysis are recommended for acceptable non-alcoholic beverage blends. This guide on the shelf life of beverages and reveals the nutritional profile to determine future applications. Further, shelf-life studies can provide packaging guidelines to enable the marketing the product. In summary, the key findings are that locally available masawu fruit can be used to formulate palatable 100% juices and beverages blends.

REFERENCES

- Adepoju, O. T., & Adeniji, T. A. (2012). Nutrient composition and micronutrient potential of three commonly consumed indigenous spices in Nigeria. *Agricultural Engineering International: CIGR Journal*, 14(1), 99-103.
- Blocher, J. M., Robinson, T. N., & Sallis, J. F. (2021). Changes in the food environment over the past 20 years: implications for the obesity epidemic. *Physiology & behaviour*, 240, 146531.
- Bongo, P. P., Dodo, E., & Muzenda-Mudavanhu, C. (2017). Exploring the Role of Indigenous Knowledge in Flood Disaster Risk Reduction in Zimbabwe. *International Journal of Humanities Social Sciences and Education (IJHSSE)*, 4, 1-20.
- Chadare, F. J., Linnemann, A. R., Hounhouigan, J. D., Nout, M. J., & van Boekel, M. A. (2009). Baobab food products: a review on their composition and nutritional value. *Critical Reviews in Food Science and Nutrition*, 49(3), 254-274. <https://doi.org/10.1080/10408390701856330>
- Chadare F. J., D. P. Gayet, P. Azokpota, M. J. R. Nout, A. R. Linnemann, J. D. Hounhouigan & M. A. J. S. van Boekel (2010) Three Traditional Fermented Baobab Foods from Benin, Mutchayan, Dikouanyouri, and Tayohounta: Preparation, Properties, and Consumption, *Ecology of Food and Nutrition*, 49:4, 279-297. <https://doi.org/10.1080/03670244.2010.491051>
- Hamad, M. N. M. (2019). Harmful Effects of Soft Drinks. *Faculty of health sciences, Elsheikh Abdallah Elbadri University, Sudan*.
- Kaboré, D., Sawadogo-Lingani, H., Diawara, B., & Compaoré, C. S. (2015). Acceptability and nutritional value of baobab, tamarind and senegal date palm fruits. *African Journal of Food, Agriculture, Nutrition and Development*, 15(3), 10015-10029.
- Katanha, G. (2018). Ziziphus mauritiana (masau) fruits fermentation in Zimbabwe: from black-box to starter culture development. *Journal of Ethnic Foods*, 5(2), 79-83.
- Kar, S., & Peru, K. C. (2020). Global fruit juice market: trends and opportunities (2015-2020). *Research and markets, 2020*. Retrieved from <https://www.researchandmarkets.com/reports/5013412/global-fruit-juice-market-trends>

- Korthals, M. (2007). Ethics of food production and consumption. *In Handbook of food products manufacturing (pp. 1149-1177)*. John Wiley & Sons.
- Lebbie, A. R., Guries, R.P., & N' Diaye, M. (1994). Acceptability of baobab non-alcoholic beverages among consumers in Senegal. *Food science and nutrition*, 34(2), 80-85. <https://doi.org/10.1080/233371994350016>
- Mabhaudhi, T., Chibarabada, T. P., & Modi, A. T. (2014). Traditional vegetables in South Africa: A resource for food security. *South African Journal of Botany*, 93, 71-84.
- Musemwa, L., Muzhingi, T., & Gadaga, T. H. (2017). Ethnobotanical survey of indigenous fruit tree species in the Zambezi Valley of Zimbabwe for food, nutrition and income security. *Journal of Horticulture and Forestry*, 9(1), 1-10.
- Nyanga, L. K. (2012). Nutritional and sensory evaluation of products made from masawu (*Ziziphus mauritiana*) fruit. *African Journal of Food Science*, 6(8), 206-212 .
- Owoyale, M. O., Adeleke, O. E., & Ogunlakin, G. O. (2016). Chemical and sensory evaluation of *Uapaca kirkiana* fruit juice. *Journal of Food Science and Technology*, 53(1), 400-406.
- Silva, S., Trindade, M., Costa Sousa, M., Figueirinha, A., & Vicente, A. (2018). The fruits of *Uapaca kirkiana*, an underutilised shrub of socio-economic importance in Angola. In Workshop proceedings' Beyond subsistence: Making a living from underutilised plant resources- Joining forces to promote profitable and sustainable use of underutilised fruits through value chain development".
- Stone, H., J.L. Sidel, and D.A. Oliver. " " Sensory evaluation practices"". Academic Press, 2012.
- Technavio. (2022). *Global fruit juice market 2022-2027*. Retrieved from <https://www.technavio.com/report/fruit-juice-market-industry-analysis>
- Turk, K.W., Boatemaa, S., & Amekuse, L. (2003). Consumer acceptability of baobab juice in Ghana. *International Journal of Food Science and Nutrition*, 54(4) 319-326. <https://doi.org/10.1080/0963748031000067528>
- United States Department of Agriculture. (2019). *FoodData Central*. Retrieved from <https://fdc.nal.usda.gov>

APPENDICES

APPENDIX 1: Questionnaire for sensory evaluation of masawu non-alcoholic beverages

My name is Auxilia Chabata, a student from Bindura University of Science Education (BUSE). I am an undergraduate pursuing a Bachelor of Science (Honours) degree in Natural Resources Management (N.R.M). As part of the study program, students are expected to engage in a field research and produce a dissertation covering their areas of interests.

Therefore; I am conducting a study on the production of *masawu* non-alcoholic beverages. I guarantee that the information gathered in this exercise will be strictly for academic use only and the confidentiality of respondents will be respected. I would like to request for your participation in this exercise. You are free to decide not to answer any questions that seem uncomfortable or to pull out of the interview if you wish to. Thank you in advance.

Use 9 point hedonic scale shown below, please fill in the table below by writing the number that you feel the beverages rates for each category.

Hedonic scale

- Dislike extremely -1
- Dislike very much -2
- Dislike moderately -3
- Dislike slightly -4
- Neither like nor dislike- 5
- Like slightly -6
- Like very much -8
- Like moderately -7
- Like extremely -9

Name of the person..... Gender:

F M

Age

Sample A

Directions: Tick one rating box for each attribute

Attribute	Like extremely	Like very much	Like moderately	Like slightly	Neither like nor dislike	Dislike slightly	Dislike moderately	Dislike Very much	Dislike Extreme
Appearance									
Taste									
Texture									
Flavour									
Overall acceptability									

Sample B

Attribute	Like extremely	Like very much	Like moderately	Like slightly	Neither like nor dislike	Dislike slightly	Dislike moderately	Dislike Very much	Dislike Extreme
Appearance									
Taste									
Texture									
Flavour									
Overall acceptability									

Sample C

Attribute	Like extremely	Like very much	Like moderately	Like slightly	Neither like nor dislike	Dislike slightly	Dislike moderately	Dislike Very much	Dislike Extreme
Appearance									
Taste									
Texture									
Flavour									
Overall acceptability									

Sample D

Attribute	Like extremely	Like very much	Like moderately	Like slightly	Neither like nor dislike	Dislike slightly	Dislike moderately	Dislike Very much	Dislike Extreme
Appearance									
taste									
Texture									

Flavour									
Overall acceptability									