EFFECTS OF BLENDING RATIO, COOKING METHOD AND COOKING TIME ON PHYSICOCHEMICAL, NUTRTIONAL CONTENT AND SENSORY ACCEPTABILITY OF TAMARIND *(TAMARINDUS INDICA)* AND ORANGE- FLESHED SWEET POTATO *(IPOMOEA BATATAS L.)* JAM

M.Sc. THESIS

EDEN ENDALE TILAHUN

NOVEMEBER 2025

HARAMAYA UNIVERSITY, ETHIOPIA

Effect of Blending Ratio, Cooking method and Cooking Time on Physicochemical, Nutritional Content and Sensory Acceptability of Tamarind *(Tamarindus Indica)* and Orange- Fleshed Sweet Potato *(Ipomoea Batatas L.)* Jam

A thesis submitted to the Postgraduate Programs Directorate, through the
Department of Food Science and Postharvest Technology,
Haramaya Institute of Technology
HARAMAYA UNIVERSITY

In Partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE IN FOOD SCIENCE AND TECHNOLOGY

EDEN ENDALE TILAHUN

NOVEMBER 2025
Haramaya University, Ethiopia

HARAMAYA UNIVERSITY

POSTGRADUATE PROGRAMS DIRECTORATE

I hereby certify that I have read and evaluated this Thesis entitled **'Effect of Blending Ratio, cooking method and Cooking Time on Physicochemical, Nutritional Content and Sensory acceptability of Tamarind *(Tamarindus Indica)* and Orange- Fleshed Sweet Potato *(Ipomoea Batatas L.)* Jam'** prepared under my guidance by Eden Endale Tilahun. I recommend that it be submitted as fulfilling the thesis requirement.

Getachew Neme (PhD)	_____	_____
Major Advisor	Signature	Date
Solomon Abera (DEng.)	_____	_____
Co-Advisor	Signature	Date
_____	_____	_____
Internal Examiner	Signature	Date
_____	_____	_____
External Examiner	Signature	Date

Final approval and acceptance of the Thesis is contingent upon the submission of its final copy to the Council of Graduate Studies (CGS) through the Department of Food Science and Postharvest Technology.

STATEMENT OF THE AUTHOR

I declare and affirm that this thesis is my own work. I collected, prepared, analyzed, and put this thesis together while following all scholarly ethical and technical guidelines. Any academic source that is mentioned in the thesis has been acknowledged through citation. This thesis is submitted to Haramaya University as a partial fulfillment of the MSc in Food Science and Technology degree requirements. The thesis is deposited at the library of Haramaya University and is made available for borrowing in accordance with the library's policies. I hereby sincerely affirm that this thesis has not been submitted to any other institution, anywhere, for the purpose of receiving a diploma, certificate, or academic degree. A brief quotation from this thesis may be made without special permission provided that accurate and complete acknowledgement of the source is made; a request for permission to extend a quotation from or reproduction of this thesis in whole or in part may be guaranteed by the head of school or the department when in his judgment the proposed use material in the interest of scholarship. In all other instances, however, permission must be obtained from the author of the thesis.

Name: Eden Endale Tilahun
Signature: _____
Date: _____
Institute: Haramaya Institute of Technology
Department: Food Science and Postharvest Technology
Place: Haramaya University

BIOGRAPHY

Eden Endale Tilahun was born in Harar, Harari Regional State, Ethiopia. She completed her primary education at Primary Second Model School and Yeshimebet School, and her secondary and preparatory education at Harar Senior Secondary School and Aboker Preparatory School. She joined Haramaya University in 2018 and graduated with a B.Sc. degree in Food Science and Post-Harvest Technology in June 2022. She received a scholarship to continue her graduate studies and began her M.Sc. in Food science and technology at Haramaya University postgraduate program in September 2022.

ACKNOWLEDGEMENT

I want to start by expressing my sincere gratitude to the Almighty God for providing me with this chance and for supporting and protecting me during the study period.
I would like to thank my advisors, Dr. Getachew Neme, Dr. Solomon Abera, and Mr. Anbesse Girma, for their invaluable support and guidance during my studies. They have been excellent mentors, sacrificing their valuable time with outstanding commitments, and providing insightful comments and feedback without tiring.

The technical staff of the laboratory, particularly Mr. Shewangizaw Teketel and Ms. Elene Samuel, who collaborated with me at Haramaya University's Department of Food Science and Technology, are also greatly appreciated for their assistance.

Sincere gratitude is extended to the Ministry of Education for providing all of the funding for my thesis work and to Haramaya University for granting me scholarship to pursue an M.Sc.
I also want to express my gratitude to my friends who supported me during my lab work, helped me exchange ideas, and helped me to finish my paper.
Lastly, I would want to sincerely thank my family for always supporting me during my study sessions.

ACRONYMS AND ABBREVIATIONS

AACC	American Association of Cereal Chemistry
ANOVA	Analysis of Variance
AOAC	Analysis of Official Analytical Chemists
CSPI	Centre for Science In The Public Interest
EDTA	Ethylamine Ditetra Acetic Acid
FAOSTAT	Food and Agriculture Organization Statistics
GE	Gross Energy
HCL	Hydrochloric Acid
HIV/AIDS Syndrome	Human Immune Deficiency Virus/ Acquire Immune Deficiency
LSD	Least Significant Difference
NPVAC	Non Pro Vitamin A Carotenoids
OFSP	Orange Fleshed Sweet Potato
SAS	Statistical Analysis Software
SNNPR	Southern Nation and Nationalities People Regions
SP	Sweet Potato
TSS	Total Soluble Solids
UK	United Kingdom
USA	United State of America
USDA	United State Department of Agriculture
UV	Ultra Violate Ray
US$	United State Dollar
VAC	Vitamin A Carotenoids
VAD	Vitamin A Deficiency
WHO	World Health Organization

Table of Content

LIST OF TABLES

LIST OF FIGURES

LIST OF TABLES IN THE APPENDIX

LIST OF FIGURES IN THE APPENDIX

EFFECTS OF BLENDING RATIO, COOKING METHOD AND COOKING TIME ON PHYSICOCHEMICAL, MICROBIAL AND SENSORIAL QUALITY OF TAMARIND *(TAMARINDUS INDICA)* AND ORANGE- FLASHED SWEET POTATO *(IPOMOEA BATATAS L.)* JAM

ABSTRACT

Underutilized crops like tamarind (Tamarindus indica) and orange-fleshed sweet potatoes (OFSP, Ipomoea batatas L.) have the potential to diversify Ethiopian diets, enhance nutrition, and lower postharvest losses. Despite their nutritional advantages, vitamin A and C deficits are still common, which emphasizes the demand for goods made from these crops that have added value. The objective of this study was to create and assess the physicochemical, nutritional, and sensory characteristics of jam made from blends of tamarind and OFSP. Three cooking methods (microwave, dry heat, and pressure cooking), three cooking times (20, 30, and 40 minutes), and three blending ratios (90:10, 80:20, and 70:30 OFSP:tamarind) were used in the study's fully randomized factorial experiment. Proximate composition, vitamin and mineral levels, and sensory appeal were among the parameters examined. The findings showed that the blending ratios had a substantial ($p < 0.05$) impact on the composition of nutrients. Blends rich in tamarinds had higher levels of protein (3.42%), ash (2.81%), iron (3.1 mg/100 g), zinc (1.42 mg/100 g), and vitamin C (19.36 mg/100 g), whereas blends rich in OFSP had higher levels of utilizable carbohydrates (75.6%), crude fiber (2.15%), calcium (54.8 mg/100 g), magnesium (23.6 mg/100 g), and β-carotene (5.21 mg/100 g). Cooking times affected vitamin stability; longer cooking times decreased the preservation of β-carotene while decreasing vitamin C. The combination of 70% OFSP and 30% tamarind cooked for 20 minutes was found to be the most acceptable by sensory evaluation; on a 7-point hedonic scale, it scored highest for taste (6.1), color (5.9), texture (5.8), scent (5.6), and overall acceptability (6.2). Overall, the OFSP–tamarind blended jam is a nutritionally improved, and technically viable product. Its production has the potential to improve food diversity, lessen postharvest losses, and address vitamin A and C shortages.

Keywords: Orange flashed sweet potato, Tamarind, underutilized, β-carotene, Jam

1. INTRODUCTION

1.1. Background

Research and development on sweet potatoes began earlier than five decades ago, along with other root crops. The research has produced amazing results regarding variety development, agronomic advice, crop protection, postharvest management, and nutrition (Gurmu, 2019). Sweet potato ranks seventh place globally among all food crops based on production volume. The "Center for Science in the Public Interest" (CSPI), in the United States, regards sweet potatoes as "Superfoods" (Behera *et al*., 2022).

Orange-fleshed sweet potatoes (OFSPs) are a great source of carbohydrates and are rich in minerals, vitamins, and amino acids, particularly in carotenoids. It has been found that approximately 85% of the carotenoids in OFSP are absorbed by humans and transformed into vitamin A, which is advantageous for pregnant women and children who are deficient in vitamin A (Yao *et al.*, 2023). With the ability to produce more edible energy per unit area than wheat, rice, or cassava, orange-fleshed sweet potatoes are also very productive. Strong antioxidants, fiber, vitamin C, minerals (Zn, K, Na, Mn, Ca, Mg, and Fe), and green leaves can be found in both the root meat and leaves (Mahmud *et al.*, 2021).

Sweet potato is high in starch and also high in dietary fiber, vitamins, minerals, and antioxidants like tocopherol, carotenoids, and phenolic acids. β-carotene is the primary pigment and a significant precursor of vitamin A in orange-fleshed sweet potatoes (Rios-Romero *et al*., 2021). It is necessary to find alternative applications for this OFSP products in order to maximize its nutritional worth.

On the other hand, Africa is the home of the tamarind fruit (*Tamarindus indica L*.).(Kiranmai *et al*., 2020) *Tamarindus indica L*. is its botanical name, and member of the Leguminosae family. It is a significant tropical fruit tree that is often grown in India. Each season, the tree produces 150–500 kg of fruits, with each fruit weighing between 15 and 30 grams (Kiranmai *et al*., 2017). Currently, this fruit is among the underutilize tropical crop that can be attributed to its importance in meeting consumer demand for nutrient-dense, naturally flavored, aesthetically pleasing meals with significant medicinal value(Groote *et al.*, 2007). They are widely

acknowledged an important component of a healthy diet since they are high in dietary fiber, vitamins, and minerals (Groote *et al*., 2007).

Tamarind is a great source of important nutrients, including antioxidants, dietary fiber, potassium, iron, and calcium, as well as vitamins A, C, E, and K (Vikram *et al*., 2023). For the maintenance of general health and wellbeing, these minerals are essential (Vikram *et al*., 2023). Due to their high nutritional and medicinal value, this underutilized fruit crop is valuable for their therapeutic qualities. It could be future horticultural assets that help countries ensure food security, nutrition and their recreational, social, and environmental significance (Meena *et al*., 2022).

Fruit and vegetables continue to go through active biological processes like respiration, fruit ripening, and senescence after harvest, hence huge postharvest loss (PHL) (30-50%) of total production).As a result it contributes to a major quality changes in some fruits and vegetables, hence postharvest storage conditions and processing procedures must be carefully managed to avoid these changes and PHLs (Sumonsiri and Barringer, 2014). Processing of fruits and vegetables in to products, *i.e.*, value-addition is one way of preventing losses. Jam is one of the most widely used shelf-stable fruit products. Jelly, preserves, and jams are commodities that are frequently processed and consumed, and their markets are growing more quickly globally. France is the leading jam-consuming and producing nation on globally (Afoakwah *et al*., 2023a). In 2016 there were about 4000 tons produced and about 3.36 billion tons consumed of jam (Afoakwah *et al*., 2023a).

1.2. Statement of the Problem

Globally, one in three persons suffer from one or more types of malnutrition: Two billion people globally suffer from micronutrient deficiencies, 1.9 billion adults are overweight or obese, and 800 million people are undernourished (Gebru *et al*., 2019).

Pregnant women and impoverished children between the ages of six months and six years are the main populations affected (Hagenimana *et al.*, 1999). Children with this deficiency are more susceptible to common infections, stunted growth and development, compromised immune systems, decreased eyesight, and in severe cases, blindness. Lack of vitamin A in women

increases their chance of dying while pregnant, having underweight children, and also spreading of HIV/AIDS virus is consequence of vitamin A deficiency (Rahman *et al.*, 2013).

The least expensive and most efficient way to fight vitamin A deficiency (VAD) is to encourage people to eat more locally grown, vitamin A-rich foods that can be cultivated in home gardens. A good food-based strategy crop is orange-fleshed sweet potatoes (OFSP) (Bao and Fweja, 2020). There is a huge potential for OFSP to improve food security, incomes, and reduce nutritional deficiencies (Babatunde *et al*., 2019). The inability to absorb vitamin A during digestion as a result of poor health brought on by intestinal parasites, malaria, measles, and other illnesses, as well as inadequate consumption of food rich in vitamin A (or its precursors), are the two main causes of vitamin A deficiency in humans (Hagenimana *et al*., 1999).

Hence, it was reported that a major public health concern in underdeveloped nations such as Ethiopia is vitamin A deficiency (VAD). In addition to supplementing with capsules and fortifying food, food-based intervention is a suitable and sustainable strategy to address this issue in Ethiopia. Because OFSP is high in β-carotene, it may be able to lessen the effects of vitamin A insufficiency. Orange-fleshed sweet potatoes have the potential to significantly and sustainably meet the vitamin A dietary needs of resource-poor Ethiopians due to their high provitamin A content, low input requirements, and adoption of African farming practices (Kurabachew, 2015). Children have been given vitamin capsules containing mega-doses of Vitamin A by public health organizations to combat VAD for the past 25 years. Hundreds of thousands of children have been put at risk by the policy, even while it has benefited millions. It has also proven to be costly (Anderson *et al*., 2007).

The main pre and post-harvest obstacles for sweet potatoes are low yield (14.2%), low dry matter content of existing varieties' roots (13.6%), poor market prices (19.1%), poor access to markets (22.6%), lack of knowledge about sweet potato processing and preservation (11.7%), lack of access to processing equipment (11.1%), and the logistics of transporting a heavy, bulky crop (7.7%) to market (Gurmu *et al*., 2015). At least one micronutrient deficit affects two- thirds of the world's population, primarily women and children from households with limited resources (Stathers *et al.*, 2018).

Tamarind (*Tamarindus indica L: Leguminosae)*, is native fruit tree of the tropics reported to be underutilized worldwide (Ebifa-Othieno *et al.*, 2017). The pulp is rich in nutrients like, phosphorous (110 mg/100 g), calcium (17 mg/100 g), and iron (17 mg/100 g). There is little use of tamarind fruits in the production of other processed foods (Kiranmai *et al.*, 2017). The fruit's flavor is best described as sweet and sour, and it contains significant amounts of sugar, tartaric acid, B vitamins, and calcium unusual for a fruit. (Toungos, 2019).

Producing jam from tamarind is one method to minimize postharvest losses while at the same time reduce malnutrition. The same argument can apply to orange flashed sweet potato. Jam processed from blends of orange fleshed sweet potato and tamarind might be complement each other and very helpful to prevent vitamin A deficiency that is a bottle neck problem in Ethiopia.

1.3. Significant of the study

The significance of this study is combat malnutrition especially vitamin A, decrease post-harvest loss, producing processed food from low price ingredients and underutilized crops.

1.4. Objectives

1.4.1. General objective

The general objective of this study was to study effect of blending ratio, cooking method and cooking time on physicochemical, nutritional content and sensorial acceptability of tamarind and orange- fleshed sweet potato jam.

1.4.2. Specific objectives

The specific objectives of this study were to:

a) Determine how blending ratios, cooking methods, and cooking durations influence the proximate composition, micronutrient profile of orange-fleshed sweet potato–tamarind jam,
b) Evaluate the effects of blending ratios, cooking methods, and cooking time on physico-chemical characteristics of orange-fleshed sweet potato–tamarind jam,
c) Examine the sensory acceptability of the formulated jam products.

2. LITERATURE REVIEW

2.1. Global Production of Sweet Potato

Sweet potatoes (*Ipomoea batatas L.)*, with an annual yield of 90 million tons, rank sixth among all food crops in the world and are critical for global food security (Yao *et al*., 2023). A significant food crop worldwide is the sweet potato. Larger regions in the Far East and USA subtropical to temperate zones, as well as little home gardens and farms in the tropics, are farmed for the crop. About 80–85% of the sweet potatoes produced worldwide come from China (Degras, 2003). Out of the approximately 1000 species in this family, only *Ipomea batatas* are important economically as a food source (Senanayake *e t al.*, 2013). Table 1 indicates taxonomic classification of sweet potato.

Table 1.Taxonomic classification of sweet potato

kingdom	Plantae
Subkingdom	Tracheobionta
Super division	Spermatophyte
Division	Sagnoliophyta
Class	magnoliopsida
Subclass	Asteridae
Order	Solanales
Family	Convolvulaceae
Genus	Ipomaea l.morning glory family
Species	I.batatas

Source: (Rehab, 2018)

Table 2 describes production of orange fleshed sweet potato among countries in 2021. And Table 3 indicates world harvested areas, productions, and productivity of sweet potatoes from 2000 to 2021.

Table 2.Production of sweet potato in 2021

Rank	Countries	Production of sweet potatoes in 2021 (Tons)
1	China, mainland	47,621,147
2	Malawi	7,449,972
3	United Republic of Tanzania	4,991,861
4	Nigeria	3,943,046
5	Angola	1,788,342
6	Ethiopia	1,697,583
7	Indonesia	1,649,000
8	Rwanda	1,328,750
9	United states of America	1,308,728
10	Uganda	1,267,697

Source: FAOSTAT, 2023

Table 3.World harvested areas, productions, and productivity of sweet potatoes from 2000 to 2021

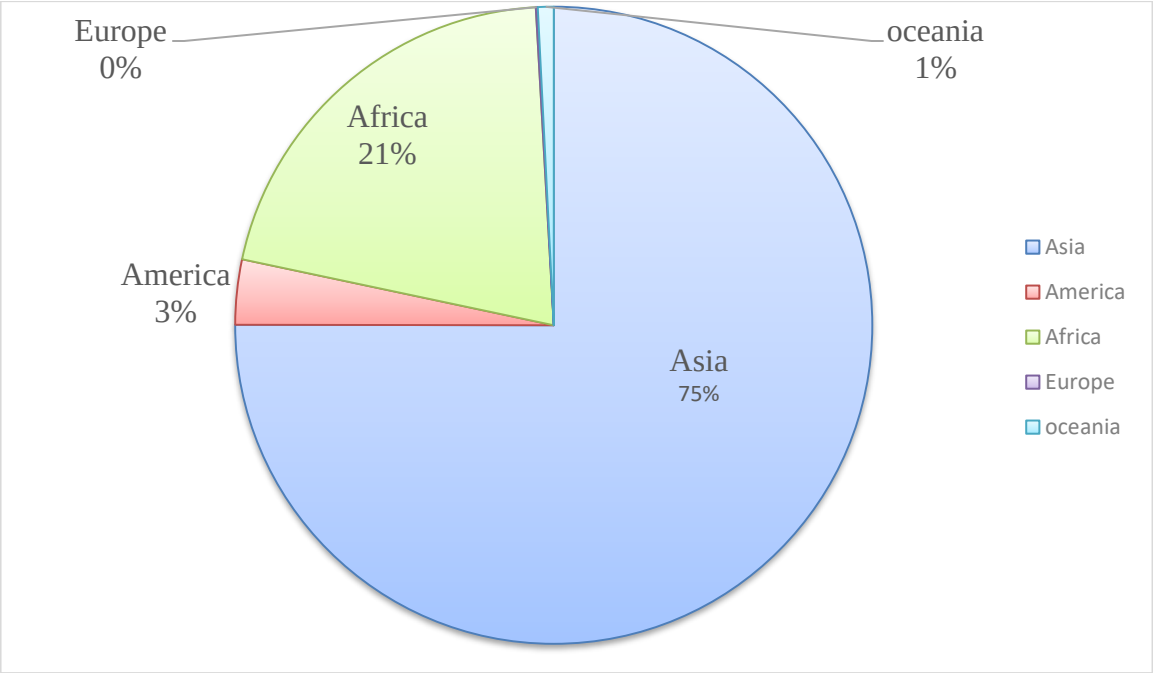
Years	Worlds Harvested Areas of Sweet Potatoes (Hectares)	World Production of Sweet Potatoes (Tons)	Yield /Productivity of Sweet Potatoes (Tons/ Hectare)
2000	9,798,396	139,706,811	14.26
2001	9,674,985	136,129,726	14.07
2002	9,416,972	136,732,461	14.52
2003	9,266,440	130,925,757	14.13
2004	9,321,600	130,713,125	14.02
2005	9,004,544	127,734,095	14.19
2006	8,104,610	106,631,204	13.16
2007	8,144,291	101,183,389	12.42
2008	7,794,746	103,174,997	13.24
2009	7,841,840	96,315,642	12.28
2010	7,923,113	93,771,217	11.84

2011	7,853,702	94,303,981	12.01
2012	7,593,347	90,709,322	11.95
2013	7,729,322	90,170,614	11.67
2014	7,858,257	93,476,327	11.90
2015	7,750,764	91,308,417	11.78
2016	7,606,849	90,249,407	11.86
2017	7,660,263	92,306,702	12.05
2018	7,450,234	91,299,491	12.25
2019	7,315,770	90,747,131	12.40
2020	7,373,035	88,739,744	12.04
2021	7,410,026	88,867,913	11.99

Source: FAOSTAT, 2023

Sweet potatoes, an inexpensive crop that requires little agricultural inputs, can grow and yield tuberous roots even under unfavorable soil conditions. Plant efficiency in converting energy per unit area per unit time contributes to the high productive yield. Due to this trait, its cultivation is practiced in over 100 countries, primarily in developing nations where agriculture lacks technological support (Cartabiano-Leite *et al*., 2020). The food crop known as sweet potatoes (*Ipomoea batatas*) has been identified as having a significant impact on the health, livelihoods, and food security of impoverished households in sub-Saharan Africa (Babatunde *et al*., 2019).

While the leaves are utilized as vegetables heavy in vital minerals, vitamins, and other compounds, the roots are heavily carbohydrate-rich and one of the world's principal food crops that yields the most edible energy per hectare per day (Neela and Fanta, 2019). Sweet potatoes were first farmed for food subsistence, but they are now recognized as valuable commercial crops with enormous potential for industrial processing. Although sweet potatoes have great potential, there aren't many published sources of information about the crop because agricultural scientists and extensionists haven't given them much attention (Degras, 2003). Due to its great yield potential and versatility in a variety of environmental settings, it is the second most significant tuberous root crop in Africa, behind cassava, which is mostly grown in Nigeria, Uganda, Tanzania, and Ethiopia (Wang *et al*., 2011). Figure 1 shows production of sweet potatoes on the globe.



Source; FAOSTAT, 2019

Figure 1.Production share of sweet potatoes by region from 2007 to 2017

2.2. Production of Sweet Potato in Ethiopia

It is one of the main traditional food crops grown in Ethiopia. Crop cultivation is common in the country's densely populated South, South-West, and Eastern regions, with the Southern Nation and Nationalities People Regions (SNNPR) producing the most crops. In areas like Wolaita, Sidama, Kanbata, Tanbaro, Gamo Gofa, and Hadiya zones in SNNPR, it is an essential food crop during times of hunger from February to May (Dako *et al*., 2016). The South Nations, Nationalities, and People's Region (SNNPR) and Oromia Regional State are the two main producing regions in the nation. Benishangul Gumuz, Harari, Gambella, Amhara, and Tigray regions also grow it, albeit in lesser amounts. Small-scale farmers with limited resources land, labor, and capital invariably cultivate sweet potatoes for household food security in the nation's South, Southwestern, and Eastern regions (Gurmu, 2019).

In southern Ethiopia, sweet potatoes are grown year-round, with patches of different ages on every farm. Sweet potato weevil infestation is possible when sweet potato plots held by the same farmers or their neighbors are located near older plots or a short distance apart. Thus, remaining

infected sweet potato tubers and nearby contaminated sweet potato fields are the main source of infestation for recently planted sweet potato plots in the vicinity (Shonga *et al.*, 2013).

2.3. Orange Fleshed Sweet Potato

Orange fleshed sweet potato is the most nutritious vegetable from a dietary standpoint. OFSP tubers are considered an important nutrition source for Non Pro Vitamin A Carotenoids (NPVAC) and Vitamin A Carotenoids (VAC) (Neela and Fanta, 2019). One of the crops being developed as a bio-fortified measure to combat vitamin A deficiency worldwide is the OFSP. It is one of the starchy staple crops that offer significant levels of β-carotene and the amino acid lysine, which is lacking in diets based on cereals like rice, and ascorbic acid. Additionally, it has antioxidant elements that can prevent the development of coronary heart disease and soluble fiber that lowers cholesterol levels (Babatunde *et al.*, 2019). Research on OFSP has increased in the last 10 years to increase its production and consumption in many countries because of the many benefits of agriculture, including food security, nutritional security, and both (Hagenimana *et al.*, 1999).

Sweet potatoes with orange flesh are a good source of several vitamins, minerals, antioxidants, and indigestible dietary fiber (Dako *et al*., 2016). Along with their antioxidant qualities, phenolic chemicals and carotenoids are what give SP its distinct flesh and skin hues (deep yellow, red to orange, purple, and light) (Steed and Truong, 2008). It has been found that approximately 85% of the carotenoids in OFSP are absorbed by humans and transformed into vitamin A, which is advantageous for pregnant women and children who are deficient in vitamin A (Yao *et al*., 2023).

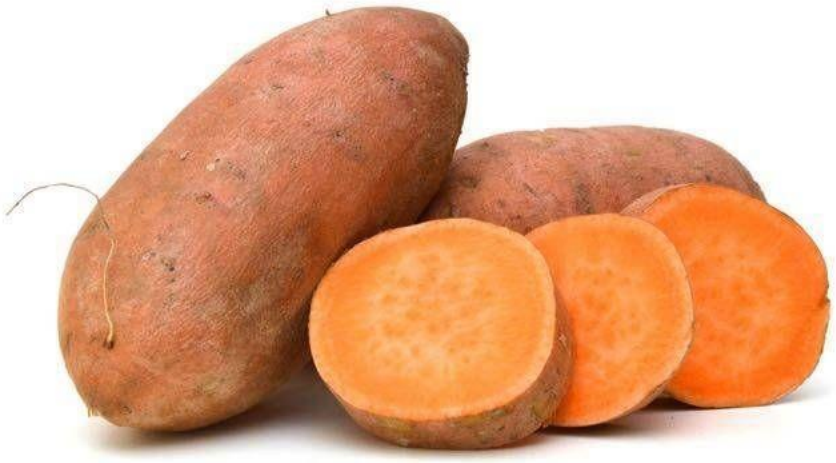


Figure 2. Orange fleshed sweet potato (Oloniyo *et al*., 2021)

2.3.1. Nutritional composition of orange fleshed sweet potato

OFSP is an excellent source of many vitamins, minerals, polyphenols, antioxidants, and fundamental nutrients (Neela and Fanta, 2019). The cultivar, growth environment, maturity, and storage all affect how nutrients are distributed throughout sweet potato roots (Truong *et al.*, 2018).

2.3.1.1 Proximate composition of orange fleshed sweet potato

The proximate composition is very important to know the nutritional benefit of orange fleshed sweet potato.

Table 4. Proximate composition of OFSP

Nutrients	**Value per 100g**
Dry matter (g)	25.09-38.56
Protein (g)	2.03-4.19
Fat (g)	1.74-2.22
Carbohydrates (g)	14.46-22.86
Ash (g)	3.03-4.70
Fiber (g)	2.19-3.00
Energy value (k Cal)	90.24-153.63
Starch (g)	7.840-16.934
Reducing sugars (mg)	335-1086
Total sugars (mg)	610-24268

Source : Owade *et al*, (2018)

Moisture content

Of the components in OFSP, moisture makes up >62% and <75% of the total (Dako *et al*., 2016). Several studies have revealed variations in the moisture content of OFSP; these could be attributed to agro-climatic conditions, agricultural techniques, variety diversity, etc (Neela and Fanta, 2019).

Carbohydrate

Sweet potatoes are mostly composed of carbohydrates, mostly sugars and starches, with smaller amounts of pectin, cellulose, and hemicellulose (Truong *et al*., 2018). According to fresh weight basis, OFSP has a high starch percentage of 65.41% (Rodrigues *et al*., 2016). One of the most favored root crops is the sweet potato, which has the largest dry matter content for human consumption (starch makes up 70% of its composition) (Mahmud *et al*., 2021). One type of non-digestible carbohydrate is crude fiber, which also helps to lower cholesterol, reduce intestinal transit, give feces their bulk, trap harmful substances including agents that cause cancer, and promote the development of the gut's natural microbial flora (Dhingra *et al*., 2012). While smaller quantities, such as 0.35%, were observed in various OFSP types, the largest reported level of total dietary fiber in OFSP is 3.6% (Dako *et al*., 2016).

Ash content

Any food substance's ash is an inorganic residue that explicitly indicates the mineral composition. The range of ash values indicated was from 1.17% to 4.33% (Muhammad *et al*., 2012).

Protein

The essential amino acids needed for metabolism are found in proteins, which are vital nutrients for the structural and functional performance of various biomolecules in the human body (Neela and Fanta, 2019). The protein is estimated in OFSP to be 1.91%–5.83% (Muhammad *et al*., 2012).

Fat

Very low- fat concentrations (<1%) have been found in OFSP; typically, roots and tubers exhibit this tendency (Rodrigues *et al*., 2016).

2.3.1.2. Mineral composition of orange fleshed sweet potato

The inorganic components known as minerals play a crucial and specialized role in metabolism. It is advised to consume the ideal concentration of minerals (Soetan *et al*., 2010).

Table 5. Mineral composition of OFSP

Minerals	**Per 100g**
Calcium, Ca	30 mg
Iron, Fe	0.61 mg
Magnesium, Mg	25 mg
Phosphorus, P	47 mg
Potassium, K	337 mg
Sodium, Na	55 mg
Zinc, Zn	0.3 mg
Copper, Cu	0.151 mg
Manganese, Mn	0.258 mg
Selenium, Se	0.6 µg

Source: Cartabiano-Leite *et al*., (2020)

2.3.1.3. Vitamin composition

Ascorbic acid, thiamin (B1), riboflavin (B2), niacin (B6), pantothenic acid (B5), folic acid, and vitamin E are among the vitamins found in sweet potato roots (Truong *et al*., 2018).

Table 6. Vitamin composition of OFSP

Vitamins	**Raw root**	**Cooked**
Vitamin A	300-1300 ug	788 ug
Thiamin (B1)	0.08 mg	0.06 mg
Riboflavin (B2)	0.06 mg	0.05 mg
Niacin (B3)	0.56 mg	0.5 mg
Vitamin B6	0.21 mg	0.17 mg
Vitamin E	0.26 mg	0.24 mg
Vitamin C	22.7 mg	12.8 mg
Folate	14 ug	6 ug
Vitamin k	1.8 mg	2.1 ug

Source: Stathers *et al*., (2013) and Low *et al*., (2009)

2.3.2. Health Benefits of Orange -Fleshed Sweet Potato

The oxidation response causes numerous issues in humans, and these issues are linked to the pathophysiology of numerous diseases, such as atherosclerosis, cancer, inflammation, and ageing (Blokhina *et al*., 2003). Vitamin C may improve skin health and reduce the length of a common cold. Potassium, a mineral that may reduce the risk of heart disease, is necessary for blood pressure control. Vitamin E, a potent fat-soluble antioxidant, may help protect the body from oxidative damage. Vitamin B6 is essential for the conversion of food into energy. Vitamin B5, also known as pantothenic acid, is a substance that is present in food to varied degrees practically everywhere. Manganese is an essential trace mineral for growth, development, and metabolism (Bhuyan *et al*., 2022).

Prevention of Vitamin A deficiency

An increased risk of infectious morbidity, dry eyes, and higher death rates for expectant and nursing mothers as well as their offspring have been linked to vitamin A deficiency. Sweet potatoes' high beta carotene content makes them a vital source of vitamin A. Every molecule of beta-carotene yields two molecules of vitamin A as it is converted into the vitamin in the liver (David *et al*., 2021). Sweet potatoes provide a lot of beta -carotene, which is vital for eye health. This condition may be avoided by consuming foods high in beta-carotene, such as sweet potatoes with orange flesh. Purple sweet potatoes are also recognized to provide benefits for vision (Bhuyan *et al*., 2022).

Managing Diabetics

Due to their relatively modest sugar content, sweet potatoes release sugar into the bloodstream more slowly than other starchy foods. This continuous release of sugar regulates people's blood sugar levels so they don't go too high or too low. Therefore, sweet potatoes can help regulate blood sugar levels, especially in diabetics. It has been shown that both type I and type II diabetes exhibit similar control (McClelland *et al*., 2007). It is also well known that sweet potato fiber helps with diabetic management. Soluble fibers like pectin, which are useful in lowering food intake and blood sugar rises, make up about 10–15% of the fiber in sweet potatoes (Adam *et al*., 2015).

Guarding against ulcers

Studies on the crop's extracts have shown that sweet potatoes have substances that can heal wounds and stomach ulcers. Therefore, consuming sweet potatoes can help prevent and treat certain types of ulcers, including those caused by alcohol and aspirin (Hermes *et al*., 2013). Sweet potatoes can be utilized to cure and manage peptic ulcers, according to the findings of the investigations (David *et al*., 2021).

Improving digestion and regularity

Sweet potatoes include a lot of fiber, which helps keep the digestive system regular and prevent constipation (Bhuyan *et al*., 2022).

Minimizing the risk of cardiovascular diseases

Humans are afraid of cardiovascular disorders due to their high rate of morbidity and mortality. When sweet potato leaf extracts were studied, however, researchers discovered that the high polyphenol content of the leaf extracts might inhibit oxidation in people, lowering their risk of cardiovascular illnesses (Ogasawara *et al*., 2011). It was discovered that a significant quantity of polyphenol and high levels of radical scavenging activity (David *et al*., 2021). Sweet potatoes' anthocyanins have been linked to anti-inflammatory properties that lower the risk of heart disease. Furthermore, any vegetable's fiber lowers cholesterol, and sweet potatoes' high potassium content lowers blood pressure (Bhuyan *et al*., 2022).

Good for our bodies/Healthy bodies

More women's groups stated that OFSP is good for the body than men's groups. Women often remarked that after they started eating OFSP, their bodies had improved and appeared healthier, especially the skin and bodies of their children. This could be related to the fact that women were better educated about nutrition than men, or it could simply be that women ended up consuming the majority of what they raised due to limited access to expensive marketplaces. Women were more likely to indicate better birth outcomes for pregnant women or improved weight for HIV-positive individuals, whereas men were more likely to note improvements in vitamin intake (Mudege *et al*., 2017).

Antioxidative and Antimutagenicity

Some malignancies, including lung and prostate cancer, may be prevented by antioxidants. Unstable molecules known as free radicals have the potential to damage cells. Beta-carotene is one antioxidant that can help prevent this harm. If the body's free radical levels rise too high, it

may cause cellular damage that increases the risk of certain disorders. Foods high in antioxidants may help ward against illnesses like cancer (Tabassum *et al*., 2022). Breast, renal, and stomach cancer risk is lowered with diets high in antioxidants such carotenoids. Sweet potatoes have strong antioxidants that may lower your cancer risk. The most active antioxidant in potatoes is found in purple ones (Bhuyan *et al*., 2022).

Boosting immunity

A 12.8 mg of vitamin C can be found in a 124g serving of sweet potatoes from an a credible source. According to current recommendations, adult men and women should consume 90 mg and 75 mg of vitamin C daily, respectively. Scurvy can occur in someone who takes little or no vitamin C Trusted Source. Tissue issues bring on numerous scurvy symptom due to decreased collagen synthesis. Moreover, iron absorption is improved and the immune system is supported by vitamin C. Iron deficiency anemia may become more likely in a person with a poor vitamin C intake (Tabassum *et al.*, 2022).

Reducing inflammation

Because they reduce inflammation, the color-related pigments found in sweet potatoes, such as carotenoids and anthocyanins, are also beneficial to health. Fibrinogen is similarly affected by the color-related sweet potato phytonutrients (Ludvik *et al*., 2008). Sufficient levels of fibrinogen, thrombin, and fibrin are essential for the body's capacity to heal wounds and halt blood loss (Lakhawat, 2018). Choline, a vitamin that aids in memory, learning, and muscle activity, is found in sweet potatoes Trusted Source. It also supports the nervous system. According to a 2010 study, giving high-dose choline supplements to asthmatic patients helped them control their inflammation. However, this does not guarantee that the choline found in sweet potatoes would function similarly (Tabassum *et al*., 2022).

2.3.3. Postharvest loss of orange fleshed sweet potato

Like many perishable goods, the roots of the sweet potato (*Ipomoea batatas (L.) Lam*) continue to function metabolically after harvest. The roots are prone to mechanical damage during handling because to their sensitive epidermis and high moisture content (between 50 and 80 %). Generally speaking, difficulties during postharvest handling and storage include weight loss, microbiological attack, weevil infestation, and sprouting (Sugri *et al*., 2019). Sweet potatoes, a perishable crop, are not kept in storage for extended periods after harvest, particularly in

underdeveloped nations without adequate storage infrastructure. Due to inadequate management, there are considerable postharvest losses for the roots along the value chain in these nations (Gurmu, 2019). It is easy for pathogenic fungi to infiltrate bruised roots. Lead degradation is caused by pathogenic contamination through natural holes and injuries. The local environmental conditions and the storage procedure significantly impact the degree of pathogenicity. In tropical agro-ecologies, when rainfall, relative humidity, and temperature (19–35 °C) seem favorable for such pathogenic fungi, there may be a larger risk of decay losses (Sugri *et al*., 2019).

2.3.4. Products of Orange Fleshed Sweet Potato

In the food industry, sweet potato roots are often processed into purées, which can be frozen, canned, or packaged under aseptic conditions to provide year-round, shelf-stable products. The entire collected crop, including the 30–40% off-grade from the fresh root markets, is used in purée processing since roots of all sizes and shapes may be utilized (Truong *et al*., 2018).

Baked goods include cakes, bread, composite bread, cookies, and Swahili buns (Mandazi). Panettones made with sourdough, Extruded goods: Extruded and non-extruded flours, pasta, noodles, instant noodles, The rice and OFSP flour-extruded product, Dried goods and flours: Spray-dried powder, sun-dried flour, low-temperature dried chips, dried and stored OFSP, Other and complementary foods: Complementary foods, weaning foods, blended foods, OFSP and haricot bean food, porridge (OFSP-mangoes), OFSP snacks, Bambara groundnut Drinks: OFSP-based juice drink, radish and OFSP juice, and Additional goods: Orange-fleshed sweet potatoes are used to make natural colorants, starch, and bioethanol (raw materials) (Neela and Fanta, 2019).

2.4. Tamarind (*Tamarindus indicia L.*)

2.4.1. Production of tamarind

Tamarindus indicia L. is a member of the Caesalpiniaceae family, a Dicotyledonous family that comprises 19 327 species and 727 genera, making it the third biggest family of flowering plants(Meher *et al.*, 2014). The plant known as tamarind (*Tamarindus indica L*.) resembles a tree. It is native to Africa's tropical regions (Meher *et al.*, 2014).

Figure 3. Tamarind tree branches and fruit (Kidaha, 2022)

Table 7. Taxonomical classification of tamarind

Kingdom	**Plantae**
Phylum	Spermatophyte
Class	Angiosperm
Sub class	Dicotyledone
Family	Leguminosae
Subfamily	Caesalpiniaceae
Genus	Tamarindus
Species	Indica

Source: Bhadoriya *et al*, (2011)

Central African Republic, Cameroon, Ethiopia, Guinea, Kenya, Nigeria, Senegal, Sudan, Tanzania, Uganda, Afghanistan, Australia, Bangladesh, Brazil, Cambodia, China, Colombia, Cuba, Egypt, Malaysia, Mexico, Myanmar, Nicaragua, Pakistan, Philippines, Sri Lanka, India, and Thailand are the main production locations(Singh *et al*., 2007). Products made from tamarind are mostly produced in India (Singh *et al*., 2007). The semi-arid regions of East Africa are home to tamarind trees, whose fruits are harvested when they reach maturity and used in homes or sold through unofficial routes (Kidaha, 2022). The main reason tamarind is grown is for its fruits, which can be eaten raw or cooked and added to various dishes as a spice or flavoring. It is well recognized for its 40% pulp, which has a sweet-sour flavor and is an excellent source of vitamin C and acids like citric, malic, and tartaric. Tartaric acid (8–18%)

makes up the majority of the content in pulp, which is often utilized in tamarind-based beverages, curries, sweet meats, and chutneys (Nagar *et al*., 2022).

Additionally, it is a fantastic source of potassium, which the body needs to regulate the effects of sodium, which in turn regulates heart rate and blood pressure. The use of pulp has been connected to a number of ailments, such as relief from sunstroke and a decrease in alcohol and cannabis intoxication. It can be applied to wounds, gargled for sore throats, and is thought to help paralyzed people regain feeling. Furthermore, tamarind pulp has been reported to be able to treat malaria (Rana *et al*., 2018).

2.4.2. Production in Ethiopia

It is widely distributed in Ethiopia's grassland, forest, and Combretum bushland, frequently in riparian habitats in the regions between 0 and 1,500 meters above sea level in Tigray, Gonder, Welo, Gojam, Shewa, Harerge, Ilubabor, Kefa, Gamo Gofa, and Sidamo (Mergence, 2013).

2.4.3. Harvesting

Tamarind should be harvested when the pod's outer shell begins to dry and the pulp's fibers start to solidify. This is also when the pulp starts to turn a brownish-red hue. It is not advisable to harvest tamarind pods until the outer shell is sufficiently dry and can be readily detached from the pulp (Vikram *et al*., 2023).

2.4.4. Importance

A natural souring ingredient, tamarind is used in cooking to give tangy flavor to a range of meals. Because of its inherent acidity,tamarind pulp or paste is utilized in food fermentation and preservation. It enhances the flavor of some goods and helps them last longer on the shelf (Vikram *et al.*, 2023). Flavonoids, carotenoids, anthocyanins, vitamin C, and phenolic components are among the many physiologically active phytochemicals found in tamarind pulp and seeds. These phytochemicals have positive effects on human health due to their potent antioxidant activity. Therefore, it is believed that increasing the quantity of antioxidants that humans ingest is crucial, and one way to do this is by including large quantities of phytochemical-rich seeds into food products. Many ailments can be alleviated by the benefits of tamarind indica. It may also be preferred as a nourishing aid for patients who are undernourished (Rana *et al*., 2018).

2.4.5. Nutrtional value of tamarind

Tamarind is rich in nutrients like carbohydrates, fiber, thiamin, niacin, iron, magnesium, phosphorus, potassium nutrients that are found in tamarind large amounts. Table 8 shows detailed information about tamarind nutritional composition.

2.4.5.1. Proximate composition of tamarind

Tamarind does not have cholesterol and provide energy in great amounts. Table 8 provides each proximate composition amount in tamarind.

2.4.5.2. Vitamins and minerals in tamarind

Vitamin A and K, iron, sodium, zinc, niacin, riboflavin, thiamin, and folate. It also contains a variety of chemical compounds that give it potent anti-inflammatory and antioxidant properties.

Table 8 . Proximate, Vitamins and Minerals composition ot tamarind

Composition	**Nutrient value**	**Percentage of RDA**
Energy	239.00 kcal	12%
Carbohydrate	62.50 g	40%
Protein	2.80 g	5%
Total fat	0.60 g	3%
Cholesterol	0 mg	0%
Dietary fiber	5.10 g	13%
Vitamins		
Folates	14.000 µg	3.5%
Niacin	1.938 mg	12.0%
Pantothenic acid	0.143 mg	3.0%
Pyridoxine	0.066 mg	5.0%
Thiamin	0.428 mg	36.0%
Vitamin A	30.000 IU	1.0%
Vitamin C	3.500 mg	6.0%
Vitamin E	0.100 mg	<1.0%
Vitamin D	2.800 µg	2.0%
Minerals		

Potassium	628 mg	13%
Sodium	28 mg	2%
Iron	2.80 mg	35.0%
Copper	0.86 mg	9.5%
Calcium	74.00 mg	7.0%
Magnesium	92.00 mg	23.0%
Phosphorus	113.00 mg	16.0%
Selenium	1.30 μg	2.0%
Zinc	0.10 mg	1.0%

Source: USDA National Nutrient data base 2017

2.4.6. Health benefits of tamarind

Because of its potential health benefits, tamarind is employed in medicine. It is said to improve digestion, reduce constipation, boost heart health, and bolster the immune system. Additionally, a number of ailments are treated with the fruit in conventional medicine (Vikram *et al.*, 2023).

Anti-inflammatory activity

The tamarind fruit pulp is known to possess anti-inflammatory qualities. This means it may be able to treat the aberrant build-up of elastase, a human neutrophil serine proteinase that causes acute and chronic inflammatory illnesses (Wanjala, 2019).

Nerve repair

It has been demonstrated that xyloglucan, which is derived from Tamarind. indica seeds, helps regenerate nerves and provides appropriate medium for deteriorated nerves (Kuru, 2014).

Diarrhea and dysentery

Tamarind can also be used to treat diarrhea and dysentery. Dysentery is a type of diarrhea that contains blood or mucus and is typically caused by an intestinal infection. Inadequate treatment of diarrhea may result in patient death and dehydration. Lemon juice and tamarind pulp are used as remedies for diarrhea and dysentery (Bhadoriya *et al*., 2011).

Helminthes infections (parasitic worms)

Tamarind leaves are utilized to extract Guinea worms and then to heal the lesions the parasite left behind. Fruits and seed macerate are both utilized as vermifuges. In some regions of

Tanzania, an extract from the leaves and root is used to cure ankylostomiasis, or hookworm (Bhadoriya *et al.*, 2011).

Anti-microbial

By measuring the diameter of the zone of inhibition against gram-positive and gram-negative bacteria and fungi using the paper disk diffusion method, the anti-microbial activity of concentrated extracts (ethanolic, acetone, and aqueous extract) was examined. Tamarind is highly effective against Staphylococcus aureus, Bacillus subtilis, Salmonella typhi, and Salmonella paratyphi (Naeem *et al*., 2017).

Anti-Oxidant Activities

Tamarind is rich in antioxidants, including polyphenols, which assist the body in scavenging damaging free radicals and may lower the risk of chronic illnesses (Vikram *et al*., 2023). The phenolic content of Tamarindus indica seeds and pericarp has been determined to have strong antioxidant potential. Methanolic extract from the plant was investigated and found to have anti-cancer and chemoprotective qualities. It was discovered that a variety of plant extracts, including linoleic acid, were active in an emulsion system. Additionally, they showed good antioxidant strength, up to 64.5–71.7%, which was even higher than synthetic antioxidants like butylated hydroxyl anisole and ascorbic acid (Ramos *et al*., 2003). Because the body's metabolic processes generate a lot of free radicals, which may increase the risk of inflammatory illnesses, antioxidants play a crucial role in purifying the body of these radicals. It has been demonstrated that Tamarind's seeds, leaves, and flowers are highly concentrated in phenolic chemicals, which have a wide range of possible biological applications. The capacity of tamarind extracts to reduce the risk of atherosclerosis formation in people, which is the primary cause of the pathophysiology of cerebral and myocardial infarction (Wanjala, 2019).

Laxative properties

Because Tamarindus indica fruit possesses a notable quantity of potassium acid, malic acid, and tartaric acid, it has been used widely in traditional medicine as a possible laxative. Young children are typically fed fruit for breakfast to manage chronic stomach issues and severe constipation (Naeem *et al*., 2017).

Blood Sugar Regulation

Tamarind's low glycemic index and capacity to block enzymes involved in the breakdown of carbohydrates make it a potential blood sugar regulator (Vikram *et al.*, 2023).

Anti-asthmatic and Hepato-Protective Activity

Some creative investigation suggests that Tamarindus indica has hepatoprotective and anti-asthmatic qualities. The methanolic extract of Tamarindus indica leaves demonstrated remarkable adaptogenic, anti-histaminic, and mast cell stabilizing properties in experimental mice. Rats were given paracetamol to test the protective effect of Tamarindus indica (Caesalpiniaceae). Aqueous extracts of certain Tamarindus indica components, such as 350 mg/kg of leaves and fruits and 700 mg/kg of unroasted seeds, showed notable hepato-regenerative effects at specific parameters (Swamy *et al.,* 2007).

Heart Health

Tamarind's potassium helps to maintain heart health by controlling blood pressure and lowering the risk of cardiovascular illnesses (Vikram *et al*., 2023).

Effect on Blood and Cardiovascular System

The effects of Tamarindus indica fruits on human body weight, lipid profile, and diastolic and systolic blood pressure were examined in Bangladesh. In hypercholestrolemic hamsters, the effects of pulp crude extract on lipid serum and atherosclerotic lesion levels were examined. Tamarind extracts have a lot of potential for reducing the risk of atherosclerosis in human medicine. Another study on hamsters found that a hydroalcoholic extract of tamarind pulp affects the inflammatory mediator system (Landi *et al*., 2007).

Wound Healing

Tamarindus indica is often used to treat cuts, wounds, and abscesses. Tamarindus indica leaves and bark are mostly applied to wounds as a powder, decoction, or poultice, either by themselves or in conjunction with other plants. Wound healing is the main goal of tamarind bark sales at Dakar's medicinal plant market. But other elements of the tamarind plant, like fruit, gum, and pod husks, are used in medicine. Another helpful remedy for wounds brought on by Guinea worm infections is a decoction made from Tamarindus indica leaves (Naeem *et al*., 2017).

Anti-Diabetic Activity

The incidence of diabetes in male rats induced with streptozotocin was considerably decreased by an aqueous extract from Tamarindus indica seeds. Measurements of the blood glucose levels of rats with severe and mild diabetes after a fast showed that the administration of an aqueous extract from Tamarindus indica seeds considerably reduced their hyperglycemia. A significant reduction in the degree of hyperlipidemia was also found in assessments of the different cholesterol amounts. This rat model also explains the foundations of ancient Indian herbal medicine (Maiti *et al*., 2005).

Fever and Malaria

Tamarind fruits are used as a febrifuge in Madagascar. Tamarind leaves are used in Ghana to treat malaria. The pulp from tamarind fruit is used as a febrifuge and laxative (Naeem *et al*., 2017).

Digestive Health

The dietary fiber and pectin found in tamarind help to maintain gastrointestinal health, ease constipation, and facilitate good digestion (Vikram *et al*., 2023).

2.4.7. Processed products of tamarind

*Tamarind Paste and Pulp***:** Tamarind pulp is used to make tamarind paste or concentrate, a staple in many cooking dishes. It comprises marinades, soups, curries, and sauces (Vikram *et al.*, 2023).

Beverages: Drinks that are popular worldwide, such as tamarind juice, tamarind tea, and agua de tamarindo, are made using tamarind (Vikram *et al*., 2023).

Tamarind pulp powder: One convenient food product made by concentrating, drying, and grinding the pulp into a powder is called Tamarind pulp powder (Singh *et al*., 2007).

*Tamarind pickle***:** In Asia, pickles are frequently served as a side dish to major courses like curries. Pickles can be kept for several months and have a fiery, spicy, salty-sour flavor (Singh *et al*., 2007).

Syrup: To make tamarind syrup, softened fruit pulp is boiled and then drained through cheesecloth. Add a half-teaspoon of baking soda to each cup of juice. The mixture is reduced in size to half by boiling it, which also gets rid of the rising scum. Once more, the juice is

strained15. Add a quarter cup of sugar for each cup that is collected. Another 20 minutes are spent boiling the mixture. Once the syrup has cooled, it is filled and sealed in sterile bottles (Singh *et al.,* 2007).

Jam: To make tamarind jam, the extracted pulp is cooked at 100ºC for 10 minutes.There are parts of sugar added for every one part of the pulp. After that, the mixture is cooked while being continuously mixed and boiled until it thickens. After cooling, the jam is sealed.

Snacks and Candies: Numerous candies, nibbles, and confections are made with tamarind. Examples include tamarind sweets, tamarind balls, and tamarind-flavored lollipops (Vikram *et al*., 2023).

Champoy: Tamarind fruits can be processed into balls, or "Champoy," a popular tamarind product in the Philippines. To make champoy, combine one cup of pulp with two cups of boiling and mashed sweet potatoes (Ipomoea batatas (Linn.) Lam.), two cups sugar, one-eighth cup salt, and one cup water. The mixture is continuously stirred while cooking over a moderate heat until it thickens and can be formed into balls (Singh *et al*., 2007).

*Chutneys and Sauces***:** In Indian cuisine, tamarind chutney is a popular condiment that's frequently served with small bites like pakoras or samosas. Middle Eastern, Mexican, and Thai cuisines also usetamarind sauce (Vikram *et al*., 2023).

Ade: In the Philippines and other tropical American nations, ripe pulp is combined with sugar and water to create this cool tamarind drink until the right flavor is achieved (Singh *et al*., 2007).

2.5. Jam Processing

A product called jam is created by pureeing entire or partially-ripe fruits, as well as concentrated or unconcentrated fruit pulp or puree. It can be combined with foods with sweetening qualities and water, either before or after the fruit is brought to the right consistency (CODEX, 2009).

A semisolid food containing at least 45% (by weight) fruit and 55% (by weight) sugar is called jam. The concentration of soluble solids in this substrate is 65% or higher. Agents for coloring and flavoring may be applied. Pectin and acid can be added to make up for the deficits in the fruit itself (Sur *et al*., 2020).

Jams are among the most widely consumed foods due to their inexpensive price, year-round availability, and organoleptic qualities (Gałkowska *et al.*, 2010). This product is created by heating entire fruits chopped or crushed—with sugar and water to activate the pectin before they are stored in containers. It's often created with the pulp and juice of one fruit, not a mix of several, and it's soft, with a thick puree-like texture and at least 65 Brix (Allen *et al.*, 2019).

2.5.1. Effect cooking on jam

When the fruit purees are cooked, there is a noticeable shift in apparent viscosity. Understanding how shear rate and temperature affect the rheological behavior of fruit purees is vital since this affects velocity and temperature profiles (Maceiras *et al*., 2007). One of the key factors influencing the rheological behavior of food is the temperature (Javanmard and Endan, 2010). Flavonoid molecular structure may become unstable. Food scientists and food engineers are interested in fruit and vegetable rheological qualities since they affect the end product's quality and acceptance. Fruit purees and jams show a notable shift in perceived viscosity during cooking (Fügel *et al*., 2005). One important aspect that influences the rheology of jam while cooking is time. Research has demonstrated that certain jams, such as pineapple jam, display thixotropic characteristics (Javanmard and Endan, 2010). The temperature parameter also adversely affects flavonoids, especially the anthocyanin molecule; at higher temperatures hydrolyzation of 3-glycoside structure can occur, which normally has a protective effect on the unstable anthocyanin or the pyrilium ring hydrolyzed resulting in the production of chalkones, which are responsible for the brown color that developes in foods containing anthocyanins (Rababah *et al*., 2015).

The physiochemical and nutritional properties of fruits and jams undergo a number of changes throughout preparation, storage, and cooking. Fiber appears to be unaffected by processing. Anthocyanin content, phenolic compounds, and antioxidant activity are all impacted by thermal processing in jams. Low methoxy pectin concentration and storage duration affect the color and antioxidant properties of jams. Therefore, adding more low methoxy pectin to a jam recipe increases antioxidant levels and bioactive compounds. However, polymeric color quality and color quality are better (Rababah *et al.*, 2015).

Throughout the cooking process, there is an adequate exchange of fruits, sugars, and liquid medium, which prevents water loss when the finished product is stored. Vacuum boiling and

open-system boiling are the two primary boiling techniques utilized in large-scale jam production utilizing cooking kettles. In vacuum systems, cooking occurs in closed kettles at reduced pressure. The primary benefits of this cooking method are its low heating temperatures and rapid cooking times. Both elements are necessary for the perfect final product in terms of appearance, color, flavor, and vitamins because the raw materials are only slightly pressured (Awulachew, 2021).

3. MATERIALS AND METHODS

3.1. Experimental Site

Sample preparation, experimental activities and data collection were performed at Haramaya University, Food Science and Postharvest Technology Department Laboratory.

3.2. Experimental Materials

Fifteen kg of orange fleshed sweet potato was purchased from Babile farmers located in east Hararghe zone, Oromia Regional State, Ethiopia. Tamarind fruit and other ingredients (sugar, cinnamon, clove and lemon) were purchased from local market in Harar and Dire Dawa cities.

3.3. Experiment Design

The experimental design consist of three factors arranged in factorial design. The factor includes Blending ratio(R) of orange fleshed sweet potato and tamarind with three levels of 90:10,80:20 and 70:30 (Quindara *et al.*, 2020), cooking time(CT) with three level 20,30and 40 minutes (Okut *et al.*, 2018)and pretreatments(PT) micro wave heating, dry heat cooking and pressure cooking (Abou and Ahmed, 2021). Table 9 presents the layout of the experimental design that was comprised of three factors and three level each.

Table 9. Experimental plan (layout)

Factor 1 (Pretreatments)	**Factor 2 (Blending ratio)**	**Factor 3 (Cooking time)**		
		T1	**T2**	**T3**
D	**R1**	DR1T1	DR1T2	DR1T3
	R2	DR2T1	DR2T2	DR2T3
	R3	DR3T1	DR3T2	DR3T3
P	**R1**	PR1T1	PR1T2	PR1T3
	R2	PR2T1	PR2T2	PR2T3
	R3	PR3T1	PR3T2	PR3T3
M	**R1**	MR1T1	MR1T2	MR1T3
	R2	MR2T1	MR2T2	MR2T3
	R3	MR3T1	MR3T2	MR3T3

Where

D= Dry heat cooked OFSP, P= Pressure cooked OFSP, M= Micro wave cooked OFSP, R1= Blending ratio 1 (90% OFSP and 10% tamarind), R2= Blending ratio 2 (80% OFSP and 20% tamarind), R3=Blending ratio 3 (70% OFSP and 30% tamarind), T1= Cooking time 1 (20 minute), T2= Cooking time 2 (30 minute), T3= Cooking time 3 (40 minute)

3.4. Sample Preparation

3.4.1. Orange fleshed sweet potato and tamarind pulp preparation

Orange fleshed sweet potato tubers were cleaned or washed to remove dirt or debris and then cut into small, uniform cubes. The prepared cubes were pretreated using three cooking methods (dry heat cooking, pressure cooking and microwave cooking).

In pressure cooking and microwave cooking orange fleshed sweet potato sample (350, 300 & 250) grams were cooked for 9 min using a domestic pressure cooker and using domestic microwave for 6 min respectively. In dry heat cooking orange fleshed sweet potato sample were cooked using a domestic gas oven at 180°C for 30 min. The pretreated sweet potato were mashed to get pulp that is ready for jam processing (Rababah *et al.*, 2015).

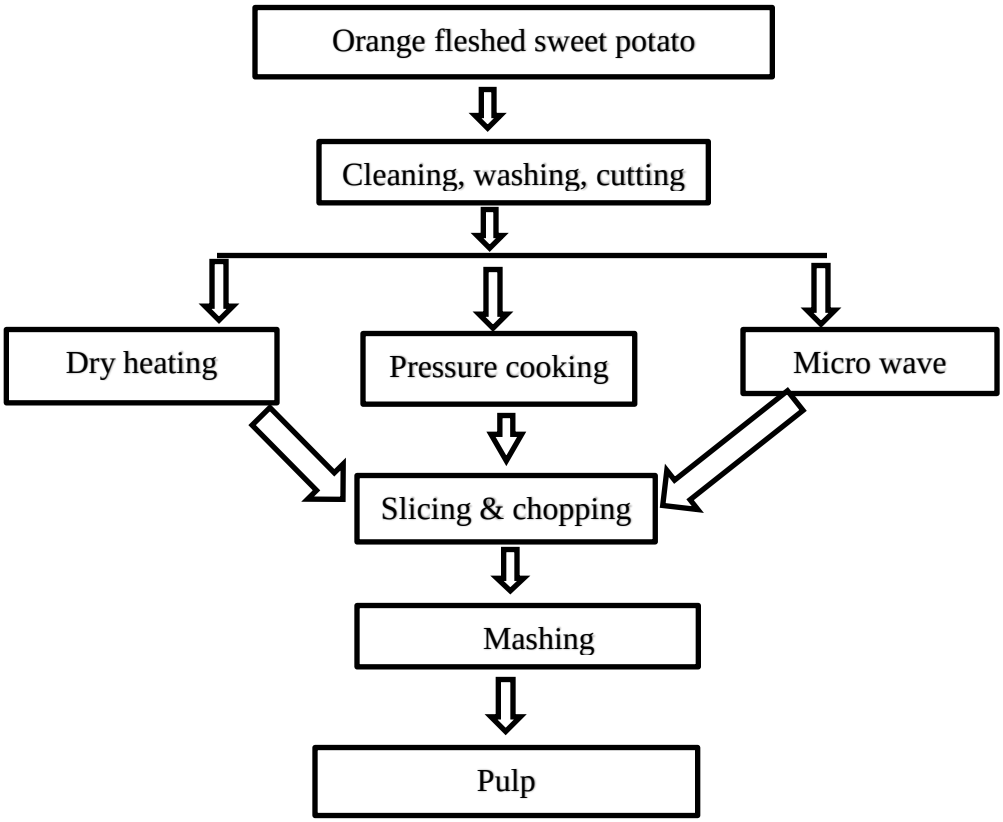


Figure 4. Flow chart of orange fleshed sweet potato pulp formation

The tamarind fruit were soaked in water for 20 minutes and boiled for10 minutes to soften the tissue (Kiranmai *et al.,* 2018). The softened tamarind were further cleaned from any seeds, fibers and other remaining solids. It was mashed to get the pulp that is used for jam production. Figure 4&5 shows how orange fleshed sweet potato and tamarind paste are prepared.

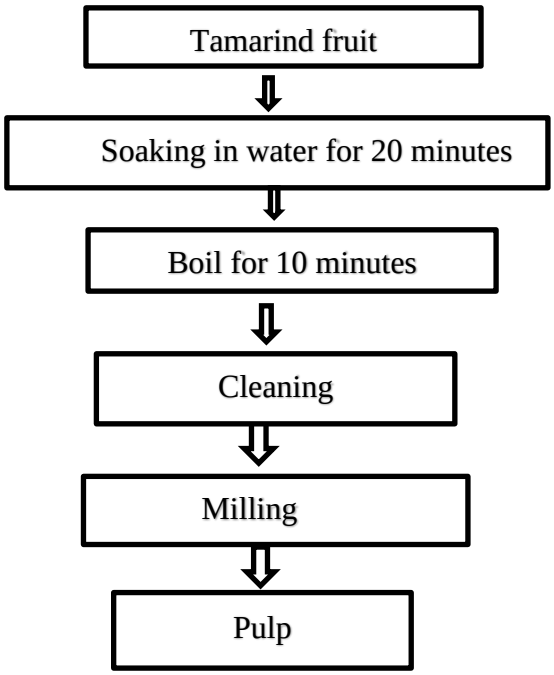


Figure 5. Flow chart of tamarind pulp preparation

3.4.2. Orange fleshed sweet potato and tamarind jam preparation

The prepared orange fleshed sweet potato and tamarind pulps were blended in 3 ratio which includes 90:10, 80:20, and 70:30. Then the blended pulp mixtures were cooked for one of 3 durations (20, 30, 40 minutes). At the first 10 minutes 150 grams of sugar were added. The remaining 100-gram sugar and 2-gram pectin was added at the last 10 minutes and also 0.5 gram of cinnamon and clove were added by using muslin cloth. Finally, 15 mL of lemon juice was added to mixture. The mixture is stirred until all ingredients are well combined. While the jam was been cooked, the jars and lids for canning were prepared by washing the jars with hot, soapy water, and sterilized by placing them in boiling water for 10 minutes. The jam is then removed from the heat when the time reach 20, 30, 40 minutes. Then jam was hot filled in to cleaned and

sterilized jars. Finally, the jars were sealed tightly and stored in the refrigerator. Figure 6 is flow chart for jam preparation (Rababah *et al.*, 2015).

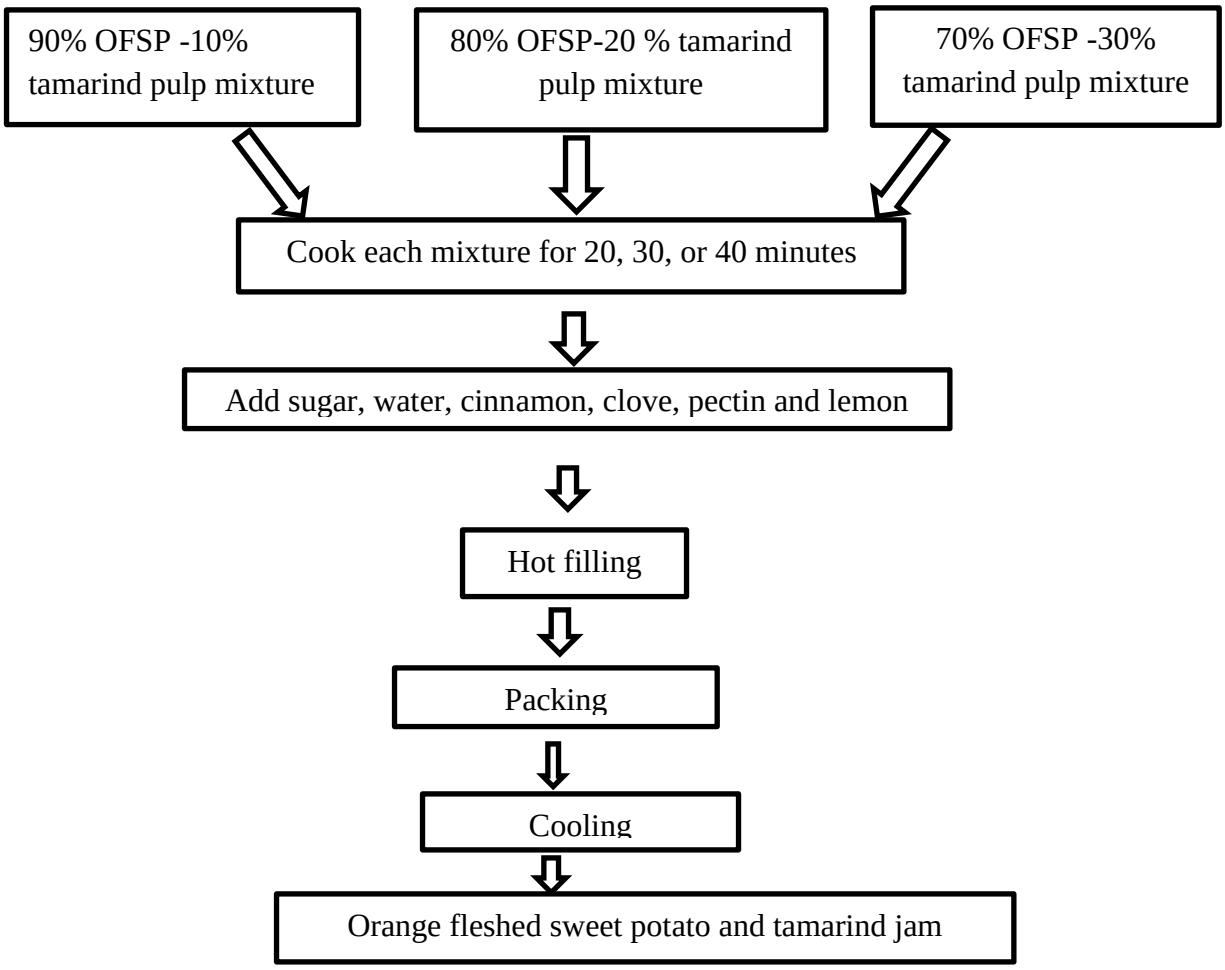


Figure 6. Flow chart of orange flashed sweet potato and tamarind blend jam

3.5. Physicochemical Parameters Analysis

3.5.1. Total soluble solids

The Hand-Refractometer (No.002603, BSeclipse, UK) was used to measure the total soluble solid (TSS). The instrument will be adjusted (calibrated) with distilled water, and then one or two drop of samples were placed on the prism's surface. The prism were then closed, and the

reading will be recorded as TSS%, to the nearest 0.01 being recorded (Ahmed and Alrhum, 2016).

3.5.2. Determination of pH

The methods outlined by Ranganna (2001) were used to ascertain the various samples' hydrogen ion concentration (pH). Principle: Using a pH meter, the PH value of various samples were determined. The sample reading is recorded as the pH value once the pH-meter electrodes have been standardized using buffer solutions.

First, the pH-meter (N0.478530, Hanna, India) was standardized using buffer solutions with pH values of 4.01 and 7.01. Then, the electrode of the pH-meter were cleaned with distilled water, submerged in the sample, and allowed to stand until a uniform reading is obtained. To the closest 0.01 pH unit, all readings was expressed as PH (Rehab, 2018).

3.6. Proximate Composition Determination

3.6.1. Moisture content

The moisture content were determined according to the standard method of the Association of Official Analytical Chemists (AOAC, 2010). The sample's moisture content can be eliminated by heating a weighted sample to 105 °C in an oven set at atmospheric pressure. The weight difference between the starting weight and the weight after drying is then computed as a percentage. Weighing a sample of 10 gm ±1 gram into a dish that has been previously dried and tarred comes first. After that, the sample were baked at 105 ± 1 °C until a consistent weight is achieved. The sample were covered, allowed to dry, and then placed in desiccators to cool to room temperature before being weighed again (Rehab, 2018). For every sample, triplicate results were acquired, and the mean value was reported to two decimal places using equation 3.2.

$$\text{Moisture content (\%)} = \frac{ws - wd \times 100\%}{sample\ weight(gm)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.2$$

Where:

Ws = weight of sample before drying, Wd = weight of sample after drying

3.6.2. Crude protein

All samples' protein contents were ascertained by the micro-Kjeldahl method with a copper sulfate-sodium sulfate catalyst following Rehab (2018).

The principle is to oxidize the sample and convert its nitrogen to ammonia, which then interacts with the excess sulfuric acid to generate ammonium sulphate. The mixture was next be made alkaline, and the ammonia were distilled into a standard boric acid solution (2%) to create the ammonia-boric acid complex. This complex is then titrated against a standard HC1 (0.1N) solution. To calculate the protein content, multiply the total percentage by 6.25, which is the protein conversion factor.

The procedure involves precisely weighing ten grams of the material, transferring it into a Kjeldahl digestion flask along with four grams of NaSO4 of Kjeldahl catalysts (No. 0665, Scharlauchemie, Spain) and twenty-five millilitres of concentrated sulfuric acid (No. 0548111, HDWIC, India). The flask was next be put into a Kjeldahl digestion unit (No.4071477, type KI 26, Gerhardt, Germany) and allowed to cool to ambient temperature for approximately two hours, or until a colorless digest is achieved. Using 20 mL of sodium hydroxide solution (45%), ammonia were distilled into 25 mL of boric acid (2%). The final step was titrating the distillate using a standard HC1 (0.1N) solution while adding two to three drops of methyl red and bromocreasol green as indicators.

$$\text{Crude Protein (\%)} = \frac{(ml\ HCl\ sample - ml\ HCl\ blank)\ x\ N\ x\ 14.00\ x\ F \times 100\%}{Sample\ weight\ (gm)\ x\ 1000} \quad \text{.....3.3}$$

Where:

N: normality of HCl.

F: protein conversion factor = 6.25

3.6.3. Crude fat

The crude fat content were determined according to the official method of the (AOAC, 2005). The procedure ascertains the materials that are extractable under the particular circumstances of the Soxhlet extraction method and soluble in petroleum ether (65–70 °C). Next, the dried ether extract (fat content) is weighed and given as a percentage using the sample's initial weight as a foundation.

Weighing out 5 grams ± l milligrams, then the sample were placed in an extraction thimble and covered with cotton that has been previously extracted with hexane (No. 9-16- 24/25-29-51, LOBA Cheme, India). The sample was next be connected to the extraction equipment (Electrothermal, England) together with a pre-weighed and dried extraction flask holding roughly 100 ml of hexanes, and the extraction procedure were last after 16 hours. The flask will be detached from the apparatus and the solvent were redistilled after the extraction time is up. Subsequently, the flask containing the leftover crude ether extract were baked at 105 °C for three hours, cooled in a desiccator to ambient temperature, and the dried extract was weighed again to determine its fat content using equation 3.4 below.

$$\text{Fat content (\%)} = \frac{w2-w1}{w3} \times 100\% \quad \text{.....3.4}$$

Where;

W2 =Weight of the flask and ether extract

W1 =Weight of the empty flask

W3=initial weight of the sample

3.6.4. Crude fiber

The approved (AOAC, 2005) technique was used to calculate crude fiber. After transferring the crude fat determination sample to a 600 ml Erlenmeyer flask and adding 200 ML of 1.25 % sulfuric acid, the combination was heated for 30 minutes while a watch glass is placed over the beaker's mouth. Hot distilled water were used to maintain the sample solution's level throughout boiling. Twenty milliliters of 20% KOH was added and heated slowly for an additional half-hour, stirring now and again, after the initial thirty minutes of heating. The bottom of the sintered glass crucible were moistened with distilled water after a layer of 10 mm sand has been added. After that, a vacuum pump were used to filter the solution inside a sintered glass crucible. Hot distilled water was used to wash the wall of the beaker repeatedly. Prior to being added to the crucible, the washing were filtered. Hot distilled water was used twice to clean and filter the residue inside the crucible. The residue is going to be filtered, rinsed with one percent H_2SO_4, rinsed with hot distilled water, rinsed with one percent KOH, and then rinsed again. At this stage, the residue was filtered, rinsed with hot, distilled water, and cleaned again. Lastly, acetone was used to clear the residue without the use of water. After being chilled for 30 minutes in a desiccator and dried for an hour at 100°C in a drying oven, the contents of the crucible was

weighed (W2). After that, the crucible was heated to 550 degrees Celsius for 30 minutes in a muffle furnace. The contents of the crucible was weighed when it is cooled in a desiccator (W3). The equation 3.5 determines the crude fiber:

$$\text{Crude fiber (\%)} = \frac{w2-w3}{w1} \times 100\% \quad \text{.....3.5}$$

Where;

W1- Weight of the fresh sample

W2-weight of crucible with the sample after oven draying

W3-weight of the crucible with the sample after ashing

3.6.5. Ash content

The ash content was determined according to the method described by the AOAC (2010).

After being ignited at a specific heat degree, the inorganic materials, which vary in concentration and composition, are typically determined as a residue.

Five g ±1 mg of the sample was weighed into a porcelain crucible that had been preheated, cooled, weighed, and tarred. It was then be placed in a Muffle furnace (No.20. 301870, Carbolite, England) and heated to 550–600 °C until a white, gray ash was formed. After being moved to a desiccator, the crucible will be weighed after cooling to room temperature. Next, the ash content will be computed as a percentage using the sample's original weight as a foundation,

$$\text{Ash \%} = \frac{w1-w2}{w3} \times 100 \quad \text{……..3.6}$$

Where

W1 =Wt of crucible +Ash

W2 =Wt of empty crucible

W3 = Initial weight

3.6.6. Total Carbohydrate

Carbohydrate content was determined by difference using equation 3.7.

$$\text{Carbohydrate} = 100 - (crude\ protein + crude\ fat + moisture\ content + ash) \quad \text{…..3.7}$$

3.6.7. Total energy

Equation 3.8 was used to calculate the gross energy (GE) content of each sample:

$$\text{(Total energy (kcal)} = 9 \times crude\ fat + 4 \times crude\ protien + 4 \times carbohydrate \ldots .3.8$$

3.7. Determination of Mineral Content

3.7.1. Iron content

An atomic absorption spectrophotometer was used to measure the iron content (AACC, 2000). After being pre-ignited at 550 OC, the 2.0 g sample was placed in the ashing vessel and allowed to cool in desiccators. After the ash had been ashied at 500 °C, it was dissolved in a minimum volume of HCl-H_2O (1:1), to which 20 mL of this solution will be added and dried in a steam bath. Once the temperature has cooled to room temperature, absorbance was measured at 248.3 nm using air-acetylene as a flame source for atomization. To prepare the Atomic Absorption standard solution (1000 µg Fe/mL), 1.000 g of pure iron wire dissolved in 30 mL of boiling 6 M HCl, then diluted to 1 L. To prepare the final standard solutions, dilution from the stock was used (0, 2, 4, 6, 8, 10, 12, 14, 16, 18 and 20 µg/mL). Equation 3.9 used to determine the samples' Fe concentrations.

$$\text{Iron content (mg/100g)} = \frac{(cs-cb)\times 10}{s} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.9$$

Where:

Cs= Concentration of sample in µg/ml,

Cb= Concentration of blank in µg/ml and

S = Sample mass in g (db).

3.7.2. Magnesium content

The Magnesium content was determined by atomic absorption spectrophotometer (AACC, 2000). A 2-gram sample weighed and placed in the ashing vessel, pre-ignited at 550 degrees Celsius and then cooled in a desiccator. After carbonizing over a blue Bunsen burner flame, the sample will be placed in a muffle furnace set at 500 OC until the ashing process is finished. Next, 10 cc of diluted 3 M HCl used to dissolve the ash. In a steam bath, the solution cooked and virtually evaporated. A 100 ml volumetric flask containing coarse porosity filter paper used to filter the residue after it had been quantitatively re dissolved in 20 mL of 2 M HCl. The paper

cleaned after a thorough water rinse and diluting to the 100 mL mark To create a calibration curve, a series of standard solutions with concentrations of 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, and 5 µg/mL prepared from analytical grade pure magnesium metal. A standard solution (1000 µg Ca/mL) dissolved 1 g in 50 mL of water and 100 mL concentrated HCl. Equation 3.10 used to calculate magnesium content.

$$\text{Magnesium (mg/100g)} = \frac{cs - cb \times 100}{s} \quad \ldots\ldots 3.10$$

Where:

Cs= Concentration of sample in µg/mL,

Cb= Concentration of blank in µg/ mL and

S = Sample mass in g (db).

3.7.3. Zinc content

Absorption Spectrophotometer AACC, 2000 was determined zinc content. The 2.0 g sample placed inside the ashing vessel, which has been chilled in desiccators after being pre-ignited at 550 °C. After 500oC ashing, the ash dissolved in a minimum amount of HCl-H2O (1:1), to which 20 mL of this solution added and evaporated in a steam bath until it is completely dry. Using air-acetylene as a source of flame for atomization, absorbance measured at 213.8 nm after cooling to room temperature. To make the Atomic Absorption standard solution (10 µg Zn/mL), 1.3830 g of analytical grade zinc dissolved in 10 mL of 6 M HCl and diluted to 100 mL. Five milliliters of this solution then taken and diluted to the 500 mL mark with distilled water. In order to create the calibration curve, a series of standard solutions with the following concentrations (0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, and 5 µg/ml) created. Equation 3.11 used to calculate zinc content.

$$\text{Zinc content (mg/100g} = \frac{cs - cb \times 10}{s} \quad \ldots\ldots 3.11$$

Where:

Cs= Concentration of sample in µg/mL,

Cb= Concentration of blank in µg/mL and

S = Sample mass in g (db).

3.7.4. Calcium content

The calcium content determined by an atomic absorption spectrophotometer (AACC, 2000). A

2-gram sample weighed and placed in an ashing vessel. It pre-ignited at 550 degrees Celsius and cooled in a desiccator. After carbonizing the sample over a blue Bunsen burner flame, it placed in a muffle furnace set at 500 OC until the ashing process is finished. After that, the ash dissolved in 10 milliliters of diluted 3 M HCl. In a steam bath, the solution cooked and virtually evaporated. The residue quantitatively redissolved in 20 milliliters of 2 M HCl and then filtered through coarse-porosity filter paper into a 100-milliliter volumetric flask. Following a thorough water rinse and diluting to the 100 mL mark, the paper cleaned. First, 1.249 g of analytical grade CaCO3 dissolved in 30 mL HCl and 50 mL distilled water to create the standard solution (25 µg Ca/mL), which then diluted to 1 l. The sample and final standard solutions (0, 2,4,6,8,10,12,14,16,18, and 20 µg/ml) next mixed with enough La stock solution to make the final dilution 1% La (i.e., 5 ml La solution to 25 mL flask, 20 mL to 100 mL flask). This allow for the measurement of calcium. An atomic absorption spectrophotometer used to read the sample's absorbance at 422.7 nm. Calcium content calculated with equation 3.12.

$$\text{Calcium=(mg/100g)} = \frac{cs - cb \times 10}{s} \quad \text{.....3.12}$$

Where:

Cs= Concentration of sample in µg/mL,

Cb= Concentration of blank in µg/mL and

S = Sample mass in g (db).

3.8. Determination of Vitamins

3.8.1. Determination of beta carotene

The AACC, (2000) method 14-50, which measures color absorbance using a UV-visible spectrophotometer at 435.8 nm and works on the premise of solvent extraction of the pigments, used to evaluate the beta carotene content of the samples. Samples tempered to 14% moisture content after being dried, crushed, and sieved through 106 mesh sieves. Samples weighing eight grams moved into 125 milliliter glass stoppered flasks, and 40 milliliters of reagent (typical butyl alcohol saturated with water, 1:5 alcohol to water)) added. After one minute of shaking, the contents left to stand for eighteen hours. After another shaking, the contents filtered into test tubes using Whatman No. 1 filter paper. The spectrophotometer calibrated at 100% transmittance at 435.8 nm using the reagent, which placed into a standard cuvette. After filling

the cuvettes with sample extracts and rinsing them multiple times, the absorbance at 435.8 nm measured. Equation 3.13 subsequently used to determine the beta carotene content (mg/g) (Fikre, 2010).

$$\text{Beta carotene (µg/g or ppm)} = \frac{Sample\ Abs. \times 0.4}{1.6632 \times Sample\ mass(dp)} \times 1000 \ldots\ldots..3.13$$

3.8.2. Vitamin C

The titration method AOAC (2010) described applied with minimal modification to ascertain the sample's vitamin C concentration. After macerated for two grams, each sample combined with 50 milliliters of 3% metaphosphoric acid. 50 milliliters of 3% metaphosphoric acid added to the filtered extracted sample. A burette filled with indophenol dye solution titrated after a known 10 mL sample is taken in a flask. The arrival of the pink color, which must last for at least 15 seconds, indicate the endpoint.

$$\text{Chlorophyll b (mg g-1)} = \frac{a \times b \times c}{d \times e} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.14$$

Where a= average burette reading for sample,

b= dye factor,

c= volume made with metaphosphoric acid,

d= volume made with metaphosphoric acid and

e = weight of the sample,

3.9. Sensory Acceptability Evaluation of Jam

Seven points hedonic scale taste method used for conducting the sensory evaluation of Jam. The rating scale were 7- like extremely, 6 -like very much, 5 - like slightly, 4 -neither like nor dislike, 3 -dislike slightly, 2 -dislike very much) and 1 -dislike extremely (Okudu and Ene-Obong, 2015). Thirty(30) Panelists were selected randomly to evaluate the jam for various sensory parameters such as color, texture, aroma, flavor, taste, and overall acceptability (Anuar and Salleh, 2019). Water was provided for panelists to rinse their mouths between each testing of the sample.

3.10. Statistical Data Analysis

Statistical analysis of the experimental data conducted using two-way Analysis of Variance (ANOVA) for Completely Randomized Design (CRD) using statistical analysis software

package, SAS System for Windows 9.4, (SAS Institute, Cary, NC, USA). All the samples analyzed in triplicate and results expressed as mean ± standard deviation. The Fisher's Least Significant Difference (LSD) test used to test difference between means and the significance will be set at ($P<0.05$) probability level.

4. RESULTS AND DISCUSSION

4.1. Effect of blending ratio on nutrient composition of jam

This section discusses the proximate composition of jam prepared using different blending ratios of orange-fleshed sweet potato (OFSP) and tamarind. The results are presented in Table 10.

Table 10. Effect of blending ratio on proximate composition blended jam

Blending ratio	**Moisture (%)**	**Crude fat (%)**	**Crude protein (%)**	**Fiber (%)**	**Ash (%)**	**Utilizable carbohydrate (%)**	**Total energy (kcal/100g)**
C	33.18±2.62^{a}	0.57±0.10^{b}	1.59±0.07^{d}	0.66±0.08^{d}	1.48±0.17^{d}	62.50±2.52^{d}	261.50±10.30^{d}
R1	31.07±2.90^{b}	0.58±0.09^{ab}	1.63±0.07^{c}	1.10±0.09^{c}	1.53±0.16^{c}	64.07±2.89^{c}	268.08±11.57^{c}
R2	29.04±3.22^{c}	0.60±0.09^{ab}	1.67±0.08^{b}	1.28±0.16^{b}	1.57±0.17^{b}	65.83±3.27^{b}	275.47±13.03^{b}
R3	27.11±3.14^{d}	0.63±0.09^{a}	1.76±0.13^{a}	1.51±0.13^{a}	1.61±0.16^{a}	67.36±3.20^{a}	282.21±12.72^{a}
CV	4.37	15.59	2.25	6.43	3.77	1.97	1.98
LSD	0.66	0.04	0.02	0.03	0.02	0.65	2.72

Where: C= control (100 % OFSP), R1= Blending ratio 1 (90% OFSP and 10% tamarind), R2= Blending ratio 2 (80% OFSP and 20% tamarind), R3=Blending ratio 3 (70% OFSP and 30% tamarind).

4.1.1. Moisture content

The moisture content considerably ($p < 0.05$) dropped as the blend's tamarind concentration rose. The control (C) sample had the highest moisture content (33.18%), followed by R1 (31.07%), R2 (29.04%), and R3 (27.11%). Neela & Fanta, (2019) speculate that the higher moisture content of the control could be due to OFSP's naturally high moisture level. However, the steady addition of tamarind, which has a lower moisture content, helped to achieve the observed drop in moisture. R3 had the lowest moisture content and the highest tamarind content.

4.1.2. Crude fat content

The crude fat content increased slightly but statistically significantly ($p < 0.05$) as the concentration of tamarind increased, from 0.57% in the control to 0.63% in R3. According to (Lola *et al.*, 2017), tamarind pulp has a comparatively higher lipid content than sweet potato,

which could explain this trend. At greater tamarind ratios, the minor increase in fat content helps to improve the jam's energy value.

4.1.3. Crude protein content

Higher tamarind concentration also resulted in a considerable rise in protein content. 70% OFSP and 30% Tamarind (R3) had the greatest value (1.76%), while the control had the lowest (1.59%). The higher protein content of tamarind pulp relative to OFSP may be the cause of this rise.(Lola *et al*., 2017) noted similar findings in composite products, emphasizing the function of tamarind as an addition that increases protein

4.1.4. Fibre content

As the tamarind ratio increased, a steady and noteworthy rise in fiber content was noted. R3 had the highest fiber content (1.51%), whereas the control had the lowest (0.66%). According to research, tamarind is a good source of dietary fiber, and adding it to the jam greatly increased this metric (Lola *et a*l., 2017).

4.1.5. Ash

The addition of tamarind resulted in a consistent rise in the ash content, which represents the overall mineral composition. R3's ash content was 1.61%, compared to 1.48% for the control. According to Lola *et al*, (2017), who discovered increased ash levels in food products containing tamarind, the observed increase is probably caused by the higher mineral content in tamarind pulp.

4.1.6. Carbohydrate

From 62.50% in the control to 67.36% in R3, the total carbohydrate content significantly increased as the tamarind ratio increased (Abou and Ahmed, 2021). The natural sugars and polysaccharides found in tamarind may be the cause of the increase in carbohydrates, which also makes the jam sweeter and more energy-dense. This pattern is consistent with earlier research conducted by Lola *et al*,(2017).

4.1.7. Total energy

The addition of tamarind considerably raised the jam's energy content (Afoakwah *et al*., 2023a). R3 had the highest energy content (282.21 kcal), whereas the control had the lowest (261.50 kcal). The combined effect of the increased protein, lipid, and carbohydrate content in tamarind-

enhanced samples is responsible for this increase. Similar patterns in the energy levels of blended fruit products were also noted by (Lola *et al*., 2017).

4.2. Effect of cooking method on nutrient composition of jam

This section assesses the effects of three distinct cooking techniques on the proximate composition of jam made from orange-fleshed sweet potatoes (OFSP): pressure cooking (P), microwave cooking (M), and dry heating (D). Table 11 presents the findings.

Table 11. Impact of cooking method on proximate composition

Cooking Method	**Moisture (%)**	**Crude fat (%)**	**Crude protein (%)**	**Fiber (%)**	**Ash (%)**	**Utilizable carbohydrate (%)**	**Total energy (kcal/100g)**
D	26.97±3.21^{c}	0.59±0.08^{b}	1.65±0.05^{b}	1.12±0.30^{b}	1.50±0.08^{b}	68.15±2.90^{a}	284.53±11.86^{a}
M	30.69±2.36^{b}	0.66±0.07^{a}	1.76±0.10^{a}	1.26±0.36^{a}	1.76±0.07^{a}	63.85±2.08^{b}	268.43±8.68^{b}
P	32.64 ±3.05^{a}	0.54±0.09^{c}	1.57±0.07^{c}	1.03±0.03^{c}	1.39±0.05^{c}	62.82±2.76^{c}	262.49±11.28^{c}
CV	4.37	15.59	2.25	6.43	3.77	1.97	1.98
LSD	0.57	0.03	0.02	0.03	0.03	0.56	2.35

Where: D= dry heated OFSP, P= pressure cooked OFSP, M= micro wave cooked OFSP

4.2.1. Moisture content

The cooking procedure had a substantial ($p < 0.05$) impact on the moisture content. Those that were pressure-cooked had the highest moisture content (32.64%), followed by those that were microwave-cooked (30.69%) and dry-heated (26.97%). In line with research by Abou and Ahmed, (2021), the decreased moisture content in dry heating might be the result of more extensive evaporation throughout the prolonged exposure to dry heat. More moisture was retained when cooking under pressure, which exposes the food to less direct heat

4.2.2. Crude fat

Crude fat concentration was lowest in pressure-cooked samples (0.54%) and highest in microwave-cooked samples (0.66%). The fat level was intermediate (0.59%) after dry heating.

The sensitivity of fat components to heat and cooking time may be the cause of these variations. According to Abou and Ahmed, (2021), microwave cooking is thought to be kinder and more consistent, potentially reducing lipid oxidation or loss.

4.2.3. Crude protein

Crude protein level was highest in microwave-cooked jam (1.76%), followed by dry heating (1.65%) and pressure cooking (1.57%). In line with findings by Abou and Ahmed, (2021), this trend implies that microwave treatment may better retain protein content because of its shorter cooking duration and less leaching, whereas pressure cooking may cause partial protein denaturation or loss due to severe thermal exposure (Rani *et al.*, 2020).

4.2.4. Fiber

The maximum fiber value (1.26%) was obtained by microwave cooking, followed by dry heating (1.12%) and pressure cooking (1.03%) (Oloniyo *et al.*, 2021). The fiber content varied considerably amongst the procedures. By reducing structural deterioration, the microwave approach probably improved the preservation of cell wall components, which is consistent with the results (Abou and Ahmed, 2021). Pressure cooking, on the other hand, has a greater capacity to soften and degrade fiber structures.

4.2.5. Ash

Samples that were microwave-cooked had the highest ash concentration (1.76%), which indicates superior mineral retention. Ash readings were 1.50% for dry heating and 1.39% for pressure cooking. (Abou and Ahmed, 2021), also observed a pattern of limited leaching and negligible mineral volatilization, which may be the cause of the greater ash concentration in microwave-treated jam.

4.2.6. Carbohydrate

Dry-heated samples had the highest total carbohydrate content (68.15%), followed by microwave- and pressure-cooked jams (63.85% and 62.82%, respectively). Greater water loss (lower moisture content), which concentrates the carbohydrate portion, may be the cause of the higher value in dry-heated samples. These findings are consistent with trends observed in heat-treated root-based products reported by Abou and Ahmed, (2021).

4.2.7. Total energy

The jam's overall energy content followed the pattern of its fat and carbohydrate content, with the highest energy value (284.53 kcal) coming from dry heating, followed by microwave

(268.43 kcal) and pressure cooking (262.49 kcal) (Owade *et al.,* 2018). The concentration impact brought on by moisture loss and macronutrient retention during the various cooking stages is seen in this pattern. These findings are consistent with research by Abou and Ahmed, (2021), who emphasized the connection between thermally processed foods' energy concentration and moisture loss.

4.3. Effect of cooking time on nutrient composition of jam

This section explains how the proximate composition of sweet potato–tamarind blended jam is affected by varying cooking times (20, 30, and 40 minutes, designated as T1, T2, and T3, respectively). Table 12 provides a summary of the findings..

Table 12. effect of cooking time on proximate compostion of blended jam

Cooking time	**Moisture (%)**	**Crude fat (%)**	**Crude protein (%)**	**Fiber (%)**	**Ash (%)**	**Utilizable carbohydrate (%)**	**Total energy (kcal/100g)**
T1	31.64±3.46[a]	0.62±0.09a	1.69±0.12a	1.17±0.33a	1.58±0.18a	63.30±3.15c	265.56±12.97c
T2	30.17±3.60[b]	0.60±0.09ab	1.67±0.10a	1.15±0.34a	1.55±0.17a	64.85±3.29b	271.51±13.53b
T3	28.50±3.50c	0.57±0.09b	1.63±0.10b	1.10±0.33b	1.52±0.17b	66.67±3.19a	278.38±13.22a
CV	4.37	15.59	2.25	6.43	3.77	1.97	1.98
LSD	0.57	0.03	0.02	0.03	0.02	0.56	2.35

Where: T1= cooking time 1(20 minute), T2= cooking time 2(30 minute), T2= coking time 3(40 minute)

4.3.1 Moisture content

As the cooking time increased, the moisture content dramatically dropped. Jam cooked for 20 minutes had the maximum moisture content (T1 = 31.64%), followed by jam cooked for 30 minutes (T2 = 30.17%) and jam cooked for 40 minutes (T3 = 28.50%). Extended heating

resulted in increased evaporation of moisture, which is in line with the effects of thermal concentrations seen by Kourouma *et al*, (2019).

4.3.2. Crude fat

The longer cooking time resulted in a small decrease in the amount of crude fat. T1 had the highest fat percentage (0.62%), while T3 had the lowest (0.57%). Long-term heating may cause lipids to oxidize or break down, which would explain this decline. Similar effects of cooking duration on fat content were reported by Kourouma *et al*, (2019).

4.3.3. Crude protein

As cooking time increased, crude protein decreased somewhat but statistically significantly. Protein content was lowest in T3 (1.63%) and highest in T1 (1.69%). Extended heating can cause leaching or denature proteins, which lowers the amount of detectable protein. This trend aligns with results found in thermally treated tuber products by Omoikhoje *et al*, (2009).

4.3.4. Fiber

The amount of fiber decreased as cooking time increased. T1 had the greatest value (1.17%), while T3 had the lowest (1.10%).The softening of plant cell walls and possible solubilization of some fiber components during extended heating likely explain this decline, as supported by Omoikhoje *et al*, (2009).

4.3.5. Ash

With longer cooking times, the amount of ash, a measure of total mineral content, decreased slightly (1.58% at T1 and 1.52% at T3). This decrease could result from mineral leaching or heat deterioration during cooking Omoikhoje *et al*, (2009).

4.3.6. Utilizable carbohydrate

Utilizable carbohydrate content increased as cooking time increased, with the highest value observed at T3 (66.67%) and the lowest at T1 (63.30%). This might be the result of partial breakdown of complex carbohydrates into simpler forms or a decrease in moisture content that concentrates the remaining nutrients. These findings align with previous research on the impact of cooking on root-based products (Abong *et al*., 2009).

4.3.7. Total energy

Cooking for 40 minutes (T3) had the highest total energy content (278.38 kcal), whereas cooking for 20 minutes (T1) had the lowest (265.56 kcal). Since energy density rises with decreasing

water content. These results are in line with the observations reported by Omoikhoje *et al*, (2009).

4.4. Effect of blending ratio on vitamin content of jam

This section assesses the impact of varying orange-fleshed sweet potato (OFSP) and tamarind pulp blending ratios on the final jam's vitamin content, particularly beta-carotene and vitamin C (Table 13).

Table 13. impact of blending ratio on blended jam

Blending ratio	Beta carotene (mg/100g)	Vitamin C (mg/100g)
C	183.70 ± 10.28[a]	11.87 ± 0.67[b]
R1	163.85 ± 13.11[b]	12.20 ± 0.55[b]
R2	146.44 ± 14.67[c]	12.38 ± 0.56[b]
R3	128.59 ± 13.67[d]	13.17 ± 1.82[a]
CV	7.54	8.04
LSD	6.37	0.54

Where: C= control (100 % OFSP), R1= Blending ratio 1 (90% OFSP and 10% tamarind), R2= Blending ratio 2 (80% OFSP and 20% tamarind), R3=Blending ratio 3 (70% OFSP and 30% tamarind)

4.4.1. Beta carotene

As the amount of tamarind in the blend increased, the beta-carotene level dramatically dropped. 70% OFSP and 30% Tamarind (R3), which contained 70% OFSP and 30% tamarind, had the lowest beta-carotene value (128.59 µg/100g), while the control sample (C), which contained 100% OFSP, had the greatest value (183.70-µg/100g). Given that tamarind delivers far less beta-carotene than OFSP, which is a major source of the vitamin, this tendency is to be expected. The reduction in beta-carotene with increasing tamarind ratio is consistent with the findings of Afoakwah *et al,* (2023b), who reported that increasing non-carotenoid ingredients in blended food products dilutes the beta-carotene concentration .

4.4.2. Vitamin c

In contrast, as the amount of tamarind increased, so did the amount of vitamin C. 70% OFSP and 30% Tamarind (R3) had the highest vitamin C content (13.17 mg/100g), while the control sample had the lowest (11.87 mg/100g). The rising trend can be explained by tamarind's high

ascorbic acid concentration. The results support the work of Afoakwah *et al*, (2023b), who observed that blending high-vitamin C fruits like tamarind into sweet potato products can enhance the overall vitamin C profile.

4.5. Effect of cooking method on vitamin content of jam

This section discusses how different cooking methods—dry heating (D), microwave (M), and pressure cooking (P)—affect the beta-carotene and vitamin C content of orange-fleshed sweet potato (OFSP) jam (Table 14).

Table 14. Impact of cooking method on vitamin content of blended jam

Cooking method	Beta carotene (mg/100g)	Vitamin C (mg/100g)
D	155.67 ± 23.67^{ab}	12.26 ± 0.35^{b}
M	160.69 ± 27.15^{a}	12.83 ± 0.36^{a}
P	150.58 ± 21.08^{b}	12.12 ± 1.84
CV	7.54	8.04
LSD	5.51	0.46

Where: D= dry heated OFSP, P= pressure cooked OFSP, M= micro wave cooked OFSP

4.5.1. Beta carotene

The amount of beta-carotene varied slightly depending on the cooking mode, with the highest levels remaining after microwave cooking (160.69 µg/100g), followed by dry heating (155.67 µg/100g) and pressure cooking (150.58 µg/100g). While there were no statistically significant differences between microwave and dry heating, there were between microwave and pressure cooking. This implies that beta-carotene may be better preserved by microwave cooking, most likely because of the shorter cooking durations and reduced exposure to heat and oxygen, which break down carotenoids. These results align with Kourouma *et al*, (2019), who found microwave methods preserve carotenoids more effectively than pressure cooking.

4.5.2. Vitamin c

Jam that was microwave-cooked had the highest vitamin C concentration (12.83 mg/100g), followed by samples that were pressure-cooked (12.12 mg/100g) and dry-heated (12.26 mg/100g). Significant differences were found between pressure and microwave cooking, suggesting that the former preserves vitamin C better than the latter, which is susceptible to oxidation and heat. This observation agrees with findings from Kourouma *et al*, (2019), who

noted that microwave treatment reduces vitamin C loss compared to traditional cooking methods.

4.6. Effect of cooking time on vitamin content of jam

This section examines the impact of varying cooking times—20 minutes (T1), 30 minutes (T2), and 40 minutes (T3)—on the beta-carotene and vitamin C content in orange-fleshed sweet potato (OFSP) jam (Table 15).

Table 15. effect of cooking time on vitamin content of jam

Cooking time	**Beta carotene (mg/100g)**	**Vitamin c (mg/100g)**
T1	163.40 ± 22.80^{a}	12.54 ± 0.58^{a}
T2	156.23 ± 22.97^{b}	12.50 ± 1.33^{a}
T3	147.30 ± 24.76^{c}	12.16 ± 1.33^{a}
CV	7.54	8.04
LSD	5.51	0.46

Where: T1= cooking time 1(20 minute), T2= cooking time 2(30 minute), T2= coking time 3(40 minute)

4.6.1. Beta Carotene

As cooking time increased, the amount of beta-carotene decreased. Twenty minutes of heating produced the maximum beta-carotene content (163.40 µg/100g), which dramatically reduced to 156.23 µg/100g at thirty minutes and then to 147.30 µg/100g at forty minutes. The statistical significance of this drop is $p < 0.05$. The reduction in beta-carotene with prolonged cooking can be attributed to its sensitivity to heat, oxygen, and prolonged thermal exposure, which can cause degradation and isomerization of carotenoids, consistent with findings by Kourouma *et al*, (2019).

4.6.2. Vitamin C

The amount of vitamin C decreased somewhat but not significantly as cooking time rose. The corresponding values for 20, 30, and 40 minutes were 12.54, 12.50, and 12.16 mg/100g respectively. Despite the trend showing considerable loss, vitamin C seems to have remained mostly steady throughout the studied cooking times, perhaps as a result of gentle cooking circumstances or partial protection from the jam matrix. This result agrees with Kourouma *et al*,

(2019), who noted that vitamin C degradation can be limited when cooking conditions are controlled.

4.7. Effect of blending ratio on mineral content of jam

Table 16 presents the influence of different blending ratios of orange-fleshed sweet potato (OFSP) and tamarind on the mineral composition of jam, focusing on iron, zinc, magnesium, and calcium content.

Table 16. impact of blending ratio of jam on mineral content

Blending ratio	**Iron (mg/100g)**	**Zinc (mg/100g)**	**Magnesium (mg/100g)**	**Calcium (mg/100g)**
C	0.46 ± 0.22^{d}	0.25 ± 0.02^{a}	19.27 ± 0.40^{d}	27.60 ± 0.70^{d}
R1	0.70 ± 0.15^{c}	0.24 ± 0.03^{b}	28.05 ± 0.62^{c}	32.74 ± 0.64^{c}
R2	0.95 ± 0.15^{b}	0.25 ± 0.02^{a}	36.89 ± 1.83^{b}	39.02 ± 1.04^{b}
R3	1.20 ± 0.17^{a}	0.26 ± 0.03^{a}	46.38 ± 0.50^{a}	45.06 ± 2.30^{a}
CV	11.82	7.45	2.74	3.34
LSD	0.05	0.01	0.48	0.65

Where: C= control (100 % OFSP), R1= Blending ratio 1 (90% OFSP and 10% tamarind), R2= Blending ratio 2 (80% OFSP and 20% tamarind), R3=Blending ratio 3 (70% OFSP and 30% tamarind), Values in a column with different alphabets are significantly different ($p < 0.05$)

4.7.1. Iron

The more tamarind there was in the blend, the higher the iron content ($p < 0.05$). The iron level of R3 (70% OFSP, 30% tamarind) was the greatest at 1.20 mg/100g, whereas the control sample (100% OFSP) had the lowest at 0.46 mg/100g. The higher iron concentration found naturally in tamarind, which enhances the mineral profile of the jam, is probably the cause of this rise (Uzoaga *et al*., 2020).

4.7.2. Zinc

The zinc concentration varied slightly between 0.24 and 0.26 mg/100g depending on the blending ratio. Only R1 had a significantly decreased zinc content (0.24 mg/100g), despite minor variations; all other treatments were statistically comparable ($p > 0.05$). This suggests that blending with tamarind has a limited effect on zinc content, consistent with reports by Garg *et al*, (2019).

4.7.3. Magnesium

With an increase in the tamarind ratio, the magnesium content gradually rose from 19.27 mg/100g in the control to 46.38 mg/100g in R3. The higher mineral content of tamarind, especially magnesium, increased the nutritional value of the jam, and this increase was significant ($p < 0.05$) (Uzoaga *et al*., 2020).

4.7.4. Calcium

With increased tamarind inclusion, the calcium content also increased significantly, rising from 27.60 mg/100g in the control to 45.06 mg/100g in the R3 blend. The higher calcium levels also show how tamarind contributes to the jam's mineral enrichment (Uzoaga *et al*., 2020).

4.8. Effect of cooking method on mineral content of jam

Table 17 demonstrates impact of different cooking method on mineral content of jam

Table 17. effect of cooking method on blended jam mineral content

Cooking method	**Iron (mg/100g)**	**Zinc (mg/100g)**	**Magnesium (mg/100g)**	**Calcium (mg/100g)**
D	0.95 ± 0.30^{a}	0.26 ± 0.02^{a}	32.70 ± 10.20^{a}	37.00 ± 6.94^{a}
M	0.63 ± 0.30^{c}	0.24 ± 0.26^{b}	32.66 ± 10.20^{a}	36.00 ± 6.94^{b}
P	0.89 ± 0.30^{b}	0.24 ± 0.02^{b}	32.53 ± 10.34^{a}	35.89 ± 6.66^{b}
CV	11.82	7.45	2.74	3.34
LSD	0.04	0.01	0.42	0.56

Where: D= dry heated OFSP, P= pressure cooked OFSP, M= micro wave cooked OFSP

4.8.1. Iron

Iron content of jam was 0.95 mg for D, 0.89 mg for P and 0.63 mg for M. The result ranges from highest 0.95(D) mg to lowest 0.63 mg (M). There is significant difference between the data. The data was similar with Abou and Ahmed, (2021). Dry heating retain iron than other pretreatments.

4.8.2. Zinc

Zinc content ranges from highest 0.26mg (D) to lowest 0.24 mg (M and P).The above table shows dry heated jam zinc content was 0.26 mg, micro wave heated and pressure cooked jam zinc content was 0.24 mg. There is no significant difference between micro wave heating and pressure cooking but there is significant difference between dry heating with both. This result shows similarity with Owade *et al*, (2018).

4.8.3. Magnesium

For magnesium content of blended jam there is no significant difference between all pretreatments. The data shows almost similar values that was 32.70 mg for D, 32.66 mg for M and 32.53 mg for P. Similarity was found with Abong *et al*, (2009). The highest value was recorded for D (32.70 mg and lowest was P (32.53 mg).

4.8.4. Calcium

Calcium content of blended jam that pretreated by microwave recorded 36.00 mg, dry heating 37.00 mg and pressure cooking 35.89 mg. Tt ranges from highest 37.00 mg (D) to lowest 35.89 mg P. There is no significant difference between micro wave heating and pressure cooking but there is significant difference between dry heating with micro wave heating and pressure cooking (Abong *et al*., 2009).

Cooking Time	**Iron (mg/100g)**	**Zinc (mg/100g**	**Magnesium (mg/100g)**	**Calcium (mg/100g)**
T1	O.87±0.32[a]	0.27±0.02[a]	33.12±10.32[a]	36.42±6.79[a]
T2	0.82±0.33[b]	0.25±0.02[b]	32.75±10.24[a]	36.28±6.81[a]
T3	0.78±0.33[b]	0.23±0.03[c]	32.08±10.23[b]	35.60±6.74[b]
CV	11.82	7.45	2.74	3.34
LSD	0.04	0.01	0.42	0.56

4.9. Effect of cooking time on mineral content of jam

Table 18 illustrates the impact of different cooking times on the mineral content of jam

Table 18. impact of different cooking time on mineral content of blended jam

Where: T1= cooking time 1(20 minute), T2= cooking time 2(30 minute), T2= coking time 3(40 minute)

4.9.1. Iron

The longer cooking time resulted in a significant ($p < 0.05$) drop in iron concentration. The greatest iron content, 0.87 mg/100g, was recorded at 20 minutes (T1) and decreased to 0.78 mg/100g after 40 minutes (T3). This reduction may be due to leaching or degradation of iron compounds during prolonged cooking, as reported by Omoikhoje *et al*, (2009).

4.9.2. Zinc

As cooking time rose, zinc levels also dramatically dropped. At 20 minutes (T1), the level was 0.27 mg/100g; at 40 minutes (T3), it was 0.23 mg/100g. This implies that there may be some zinc loss during prolonged cooking, either as a result of solubility into cooking water or heat sensitivity Omoikhoje *et al*, (2009).

4.9.3. Magnesium

With prolonged cooking times, the magnesium content decreased slightly but significantly. At 20 minutes, the levels were 33.12 mg/100g; at 40 minutes, they had dropped to 32.08mg/100g.Although the decrease is modest, it indicates some mineral loss occurs with extended cooking time, in line with observations by Omoikhoje *et al*, (2009).

4.9.4. Calcium

A similar pattern was seen in the calcium level, which decreased somewhat but noticeably as cooking time rose. At 20 minutes, it was 36.42 mg/100g; at 40 minutes, it was 35.60 mg/100g. Leaching or structural alterations brought on by extended exposure to heat could be the reason of this decline. While longer boiling times result in some losses of iron, zinc, magnesium, and calcium, shorter cooking times (20 minutes) are often better at maintaining the blended jam's greater mineral content. These findings emphasize how crucial it is to maximize cooking time in order to maintain nutritional quality(Omoikhoje *et al.*, 2009).

4.10. Effect of blending ratio on physicochemical property of jam

This table shows the result of physicochemical property of different blending ratio.

Table 19. Different blending ratio on physicochemical property of blended jam

Blending ratio	pH	TSS
C	4.55 ± 0.22^{a}	60.19 ± 2.02^{d}
R1	2.97 ± 0.11^{b}	63.62 ± 1.62^{c}
R2	2.47 ± 0.21^{c}	65.93 ± 1.38^{b}
R3	2.02 ± 0.06^{d}	67.85 ± 1.75^{a}
CV	1.93	1.64
LSD	0.03	0.57

Where: C= control (100 % OFSP), R1= Blending ratio 1 (90% OFSP and 10% tamarind), R2= Blending ratio 2 (80% OFSP and 20% tamarind), R3=Blending ratio 3 (70% OFSP and 30% tamarind),

4.10.1. PH

The result of blending ratio on pH was recorded 4.55% for C, 2.97% for R1, 2.47% for R2 and 2.02% for R3 .The highest value for pH value was 4.55% for control and the lowest range recorded for R3, which was 2.02%.Becouse tamarind is high in tartaric acid content so, when tamarind amount increases the jam pH also decreases (Kiranmai *et al*., 2020). There are significant differences among all values.

4.10.2. TSS

TSS value ranged the highest 67.87% to lowest 60.19%which is for R3 and control respectively. Table 19 illustrate that TSS value for different blending ratio and it shows 67.85% for R3, 65.93% for R2, 63.62% for R1 and 60.19% for control (Kiranmai *et al.*, 2020). There is significant difference between TSS results.

4.11. Effect of cooking method on physicochemical property of jam

Table 20 presents the influence of different cooking methods on the physicochemical properties of the blended jam, specifically pH and Total Soluble Solids (TSS).

Table 20**.** The impact of cooking method on physicochemical property of blended jam

Cooking method	**PH**	**TSS**
D	3.10 ± 0.93^{a}	65.27 ± 3.19^{a}
M	3.04 ± 1.05^{b}	63.44 ± 3.70^{c}
P	2.86 ± 0.93^{c}	64.47 ± 2.86^{b}
CV	1.93	1.64
LSD	0.02	1.99

Where: D= dry heated OFSP, P= pressure cooked OFSP, M= micro wave cooked OFSP

4.11.1. PH

The cooking process had a substantial ($p < 0.05$) impact on the jam's pH. The highest reported pH was 3.10 for dry heated jam (D), followed by 3.04 for microwave-cooked jam (M), and 2.86 for pressure-cooked jam (P). Pressure-cooked samples may have a lower pH because of the breakdown of organic acids brought on by the increased heat and pressure, or other chemical changes that affect acidity (Feng *et al.*, 2012).

4.11.2. TSS

Significant variations in TSS concentration were also observed across cooking techniques. The greatest TSS value (65.27 °Brix) was found in dry heated jam, which suggests a larger concentration of dissolved solids or sugar. Microwave-cooked jam had the lowest TSS (63.44 °Brix), while pressure-cooked jam had a slightly lower TSS (64.47 °Brix). Differences in water evaporation and solute concentration brought on by different cooking methods may cause variations in TSS (Abong *et al.*, 2009).

4.12. Effect of cooking time on physiochemical property of jam

Table 21 shows the impact of cooking time on physiochemical property

Table 21**.** Cooking time effect on TSS and PH of blended jam

Cooking time	**PH**	**TSS**
T1	3.08 ± 1.02^{a}	65.70 ± 3.02^{a}
T2	3.00 ± 0.97^{b}	64.42 ± 3.16^{b}
T3	2.92 ± 0.93^{c}	63.08 ± 3.34^{c}
CV	1.93	1.64
LSD	0.03	0.50

Where: T1= cooking time 1(20 minute), T2= cooking time 2(30 minute), T2= coking time 3(40 minute)

4.12.1. PH

The results recorded from cooking blended jam by different cooking time were as follow 3.08% for T1, 3.00% for T2 and 2.92% for T3.There are significant differences ($p < 0.05$) between results. It ranges from highest T1 (3.08%) to lowest T3(2.92%).when time of cooking increased PH of the jam decreased (Feng *et al*., 2012).

4.12.2. TSS

The highest range for TSS was 65.70% for T1, and the lowest is 63.08% for T3.The results were 63.08% for T3, 64.42% for T2 and 65.70 for T1. There are significant differences among TSS results. It was observed that the TSS of blended jam decreased with increased in cooking time (Swami *et al*., 2017).

4.13. Effect of Blending ratio on sensory acceptance of blended jam

The sensory evaluation results for different blending ratios are presented in Table 25. The blending ratio had a significant ($p < 0.05$) effect on all sensory attributes — color, texture, aroma, taste, and overall acceptability — as indicated by the differences in mean scores and LSD test groupings.

Table 22.effect of blending ratio on sensory acceptance of jam

Blending Ratio	**Color**	**Texture**	**Aroma**	**Taste**	**Overall Acceptability**
C	6.38 ± 0.18^{a}	4.70 ± 0.35^{c}	5.58 ± 0.19^{a}	6.01 ± 0.32^{a}	5.67 ± 0.14^{a}
R1	5.68 ± 0.25^{b}	5.14 ± 0.27^{b}	5.56 ± 0.16^{a}	5.45 ± 0.25^{b}	5.46 ± 0.17^{b}
R2	5.30 ± 0.28^{c}	5.29 ± 0.24^{b}	5.51 ± 0.21^{a}	5.23 ± 0.22^{c}	5.34 ± 0.17^{c}
R3	5.12 ± 0.26^{d}	5.97 ± 0.51^{a}	5.57 ± 0.16^{a}	5.16 ± 0.25^{c}	5.45 ± 0.19^{b}
CV	4.92	5.84	3.09	4.37	2.54
LSD	0.15	0.16	0.09	0.12	0.07

4.13.1. Color

The highest color score was recorded for the control sample (C) with a mean value of 6.38 ± 0.18a, which was significantly higher than all other treatments. This suggests that the control jam had the most appealing visual appearance, possibly due to the retention of the natural pigment and clarity associated with single-fruit jams. As the blending ratio of tamarind increased , the color scores decreased significantly, with the lowest value observed for 70% OFSP and 30% tamarind (R3) (5.12).This decline may be due to increased browning or pigment interactions between sweet potato and tamarind, which has been reported to cause darker hues and lower visual brightness (Abong *et al.*, 2009).

4.13.2. Texture

The texture characteristic increased with blending up to R3, in contrast to color. In contrast to the control sample (4.70), the R3 sample had the highest texture score (5.97).The pectin–sugar–acid balance from the tamarind addition may be responsible for the blended samples' higher texture score, which is also connected to better gel formation and consistent consistency (Kourouma *et al*., 2019).

4.13.3. Aroma

All samples had the same grouping letter (a), indicating that there were no significant differences in aroma scores ($p > 0.05$) between treatments. This suggests that the jam's perceived scent intensity and pleasantness were not significantly impacted by the blending ratio. This outcome is consistent with research by Abou and Ahmed, (2021), who found that when fruits with complimentary aromatic profiles are employed, the cooking process has a greater impact on volatile fragrance compounds in jams than the mixing ratio.

4.13.4. Taste

As the blending ratio increased, taste scores decreased. The control sample had the greatest score (6.01), followed by R1 (5.45), while 80% OFSP and 20% Tamarind (R2), 70% OFSP and 30% Tamarind R3 (both in group c) had the lowest values. Higher tamarind ratios may result in less taste acceptance because of their greater acidity and tartness, which could overpower the sweet potato's inherent sweetness. Owade *et al*, (2018) also noted this pattern in composite fruit jams.

4.13.5. Overall Acceptability

With the exception of R3, which marginally improved in score (5.45), presumably as a result of better texture offsetting the lower taste and color scores, overall acceptability was highest in the control group (5.67) and gradually decreased as the blending ratio increased. Although textural enhancements at greater blending ratios can partially offset flavor and color alterations, this shows that customer preference tended toward jams with a dominating sweet potato foundation (Owade *et al*., 2018).

4.14. Effect of cooking method on sensory acceptance of blended jam

Table 26 shows effect of cooking method on sensory acceptability of blended jam

Table 23. Impact of cooking method on sensory acceptance of blended jam

Cooking method	**Color**	**Texture**	**Aroma**	**Taste**	**Overall acceptability**
D	5.67 ± 0.51^{a}	5.52 ± 0.60^{a}	5.66 ± 0.20^{a}	5.58 ± 0.40^{a}	5.60 ± 0.19^{a}
M	5.63 ± 0.55^{a}	5.01 ± 0.46^{c}	5.50 ± 0.15^{b}	5.27 ± 0.41^{b}	5.35 ± 0.17^{c}
P	5.56 ± 0.60^{a}	5.29 ± 0.57^{b}	5.52 ± 0.16^{b}	5.53 ± 0.40^{a}	5.48 ± 0.18^{b}
CV	4.92	5.84	3.09	4.37	2.54
LSD	0.13	0.14	0.08	0.11	0,06

4.14.1. Color

There was no significant difference ($p > 0.05$) in color scores among the three cooking methods. Dry heating (5.67), microwave (5.63) and pressure cooking (5.56) were all rated similarly, indicating that the visual appearance of the jam was not notably affected by the cooking technique. This aligns with findings by (Afoakwah *et al.*, 2023b), who observed minimal color variation in fruit products subjected to different heating methods.

4.14.2. Texture

Dry heating received the highest rating 5.52, followed by pressure cooking 5.29 and microwave cooking 5.01. Texture evaluations varied substantially ($P < 0.05$). The uneven heating that affects gel consistency may be the cause of the microwave-treated jam's lower texture score (Syukri *et al*., 2022).

4.14.3. Aroma

The most aromatic jam was made by dry heating 5.66, which was much more than the microwave 5.50 and pressure 5.52 methods. The creation of aroma is impacted by Maillard reactions and flavor ingredient volatilization, which happen more uniformly during pressure and conventional heating (Quindara *et al*., 2020).

4.14.4. Taste

Dry heating was clearly preferred (5.58) and pressure cooking (5.53), both of which were significantly ($P < 0.05$) higher than (5.27) of microwave method. Better sugar concentration and caramelization from more even heating may be the cause of these techniques' enhanced flavor (Quindara *et al., 2020).*

4.14.5. Overall Acceptability

The greatest overall acceptance scores 5.60 went to dry-heated jam, which was followed by microwave (5.35) and pressure cooking (5.48). Superior taste, aroma, and texture from traditional heating techniques are all combined to create this trend. Consequently, according to customer sensory reaction, dry heating is the most favored technique (Abong *et al*., 2009).

4.15. Cooking time effect on sensory acceptance of blended jam

Table 27 shows the result for sensory acceptability of blended jam by different cooking time

Table 24. Impact of cooking time on sensory acceptance of blended jam

Cooking time	Color	Texture	Aroma	Taste	Overall Acceptability
T1	5.65±0.54[a]	5.19±0.58[b]	5.55±0.21[a]	5.38±0.44[b]	5.44±0.21[b]
T2	5.62±0.54[a]	5.28±0.57[ab]	5.55±0.18[a]	5.47±0.40[ab]	5.48±0.19[ab]
T3	5.60±0.56[a]	5.35±0.58[a]	5.57±0.16[a]	5.53±0.42[a]	5.51±0.20[a]
CV	4.92	5.84	3.09	4.37	2.54
LSD	0.13	0.14	0.08	0.11	0.06

4.15.1. Color

The three cooking durations did not significantly differ in color scores (P > 0.05). T1 (20 minutes), T2 (30 minutes), and T3 (40 minutes) all obtained scores that were comparable, ranging from (5.60) to (5.65). This implies that the jam's visual appeal was not much affected by cooking time, which is consistent with earlier research showing that color stays constant under well-regulated heating circumstances (Syukri *et a*l., 2022).

4.15.2. Texture

Longer cooking periods resulted in somewhat higher texture scores. T3 received the highest rating (5.35), followed by T2 (5.28) and T1 (5.19). Better gel consistency and pectin breakdown may be the cause of the improvement of texture over extended periods of time. There was a statistically significant difference between T1 and T3 (P< 0.05) (Abou and Ahmed, 2021).

4.15.3. Aroma

All cooking durations had the same aroma scores (5.55–5.57), and there was no discernible variation (p > 0.05). This suggests that cooking for an additional 20 to 40 minutes had no discernible impact on the formation of scent (Syukri *et a*l., 2022)

4.15.4. Taste

As cooking time increased, taste improved slightly: T3 (5.53) scored better than T1 5.38, with T2 5.47 falling in between. According to Sagar and Kumar (2014), longer cooking times may improve flavor development and sugar concentration, which would improve taste. Between T1 and T3, there was a significant difference (p < 0.05) (Quindara *et al.*, 2020).

4.15.5. Overall Acceptability

Overall acceptability increased from 5.44 (T1) to 5.51 (T3), following a similar pattern to flavor and texture. The higher score for T3 was statistically significant, despite the fact that the differences were slight, suggesting that cooking for 40 minutes produced a better product.

While longer cooking times (up to 40 minutes) had no detrimental effects on color or aroma, they did modestly improve the blended jam's texture, taste, and general acceptability. According to these results, cooking for moderate to long periods of time improves the sensory results (Kourouma *et al*., 2019).

4.16. Interaction effect on nutrient composition of blended jam

Table 28 demonstrates interaction impact on proximate composition of jam

Table 25. Interaction effect on proximate composition of jam

Code	Moisture (%)	Crude Protein (%)	Fiber (%)	Crude Fat (%)	Ash (%)	Total Carbohydrate (%)	Total Energy(kcal\100g)
DCT1	32.00 ± 1.00^{cdefghıjk}	1.62 ± 0.03^{eghjklmnop}	0.71 ± 0.02^{kl}	0.57 ± 0.01^{abdefg}	1.44 ± 0.00^{ab}	63.66 ± 0.97^{ıjk}	266.26 ± 3.71^{e}
DCT2	31.00 ± 1.00^{dfhıjk}	1.62 ± 0.04^{eghjklmnop}	0.68 ± 0.01^{klm}	0.55 ± 0.01^{abdefg}	1.42 ± 0.00^{ab}	64.72 ± 0.95^{ıjk}	270.30 ± 3.79^{def}
DCT3	29.33 ± 1.15^{fhıkjlmn}	1.58 ± 0.05^{egjklmnop}	0.63 ± 0.02^{klm}	0.51 ± 0.01^{abdefg}	1.39 ± 0.00^{ab}	66.54 ± 0.98^{de}	277.15 ± 5.00^{de}
DR1T1	29.66 ± 0.57^{fhıkjlm}	1.65 ± 0.02^{eghjklm}	1.15 ± 0.01^{gh}	0.61 ± 0.01^{abcd}	1.51 ± 0.00^{ab}	65.40 ± 0.67^{def}	273.71 ± 2.16^{def}
DR1T2	28.00 ± 1.00^{fhıkjlnop}	1.66 ± 0.02^{efghjklm}	1.13 ± 0.02^{hı}	0.58 ± 0.01^{abcd}	1.48 ± 0.00^{ab}	67.14 ± 0.97^{de}	280.46 ± 4.21^{de}
DR1T3	26.33 ± 1.52^{hıkjloφr}	1.59 ± 0.01^{eghjklmno}	1.07 ± 0.02^{ij}	0.57 ± 0.01^{abdefg}	1.46 ± 0.00^{ab}	68.96 ± 1.40^{bc}	287.37 ± 6.30^{bc}
DR2T1	27.33 ± 1.52^{fhıkjlopφ}	1.68 ± 0.05^{efghij}	1.24 ± 0.05^{g}	0.61 ± 0.01^{abcd}	1.55 ± 0.00^{abc}	67.56 ± 1.61^{cd}	282.56 ± 6.00^{cd}
DR2T2	25.33 ± 1.52^{hıkjlos}	1.66 ± 0.02^{efghjkl}	1.23 ± 0.01^{g}	0.60 ± 0.01^{abcd}	1.53 ± 0.00^{abc}	69.64 ± 1.65^{bc}	290.64 ± 5.98^{bc}
DR2T3	23.66 ± 2.25^{hıkjlost}	1.63 ± 0.02^{eghjklmno}	1.16 ± 0.01^{gh}	0.58 ± 0.01^{abcd}	1.51 ± 0.00^{ab}	71.44 ± 2.59^{ab}	297.55 ± 10.13^{ab}
DR3T1	25.00 ± 1.00^{hıkjlos}	1.73 ± 0.03^{def}	1.54 ± 0.02^{bcd}	0.65 ± 0.01^{abcdef}	1.60 ± 0.00^{abc}	69.46 ± 0.85^{bc}	290.66 ± 4.12^{bc}
DR3T2	23.30 ± 1.52^{hıkjlos}	1.72 ± 0.04^{efg}	1.52 ± 0.01^{bcde}	0.62 ± 0.01^{abcdefg}	1.57 ± 0.00^{abc}	71.22 ± 1.38^{a}	297.41 ± 6.31^{a}

DR3T3	22.66 ± 1.15^{t}	1.66 ± 0.03^{efghjkl}	1.43 ± 0.05^{cdef}	0.59 ± 0.01^{abcd}	1.55 ± 0.00^{abc}	72.09 ± 1.01^{a}	300.35 ± 4.85^{a}
MCT1	34.66 ± 0.57^{bcd}	1.68 ± 0.01^{efghij}	0.79 ± 0.01^{k}	0.65 ± 0.01^{abcde}	1.74 ± 0.00^{ab}	60.46 ± 0.45^{φ}	254.49 ± 2.45^{fg}
MCT2	33.00 ± 1.00^{cdefghıjk}	1.67 ± 0.02^{efghjk}	0.75 ± 0.04^{k}	0.64 ± 0.01^{abcd}	1.71 ± 0.00^{ab}	62.22 ± 0.88^{mn}	261.34 ± 3.91^{ef}
MCT3	31.00 ± 1.00^{dfhıjk}	1.65 ± 0.04^{eghjklm}	0.70 ± 0.01^{kl}	0.61 ± 0.01^{abcd}	1.67 ± 0.00^{ab}	64.36 ± 0.87^{ıjk}	269.57 ± 4.32^{def}
MR1T1	33.33 ± 0.57^{cdefghı}	1.71 ± 0.02^{efgh}	1.22 ± 0.03^{g}	0.67 ± 0.01^{abc}	1.77 ± 0.00^{abc}	61.28 ± 0.46^{φ}	258.06 ± 2.70^{f}
MR1T2	31.33 ± 1.15^{cdfghıj}	1.70 ± 0.02^{efghı}	1.20 ± 0.03^{g}	0.63 ± 0.01^{abcd}	1.75 ± 0.00^{ab}	63.37 ± 0.93^{n}	266.00 ± 4.69^{e}
MR1T3	30.33 ± 1.52^{dfhıkjl}	1.69 ± 0.01^{efghı}	1.15 ± 0.01^{gh}	0.61 ± 0.01^{abcd}	1.71 ± 0.00^{ab}	64.49 ± 1.40^{ıjklm}	270.29 ± 6.32^{def}
MR2T1	31.66 ± 0.57^{cdefghı}	1.80 ± 0.02^{cd}	1.49 ± 0.17^{bcdef}	0.69 ± 0.01^{abc}	1.80 ± 0.00^{ab}	62.55 ± 0.58^{mn}	263.58 ± 2.79^{ef}
MR2T2	30.00 ± 1.00^{dfhıkjl}	1.78 ± 0.01^{de}	1.47 ± 0.17^{bcdef}	0.67 ± 0.01^{abcde}	1.79 ± 0.00^{ab}	64.28 ± 0.87^{mn}	264.28 ± 0.87^{e}
MR2T3	28.00 ± 1.00^{fhıkjlnop}	1.70 ± 0.04^{efghı}	1.42 ± 0.15^{cdef}	0.63 ± 0.01^{abcd}	1.73 ± 0.00^{ab}	66.51 ± 0.83^{ıjklm}	278.55 ± 4.23^{de}
MR3T1	29.66 ± 0.57^{fhıkjlm}	1.99 ± 0.07^{a}	1.67 ± 0.13^{efg}	0.72 ± 0.01^{a}	1.85 ± 0.00^{a}	64.08 ± 0.67^{ıjklm}	270.83 ± 2.90^{de}
MR3T2	28.66 ± 0.57^{fhıkjlmo}	1.91 ± 0.02^{b}	1.65 ± 0.13^{ef}	0.71 ± 0.01^{ab}	1.81 ± 0.00^{ab}	65.24 ± 0.61^{ıjklm}	275.01 ± 2.83^{de}
MR3T3	26.66 ± 0.57^{hıkjlopφ}	1.85 ± 0.04^{bc}	1.59 ± 0.17^{ef}	0.68 ± 0.01^{abcd}	1.77 ± 0.00^{abc}	67.43 ± 0.63^{efg}	283.23 ± 3.07^{cd}
PCT1	37.33 ± 0.57^{a}	1.51 ± 0.02^{φr}	0.60 ± 0.03^{klm}	0.54 ± 0.01^{adg}	1.34 ± 0.00^{ab}	58.67 ± 0.53^{g}	245.59 ± 2.49^{h}
PCT2	36.00 ± 0.00^{ab}	1.50 ± 0.02^{φr}	0.58 ± 0.01^{lm}	0.52 ± 0.01^{eg}	1.32 ± 0.00^{ab}	60.07 ± 0.07^{g}	251.00 ± 0.75^{g}
PCT3	34.33 ± 1.15^{bcd}	1.48 ± 0.02^{r}	0.54 ± 0.02^{m}	0.50 ± 0.01^{φ}	1.29 ± 0.00^{ab}	61.84 ± 1.04^{f}	257.83 ± 5.07^{f}
PR1T1	35.33 ± 1.15^{abc}	1.59 ± 0.03^{eghjklmno}	1.01 ± 0.02^{j}	0.56 ± 0.01^{abdfg}	1.39 ± 0.00^{ab}	60.11 ± 1.22^{φ}	251.87 ± 4.64^{fg}

PR1T2	33.66 ± 1.15^{cde}	1.56 ± 0.05^{gφ}	1.00 ± 0.01^{j}	0.52 ± 0.01^{abdefg}	1.37 ± 0.00^{ab}	61.86 ± 1.31^{f}	258.44 ± 1.31^{f}
PR1T3	31.66 ± 0.52^{cdefghıj}	1.52 ± 0.06^{φr}	0.96 ± 0.03^{j}	0.49 ± 0.01^{gop}	1.34 ± 0.00^{ab}	64.01 ± 1.71^{e}	266.57 ± 5.75^{e}
PR2T1	33.00 ± 1.00^{cdefghıjk}	1.60 ± 0.05^{eghjklmno}	1.18 ± 0.02^{gh}	0.57 ± 0.01^{abdefg}	1.42 ± 0.00^{ab}	62.20 ± 0.92^{mn}	260.44 ± 4.11^{ef}
PR2T2	30.33 ± 0.57^{dfhıkjl}	1.62 ± 0.04^{eghjklmnop}	1.14 ± 0.03^{gh}	0.51 ± 0.01^{abdefg}	1.37 ± 0.00^{ab}	65.05 ± 0.50^{ıjk}	271.18 ± 2.77^{e}
PR2T3	30.33 ± 0.57^{dfhıkjl}	1.58 ± 0.04^{eghjklmno}	1.15 ± 0.01^{gh}	0.51 ± 0.01^{abdefg}	1.37 ± 0.00^{ab}	65.05 ± 0.50^{ıjk}	271.18 ± 2.77^{e}
PR3T1	30.66 ± 2.08^{dfhıkjl}	1.66 ± 0.06^{efghjkl}	1.42 ± 0.02^{cdef}	0.60 ± 0.01^{abcd}	1.48 ± 0.00^{ab}	64.17 ± 2.00^{ıjk}	280.94 ± 11.78^{cd}
PR3T2	29.66 ± 3.05^{dfhıkjlm}	1.64 ± 0.05^{eghjklmn}	1.41 ± 0.04^{cdef}	0.58 ± 0.01^{abcd}	1.45 ± 0.00^{ab}	65.24 ± 3.00^{ıjk}	272.76 ± 12.49^{def}
PR3T3	27.66 ± 2.88^{fhıkjlopn}	1.62 ± 0.05^{eghjklmnop}	1.37 ± 0.02^{def}	0.55 ± 0.01^{abdefg}	1.42 ± 0.00^{ab}	67.37 ± 2.78^{efg}	280.94 ± 11.78^{cd}
CV	4.37	2.25	6.43	15.59	3.77	1.97	1.98
LSD	2.14	0.06	0.12	0.15	0.09	2.08	8.78

4.16.1. Moisture

Moisture ranged from about 22.66 to 37.33%. The wettest samples were PCT1 = 37.33 ± 0.57 (group A) and PCT2 = 36.00 ± 0.00 (A–B), while the driest samples grouped in the DR3 and DR3T3 range (e.g., DR3T3 = 22.66 ± 1.15, group T). This suggests that while the "PCT" condition held onto the most moisture, the particular dry heated with 70% OFSP and 30% Tamarind "DR3" condition at the higher blending level (T3) removed the most water. These variations are consistent with research demonstrating that longer or more intensive heating/mass transfer processes decrease moisture and water activity, particularly when pectin–sugar matrices form rapidly (Abou and Ahmed, 2021).

4.16.2. Protein

Overall crude protein content was low (as is common for jams made with fruit), but there were noticeable interaction effects. Group A had MR3T1 = 1.99 ± 0.07, group B had MR3T2 = 1.91 ± 0.02, and group B–C had MR3T3 = 1.85 ± 0.04, the highest results under the micro wave heating with 70% OFSP and 30% Tamarind "MR3" condition. Conversely, the "PCT" set had

the lowest (≈1.48–1.51%). There have been reports that milder, solids-preserving conditions can marginally increase apparent protein in tuber-fruit preserves, and the higher protein in MR3 may indicate improved preservation of sweet-potato solids (especially from orange-fleshed varieties) and less dilution by process moisture (Owade *et al*., 2018).

4.16.3. Fiber

At higher T levels, dietary fiber increased significantly with MR and DR conditions: MR3T1 = 1.67 ± 0.13, MR3T2 = 1.65 ± 0.13, and DR3T1 = 1.54 ± 0.02; all of these values fall into the top tiers. PCT2–PCT3 had the lowest fiber levels (≈0.54–0.58%). These trends imply that (i) a larger percentage of sweet potatoes and (ii) processing that reduces fiber deterioration and leaching maintains the architecture of insoluble and soluble fibers. Previous research also demonstrates that during jam concentration, fiber retention is sensitive to matrix pH and soluble particles as well as heat severity (Abong *et al.,* 2009*).*

4.16.4. Crude fat

Despite being low (≈0.49–0.72%), crude fat continued to show interaction effects. The lowest values concentrated around PR1T3 = 0.49 ± 0.01 and PCT3 = 0.50 ± 0.01; the highest values were MR3T1 = 0.72 ± 0.01 and MR3T2 = 0.71 ± 0.01. Small increases under MR3T1may be the result of improved retention of sweet potato's endogenous lipids, which are primarily membrane-associated and can be lost through more watery, harsher, or prolonged procedures (Kourouma *et al*., 2019).

4.16.5. Ash

Ash was lowest in PCT (≈1.29–1.34%) and highest under MR3 (e.g., MR3T1 = 1.85 ± 0.00, MR3T2 = 1.81 ± 0.00). These data show that MR3 conditions helped maintain mineral fractions (e.g., K, Mg, Ca, Fe), which is consistent with findings that shorter exposure and less leaching protect minerals in root-fruit products, given that ash approximates mineral content(Abou and Ahmed, 2021).

4.16.6. Total carbohydrate and energy

As anticipated, there was an inverse relationship between total carbohydrates and moisture. DR3T3 = 72.09 ± 1.01 (group A) and DR3T2 = 71.22 ± 1.38 (A) had the highest carbohydrate content, whereas MCT1 (60.46 ± 0.45) and PCT1 (58.67 ± 0.53) had the lowest. The energy density (kcal/100 g) thus showed the similar pattern: the most energy-dense were DR3T3 = 300.35 ± 4.85 and DR3T2 = 297.41 ± 6.31, while the least were PCT1 = 245.59 ± 2.49 and

PCT2 = 251.00 ± 0.75. Jams typically exhibit a strong moisture–carbohydrate–energy coupling, with the concentration of sucrose and soluble solids rising as water is displaced (Abong *et al.*, 2009).

4.17. Interaction effect on vitamin content of blended jam

Table 29 shows interaction effect on vitamin content of blended jam

Table 26. Interaction effect on vitamin content of blended jam

Code	Beta carotene	Vitamin C
DCT1	188.29 ± 9.12^{bac}	12.17 ± 0.15^{fgdech}
DCT2	182.89 ± 5.58^{ebdac}	11.97 ± 0.15^{fgdech}
DCT3	178.95 ± 2.43^{ebdfc}	11.73 ± 0.21^{fgdeh}
DR1T1	169.45 ± 10.43^{ehgfig}	12.40 ± 0.10^{fgdech}
DR1T2	161.50 ± 20.40^{hjfig}	12.23 ± 0.15^{fgdech}
DR1T3	155.62 ± 14.97^{lhjki}	11.87 ± 0.25^{fgdeh}
DR2T1	157.00 ± 12.77^{hjkig}	12.63 ± 0.25^{fgdech}
DR2T2	145.75 ± 21.89^{lopknpm}	12.30 ± 0.20^{fgdech}
DR2T3	134.36 ± 19.05^{oqrnpqm}	12.13 ± 0.21^{fgdech}
DR3T1	138.94 ± 14.05^{oqrnpqm}	12.87 ± 0.25^{fbdech}
DR3T2	131.59 ± 11.72^{oqrnp}	12.60 ± 0.17^{fgdech}
DR3T3	123.75 ± 9.55^{sqr}	12.23 ± 0.15^{fgdech}
MCT1	198.80 ± 3.00^{a}	12.87 ± 0.25^{fbdech}
MCT2	189.95 ± 7.35^{bac}	12.53 ± 0.21^{fgdech}
MCT3	186.41 ± 6.84^{bdac}	12.20 ± 0.10^{fgdech}
MR1T1	178.91 ± 10.07^{ebdfc}	13.03 ± 0.15^{bdec}
MR1T2	172.60 ± 11.08^{edfcig}	12.80 ± 0.20^{fbdech}
MR1T3	162.90 ± 9.62^{hjfig}	12.53 ± 0.25^{fgdech}
MR2T1	161.78 ± 18.55^{hjfig}	13.20 ± 0.10^{bdec}
MR2T2	151.84 ± 15.16^{lhjkim}	13.00 ± 0.17^{bdec}
MR2T3	141.50 ± 11.40^{loqknpm}	12.53 ± 0.15^{fgdech}
MR3T1	132.53 ± 19.56^{oqrnp}	13.40 ± 0.20^{bac}
MR3T2	133.28 ± 17.75^{oqrnpm}	13.13 ± 0.15^{bdec}

MR3T3	117.76 ± 12.27^{sr}	12.80 ± 0.10^{fbdech}
PCT1	183.16 ± 10.04^{ebac}	11.47 ± 0.25^{fgdeh}
PCT2	177.32 ± 6.32^{ebfc}	11.13 ± 0.15^{gh}
PCT3	167.60 ± 8.66^{ehfig}	10.77 ± 0.40^{h}
PR1T1	164.73 ± 8.04^{hjfig}	11.90 ± 0.30^{fgdeh}
PR1T2	157.87 ± 10.00^{hjkig}	11.67 ± 0.21^{fgdeh}
PR1T3	151.08 ± 9.59^{lhjkinm}	11.33 ± 0.23^{gh}
PR2T1	149.84 ± 1.63^{lojknp}	12.20 ± 0.36^{fgdech}
PR2T2	140.33 ± 1.67^{lo}ϥ^{knpm}	11.93 ± 0.35^{fgdeh}
PR2T3	135.57 ± 3.91^{o}ϥ^{rnpm}	11.50 ± 0.53^{fgdeh}
PR3T1	137.39 ± 6.75^{o}ϥ^{rnpm}	12.43 ± 0.35^{fgdech}
PR3T2	129.87 ± 10.13^{s}ϥ^{r}	14.73 ± 4.14^{a}
PR3T3	112.18 ± 6.66^{s}	14.37 ± 4.11^{ba}
CV	7.54	8.04
LSD	19.11	1.62

4.17.1. β-Carotene

The range of β-Carotene content was 198.80 ± 3.00 µg/g (MCT1, group a) to 112.18 ± 6.66 µg/g(PR3T3groups).

Maximum β-carotene: The MCT group continuously maintained greater levels of carotenoid (MCT1 = 198.80, MCT2 = 189.95, and MCT3 = 186.41 µg/g), with DCT1 = 188.29 and PCT1 =183.16 coming in close behind.

Lowest β-carotene: The PR3T3, PR3T2, and DR3T3 combinations had the lowest concentrations due to prolonged processing and high blending levels, which may indicate more pigment degradation.

The results show that β-carotene is sensitive to oxygen and extended heat exposure, but it has a moderate level of heat stability in low-water matrices. enhanced sweet potato fractions—rich in orange-fleshed cultivars—and moderate heating intensities are probably the causes of the enhanced retention in MCT and DCT (Owade et al., 2018). Lower values in DR3T3 and PR3T3,

on the other hand, might be the consequence of cumulative thermal-oxidative loss across prolonged concentration stages (Kourouma *et al.*, 2019).

4.17.2. Vitamin C

Vitamin C content ranged from 10.77 ± 0.40 mg/100 g **(**PCT3, group h**)** to 14.73 ± 4.14 mg/100 g **(**PR3T2, group a).

Highest vitamin C: MR3T1 (13.40 mg/100 g). These results show that some "MR" treatments with larger blending ratios retained more ascorbic acid, maybe as a result of either a higher tamarind content, which can supply its own vitamin C, or a shorter exposure to high temperatures during final concentration(Abou and Ahmed, 2021).

Lowest vitamin C: Longer cooking periods, higher pH, and increased exposure to oxidative conditions—factors known to promote vitamin C degradation—were probably the causes of the PCT series', especially PCT3, lowest values(Kourouma *et al*., 2019).

These findings support the known fact that vitamin C is one of the most heat-labile micronutrients, and that prolonging processing, lowering oxygen exposure, and high temperatures are forbidden for its preservation(Owade *et al.*, 2018).

4.18. Interaction effect on mineral content of blended jam

The combination of cooking method, cooking duration, and blending ratio resulted in a substantial ($p < 0.05$) variation in the mineral composition of the sweet potato–tamarind blended jams (Table 30). The interaction effects for each mineral component separately are shown in the ensuing subsections.

Table 27. Interaction effect on mineral content of blended jam

Code	Iron	Zinc	Magnesium	Calcium
DCT1	0.5933 ± 0.01^{k}	0.2900 ± 0.01^{ab}	19.6667 ± 0.00^{f}	19.63 ± 0.44^{d}
DCT2	0.5667 ± 0.01^{k}	0.2733 ± 0.01^{abcdef}	19.4667 ± 0.00^{f}	19.50 ± 0.30^{d}
DCT3	0.5267 ± 0.01^{k}	$0.2467 \pm 0.01^{abcdfghij}$	19.1667 ± 0.00^{f}	19.35 ± 0.36^{d}

DR1T1	0.8500 ± 0.01^{hfge}	0.2733 ± 0.01^{abcdef}	28.8000 ± 0.00^{d}	28.78 ± 0.28^{c}
DR1T2	0.8333 ± 0.01^{hg}	0.2533 ± 0.01^{abcdfghi}	28.4333 ± 0.00^{ed}	28.72 ± 0.31^{c}
DR1T3	0.8033 ± 0.01^{hg}	0.2400 ± 0.01^{bcfghij}	28.1667 ± 0.00^{ed}	28.50 ± 0.30^{c}
DR2T1	1.1167 ± 0.01^{dcb}	0.2867 ± 0.01^{abc}	37.8000 ± 0.00^{b}	37.69 ± 0.50^{b}
DR2T2	1.0733 ± 0.01^{dc}	0.2567 ± 0.01^{abcdfgh}	37.4000 ± 0.00^{b}	37.46 ± 0.47^{b}
DR2T3	1.0400 ± 0.01^{dc}	0.2433 ± 0.01^{bcfghij}	33.6333 ± 0.00^{c}	37.30 ± 0.40^{b}
DR3T1	1.3833 ± 0.01^{a}	0.2967 ± 0.01^{a}	46.8667 ± 0.00^{a}	46.56 ± 0.24^{a}
DR3T2	1.3567 ± 0.01^{a}	0.2767 ± 0.01^{abcde}	46.4000 ± 0.00^{a}	46.39 ± 0.40^{a}
DR3T3	1.3200 ± 0.01^{a}	0.2500 ± 0.01^{abcdfghi}	46.1000 ± 0.00^{a}	46.31 ± 0.49^{a}
MCT1	0.5733 ± 0.01^{k}	0.2500 ± 0.01^{abcdfghi}	19.5333 ± 0.00^{f}	19.57 ± 0.38^{d}
MCT2	0.5333 ± 0.01^{l}	0.2500 ± 0.01^{abcdfghi}	19.4333 ± 0.00^{f}	19.45 ± 0.38^{d}
MCT3	0.4500 ± 0.01^{l}	0.2267 ± 0.01^{bfghjkl}	18.9667 ± 0.00^{f}	19.33 ± 0.41^{d}
MR1T1	0.5167 ± 0.01^{k}	0.2467 ± 0.01^{bcfghij}	28.5333 ± 0.00^{ed}	28.75 ± 0.24^{c}
MR1T2	0.4767 ± 0.01^{k}	0.2367 ± 0.01^{bfghj}	28.0333 ± 0.00^{ed}	28.60 ± 0.36^{c}
MR1T3	0.4633 ± 0.01^{k}	0.2000 ± 0.01^{gkl}	27.5000 ± 0.00^{e}	28.44 ± 0.37^{c}

MR2T1	0.7700 ± 0.01^{h}	0.2567 ± 0.01^{abcdfgh}	37.7667 ± 0.00^{b}	37.64 ± 0.45^{b}
MR2T2	0.7400 ± 0.01^{hi}	0.2433 ± 0.01^{bcfghij}	37.4000 ± 0.00^{b}	37.44 ± 0.47^{b}
MR2T3	0.7100 ± 0.01^{ij}	0.2300 ± 0.01^{bfghjk}	36.7333 ± 0.00^{b}	37.27 ± 0.36^{b}
MR3T1	1.0067 ± 0.01^{dce}	0.2667 ± 0.01^{abcdefg}	46.8000 ± 0.00^{a}	46.48 ± 0.47^{a}
MR3T2	0.9633 ± 0.01^{dfce}	0.2500 ± 0.01^{abcdfghi}	46.3667 ± 0.00^{a}	46.35 ± 0.47^{a}
MR3T3	0.9500 ± 0.01^{dfge}	0.2167 ± 0.01^{fgjkl}	46.0333 ± 0.00^{a}	44.47 ± 0.41^{a}
PCT1	0.5333 ± 0.01^{k}	0.2733 ± 0.01^{abcdef}	19.3333 ± 0.00^{f}	19.53 ± 0.38^{d}
PCT2	0.5000 ± 0.01^{k}	0.2533 ± 0.01^{abcdfghi}	19.0667 ± 0.00^{f}	19.40 ± 0.40^{d}
PCT3	0.4500 ± 0.01^{k}	0.2233 ± 0.01^{bfghjkl}	18.8333 ± 0.00^{f}	19.30 ± 0.35^{d}
PR1T1	0.7933 ± 0.01^{h}	0.2500 ± 0.01^{abcdfghi}	28.2000 ± 0.00^{ed}	28.73 ± 0.38^{c}
PR1T2	0.7667 ± 0.01^{h}	0.2300 ± 0.01^{bfghjk}	27.6667 ± 0.00^{ed}	28.54 ± 0.26^{c}
PR1T3	0.7133 ± 0.01^{hij}	0.1967 ± 0.01^{l}	27.1333 ± 0.00^{e}	28.39 ± 0.35^{c}
PR2T1	1.0533 ± 0.01^{dc}	0.2633 ± 0.01^{abcdefg}	37.4667 ± 0.00^{b}	37.48 ± 0.31^{b}
PR2T2	1.0333 ± 0.01^{dc}	0.2567 ± 0.01^{abcdfgh}	37.1000 ± 0.00^{b}	37.38 ± 0.41^{b}
PR2T3	1.0033 ± 0.01^{dce}	0.2233 ± 0.01^{bfghjkl}	36.7000 ± 0.00^{b}	37.21 ± 0.46^{b}

PR3T1	1.3233 ± 0.01[a]	0.2833 ± 0.01[bdac]	46.7000 ± 0.00[a]	46.49 ± 0.40[a]
PR3T2	1.2867 ± 0.01[a]	0.2633 ± 0.01[abcdefg]	46.2333 ± 0.00[a]	46.36 ± 0.37[a]
PR3T3	1.2433 ± 0.01[bac]	0.2433 ± 0.01[bcfghij]	46.0000 ± 0.00[a]	46.25 ± 0.37[a]
CV	11.82	7.45	2.74	3.34
LSD	0.15	0.03	1.45	1.96

4.18.1. Iron

The iron concentration varied between 0.45 ± 0.01 mg/100 g in MCT3 and PCT3 samples and 1.38 ± 0.01 mg/100 g in DR3T1, suggesting that a larger tamarind fraction and longer cooking time combined with dry roasting significantly improved iron retention. The naturally high iron content of tamarind pulp and decreased leaching losses after dry-heat processing could be the cause of this(Owade *et al.*, 2018). At larger dilution ratios, however, moist cooking and pressure cooking produced lower iron values, most likely due to mineral solubility in cooking water.

4.18.2. Zinc

Zinc levels varied less than iron, ranging from 0.1967 ± 0.01 mg/100 g in PR1T3 to 0.2967 ± 0.01 mg/100 g in dry heated with 70% OFSP and 30% Tamarind and cooked for 20 minutes (DR3T1). This is consistent with Kourouma *et al*, (2019), who observed that higher protein binding in plant tissues makes zinc less likely to leak. The little but noteworthy variations, however, imply that dry-heat techniques continue to promote zinc retention, possibly as a result of insufficient exposure to watery fluids.

4.18.3. Magnesium

From 18.83 ± 0.00 mg/100 g in PCT3 to 46.86 ± 0.00 mg/100 g in dry heated with 70% OFSP and 30% Tamarind and cooked for 20 minutes (DR3T1), the magnesium content varied greatly, exhibiting a trend like that of iron, where larger mineral concentrations were kept by dry roasting at longer cooking periods. Because magnesium dissolves in water, losses are more likely to occur when boiling or blanching(Abou and Ahmed, 2021). The higher results in the dry heated with 70% OFSP and 30% Tamarind (DR3) and micro wave heated with 70% OFSP and 30%

Tamarind (MR3) treatments also imply that the jam's magnesium enrichment is much aided by larger tamarind proportions.

4.18.4. Calcium

In PCT3, the calcium concentration was 19.30 ± 0.35 mg/100 g, while in DR3T1, it was 46.56 ± 0.24 mg/100 g. Previous findings that tamarind pulp is high in calcium and can improve the mineral profile of composite fruit products are supported by the higher calcium content in treatments with a_2 higher tamarind ratio (Owade *et al*., 2018) . Compared to moist cooking and pressure cooking, dry roasting and microwave roasting treatments demonstrated higher calcium retention, most likely as a result of less mineral leaching.

4.19. Interaction effect on physicochemical property of blended jam

Table 31 demonstrates interaction effect on physicochemical property of blended jam

Table 28. Interaction effect of physicochemical property of jam

Code	pH	TSS
DCT1	4.76 ± 0.10^{b}	59.67 ± 0.58^{rqs}
DCT2	4.60 ± 0.13^{c}	61.67 ± 0.58^{op}
DCT3	4.31 ± 0.17^{e}	63.00 ± 1.00^{olmn}
DR1T1	3.19 ± 0.10^{f}	62.67 ± 0.58^{opmn}
DR1T2	3.04 ± 0.07^{g}	64.67 ± 0.58^{klj}
DR1T3	2.97 ± 0.05^{hgı}	65.67 ± 0.58^{fgijh}
DR2T1	2.80 ± 0.04^{k}	65.00 ± 1.00^{kij}
DR2T2	2.70 ± 0.07^{l}	66.33 ± 1.53^{fgieh}
DR2T3	2.67 ± 0.05^{l}	67.33 ± 1.53^{fbecd}
DR3T1	2.09 ± 0.04^{p}	68.00 ± 1.73^{bcde}
DR3T2	2.08 ± 0.03^{p}	69.00 ± 1.00^{ba}
DR3T3	$2.04 \pm 0.02ϥ^{p}$	70.33 ± 1.53^{a}
MCT1	4.91 ± 0.12^{a}	57.00 ± 1.00^{t}
MCT2	4.68 ± 0.06^{cb}	58.00 ± 1.00^{ts}
MCT3	4.61 ± 0.03^{c}	59.67 ± 1.15^{rqs}
MR1T1	3.03 ± 0.02^{h}	61.33 ± 1.15^{pϥ}
MR1T2	2.97 ± 0.02^{hı}	63.00 ± 1.73^{olmn}

MR1T3	2.90 ± 0.06^{kji}	64.67 ± 0.58^{klj}
MR2T1	2.51 ± 0.03^{m}	64.00 ± 1.00^{klmj}
MR2T2	2.45 ± 0.03^{m}	65.33 ± 0.58^{gjih}
MR2T3	2.35 ± 0.03^{n}	66.67 ± 0.58^{fgecdh}
MR3T1	2.05 ± 0.01^{p}	66.00 ± 1.00^{fgieh}
MR3T2	2.04 ± 0.01^{ዓp}	67.33 ± 1.15^{fbecd}
MR3T3	2.02 ± 0.03^{p}	68.33 ± 0.58^{bc}
PCT1	4.41 ± 0.06^{d}	59.33 ± 0.58^{r}
PCT2	4.37 ± 0.02^{ed}	61.00 ± 0.00^{rዓ}
PCT3	4.30 ± 0.05^{e}	62.33 ± 0.58^{opn}
PR1T1	2.93 ± 0.03^{ji}	62.00 ± 0.00^{opn}
PR1T2	2.85 ± 0.01^{kj}	63.33 ± 0.58^{lmn}
PR1T3	2.83 ± 0.01^{k}	65.33 ± 0.58^{gjih}
PR2T1	2.29 ± 0.02^{on}	65.00 ± 0.00^{kij}
PR2T2	2.24 ± 0.02^{o}	66.00 ± 0.00^{fgih}
PR2T3	2.22 ± 0.01^{o}	67.67 ± 0.58^{becd}
PR3T1	2.03 ± 0.03^{ዓp}	67.00 ± 1.00^{fged}
PR3T2	1.95 ± 0.06^{rዓ}	67.33 ± 1.53^{fbecd}
PR3T3	1.92 ± 0.02^{r}	67.33 ± 2.89^{fbecd}
CV	1.93	1.64
LSD	0.09	1.72

4.19.1. PH

The jam samples' pH values ranged widely from 1.92 to 4.91; MCT samples had the greatest pH values, which indicated less acidity, while PR3T3 samples had the lowest pH, which indicated increased acidity. By preventing microbial development, lower pH values in some treatments may increase shelf life(Owade *et al*., 2018). The natural acidity of tamarind pulp is

consistent with the pH drop observed in samples that have undergone extended heat treatment or have a higher tamarind percentage.

The differences imply that cooking techniques and mixing ratios interact to affect the chemical makeup. Because of acid release and water evaporation, heat treatments (DR, MR) typically decreased pH. The findings highlight how crucial it is to balance taste, acidity, and preservation quality by optimizing processing parameters(Abong *et al*., 2009).

4.19.2. TSS

Total Soluble Solid (TSS) levels, which indicate the content of sugar, varied from 57.00 to 70.33 °Brix. MCT1 had the lowest TSS, indicating less caramelization or sugar concentration, while DR3T3 had the greatest TSS, perhaps as a result of water loss during cooking, which concentrated soluble solids. Higher TSS is typically linked to improved viscosity, flavor, and customer acceptability(Kourouma *et al*., 2019).

4.20. Interaction effect on sensory acceptance of blended jam

Table 33 demonstrate interaction effect of sensory acceptance of blended jam

Table 29. Interaction effect on sensory acceptance of blended jam

Code	Color (Mean ± SD + group)	Texture (Mean ± SD + group)	Aroma (Mean ± SD + group)	Taste (Mean ± SD + group)	Overall Acceptability (Mean ± SD + group)
DCT1	6.40 ± 0.30^{a}	4.83 ± 0.23^{de}	5.40 ± 0.17^{ef}	6.10 ± 0.10^{bc}	5.70 ± 0.09^{bc}
DCT2	6.43 ± 0.15^{a}	4.90 ± 0.45^{de}	5.60 ± 0.02^{e}	6.20 ± 0.20^{ab}	5.80 ± 0.15^{ab}
DCT3	6.43 ± 0.20^{a}	5.20 ± 0.50^{cde}	5.60 ± 0.40^{e}	6.23 ± 0.15^{a}	5.90 ± 0.21^{a}
DR1T1	5.80 ± 0.15^{b}	5.30 ± 0.30^{de}	5.80 ± 0.11^{ab}	5.60 ± 0.26^{hı}	5.60 ± 0.20^{fg}
DR1T2	5.80 ± 0.15^{b}	5.20 ± 0.15^{cde}	5.63 ± 0.23^{e}	5.60 ± 0.36^{hıg}	5.54 ± 0.20^{hı}
DR1T3	5.70 ± 0.10^{bc}	5.30 ± 0.10^{cde}	5.63 ± 0.15^{e}	5.50 ± 0.06^{hıj}	5.52 ± 0.07^{hı}

DR2T1	5.40 ± 0.35^{fceb}	5.40 ± 0.26^{bcd}	5.73 ± 0.23^{ac}	5.23 ± 0.15^{mn}	5.43 ± 0.20^{lm}
DR2T2	5.30 ± 0.06^{fce}	5.50 ± 0.26^{abc}	5.73 ± 0.15^{ac}	5.30 ± 0.11^{mn}	5.44 ± 0.12^{lm}
DR2T3	5.33 ± 0.25^{fce}	5.50 ± 0.30^{abc}	5.63 ± 0.15^{e}	5.40 ± 0.17^{ijk}	5.50 ± 0.11^{ij}
DR3T1	5.06 ± 0.20^{fg}	6.40 ± 0.20^{a}	5.90 ± 0.23^{a}	5.30 ± 0.34^{m}	5.64 ± 0.24^{ef}
DR3T2	5.30 ± 0.20^{fce}	6.40 ± 0.11^{a}	5.70 ± 0.20^{de}	5.30 ± 0.26^{m}	5.65 ± 0.20^{de}
DR3T3	5.30 ± 0.20^{fce}	6.50 ± 0.20^{a}	5.70 ± 0.06^{de}	5.33 ± 0.15^{lm}	5.70 ± 0.06^{bc}
MCT1	6.23 ± 0.25^{a}	4.33 ± 0.35^{e}	5.70 ± 0.17^{de}	5.80 ± 0.20^{def}	5.50 ± 0.05^{ij}
MCT2	6.43 ± 0.20^{a}	4.50 ± 0.29^{e}	5.53 ± 0.11^{ef}	5.70 ± 0.50^{fg}	5.53 ± 0.09^{hı}
MCT3	6.40 ± 0.20^{a}	4.53 ± 0.23^{e}	5.53 ± 0.06^{ef}	5.90 ± 0.45^{de}	5.60 ± 0.04^{fg}
MR1T1	5.80 ± 0.40^{b}	4.83 ± 0.20^{de}	5.43 ± 0.15^{f}	5.07 ± 0.32^{op}	5.27 ± 0.16^{pqr}
MR1T2	5.63 ± 0.32^{cbd}	4.93 ± 0.15^{de}	5.50 ± 0.17^{ef}	5.26 ± 0.06^{mn}	5.33 ± 0.13^{nop}
MR1T3	5.53 ± 0.50^{cebd}	4.90 ± 0.10^{de}	5.50 ± 0.15^{ef}	5.30 ± 0.17^{m}	5.30 ± 0.21^{pq}
MR2T1	5.50 ± 0.56^{fceb}	5.10 ± 0.10^{cde}	5.43 ± 0.15^{f}	4.93 ± 0.47^{qr}	5.24 ± 0.26^{qr}
MR2T2	5.43 ± 0.50^{fceb}	5.13 ± 0.20^{cde}	5.30 ± 0.17^{f}	5.17 ± 0.15^{no}	5.26 ± 0.23^{pqr}
MR2T3	5.23 ± 0.20^{fe}	5.30 ± 0.17^{cde}	5.50 ± 0.17^{ef}	5.40 ± 0.11^{ijk}	5.35 ± 0.09^{no}
MR3T1	5.13 ± 0.23^{fe}	5.40 ± 0.26^{bcd}	5.50 ± 0.11^{ef}	4.90 ± 0.26^{r}	5.22 ± 0.02^{r}
MR3T2	5.17 ± 0.15^{fe}	5.57 ± 0.20^{ab}	5.53 ± 0.11^{ef}	5.00 ± 0.26^{pq}	5.31 ± 0.06^{opq}
MR3T3	5.13 ± 0.51^{fe}	5.67 ± 0.29^{a}	5.57 ± 0.05^{ef}	5.00 ± 0.29^{pq}	5.33 ± 0.17^{nop}
PCT1	6.50 ± 0.11^{a}	4.60 ± 0.10^{e}	5.60 ± 0.20^{e}	5.90 ± 0.43^{de}	5.63 ± 0.01^{ef}
PCT2	6.33 ± 0.11^{a}	4.67 ± 0.15^{e}	5.57 ± 0.20^{ef}	6.10 ± 0.10^{bc}	5.70 ± 0.08^{bc}

PCT3	6.33 ± 0.20[a]	4.80 ± 0.21[de]	5.70 ± 0.26[de]	6.30 ± 0.25[a]	5.80 ± 0.09[ab]
PR1T1	5.63 ± 0.25[cbd]	5.23 ± 0.35[cde]	5.43 ± 0.15[f]	5.53 ± 0.06[hıj]	5.46 ± 0.08[ıj]
PR1T2	5.63 ± 0.15[cbd]	5.23 ± 0.20[de]	5.63 ± 0.05[e]	5.60 ± 0.10[ghı]	5.52 ± 0.02[hı]
PR1T3	5.70 ± 0.30[bc]	5.40 ± 0.30[bcd]	5.60 ± 0.06[e]	5.63 ± 0.15[fgh]	5.60 ± 0.10[fg]
PR2T1	5.27 ± 0.20[fce]	5.13 ± 0.30[cde]	5.40 ± 0.26[f]	5.07 ± 0.15[op]	5.22 ± 0.20[r]
PR2T2	5.17 ± 0.21[feg]	5.33 ± 0.15[cde]	5.40 ± 0.20[f]	5.27 ± 0.06[mn]	5.30 ± 0.09[opϥ]
PR2T3	5.20 ± 0.26[feg]	5.27 ± 0.32[cde]	5.50 ± 0.10[ef]	5.40 ± 0.17[ıjk]	5.34 ± 0.08[no]
PR3T1	5.17 ± 0.32[feg]	5.80 ± 0.65[a]	5.43 ± 0.11[f]	5.23 ± 0.11[mn]	5.40 ± 0.07[lm]
PR3T2	4.93 ± 0.15[g]	6.10 ± 0.53[a]	5.53 ± 0.11[ef]	5.20 ± 0.20[no]	5.44 ± 0.05[lm]
PR3T3	4.93 ± 0.32[g]	6.00 ± 0.78[a]	5.50 ± 0.05[ef]	5.20 ± 0.10[no]	5.40 ± 0.11[lm]
CV	4.92	5.84	3.09	4.37	2.54
LSD	0.45	0.50	0.27	0.38	0.22

4.24.1. Color

The sweet potato-tamarind jam samples' color scores varied significantly between treatments, ranging from 4.93 ± 0.15 g in PR3T2 to 6.50 ± 0.11 an in PCT1. Due to improved pigment retention and less browning during processing, the treatments with the highest color ratings were typically those that involved traditional cooking with orange-fleshed sweet potatoes (PCT1, PCT2, PCT3) and microwave-cooked orange-fleshed sweet potatoes (MCT1, MCT2, MCT3). These results are consistent with the findings of Kourouma *et al*, (2019), who observed that mild heat treatments preserve more vibrant colors and that anthocyanins and carotenoids in sweet potatoes are responsive to processing techniques. On the other hand, PR3T2 and PR3T3's lowest color scores can result from roasting-induced pigment deterioration and Maillard browning, as shown by Owade *et al*, (2018).

4.24.2. Texture

Roasted treatments (especially DR3T1–DR3T3 and PR3T1–PR3T3) were rated higher, with texture scores ranging from 4.33 ± 0.35 e in MCT1 to 6.50 ± 0.20 an in DR3T3. These samples' better texture may be due to the production of pectin gel and the reduction of moisture during roasting, which results in a firmer, more spreadable consistency (Abong *et al*., 2009). Conversely, some microwave-cooked treatments scored lower on texture tests, maybe as a result of the pectin's irregular gelation and softer consistency brought on by the quick heating (Owade *et al*., 2018).

4.24.3. Aroma

The aroma scores were 5.90 ± 0.23 a (DR3T1) to 5.30 ± 0.17 f (MR2T2). Roasted samples (particularly DR3T1) had the highest scent scores; this could be because of the increased synthesis of volatile compounds during the Maillard reaction and caramelization, which improves the perceived complexity of aroma (Abou and Ahmed, 2021). Limited flavor component production under brief heating times may be the cause of lower aroma scores in some microwave and mixed roasting methods.

4.24.4. Taste

From 4.90 ± 0.26 r (MR3T1) to 6.30 ± 0.25 a (PCT3), taste scores differed greatly. The highest PCT3 and DCT3 scores indicate that the tamarind addition's improved sugar development and acidity balance were made possible by carefully regulated traditional cooking, which improved flavor harmony. These findings align with those of Abou and Ahmed, (2021), who highlighted how heat treatment influences fruit-based goods' perceptions of acidity and sugar caramelization. Overcooking or uneven heat distribution may be the cause of lower scores in some roasted-microwave treatments, which can result in excessive caramelization and a little bitter aftertaste.

4.24.5. Overall Acceptability

The overall acceptability scores varied between 5.90 ± 0.21 a (DCT3) and 5.22 ± 0.02 r (MR3T1). Higher acceptance samples (DCT3, PCT3, and DCT2) typically had a pleasing aroma, balanced texture, appealing color, and a sweet-to-acidic taste balance, all of which were in line with consumer preferences for jams(Owade *et al*., 2018). Panelist satisfaction was lowered by texture flaws and diminished flavor intensity, according to lower ratings in MR3T1

and PR2T1, which supports the idea that total acceptability is closely tied to sensory harmony across all qualities (Kourouma *et al*., 2019).

5. CONCLUSIONS AND RECOMMENDATION

5.1 Conclusion

This study assessed how blending ratio, cooking method, and cooking time influence the nutritional, physicochemical, and sensory qualities of tamarind–OFSP blended jam. All three factors significantly affected the product's composition and acceptability.

Blending tamarind with OFSP increased crude protein, fat, fiber, ash, carbohydrates, energy, vitamin C, and minerals (Ca, Fe, Mg), but reduced beta-carotene, pH, moisture, color, and flavor at higher tamarind levels. Blends with 20–30% tamarind offered improved nutrient density and better texture, though the 100% OFSP control remained most preferred in color and flavor.

Microwave cooking retained the highest levels of heat-sensitive nutrients, while dry heating produced jams with higher carbohydrates, total soluble solids, and energy due to greater moisture loss. Sensory scores favored dry-heated samples, especially for texture, aroma, and taste.

Longer cooking times lowered moisture and most nutrients but enhanced texture, taste, and overall acceptability because of concentration and flavor development.

Overall, OFSP–tamarind blended jam can serve as a nutrient-rich functional food with good sensory appeal and potential to address micronutrient deficiencies.

5.2Recommendation

Food industries, policymakers, nutrition programs, and development partners are encouraged to apply the optimal blending ratios and cooking conditions identified in this study when producing tamarind–OFSP jam at scale. They are also encouraged to promote this nutrient-dense product in national nutrition initiatives—such as school feeding and maternal–child programs—while supporting improved packaging technologies and value-addition in tamarind and OFSP production.

Researchers are encouraged to investigate shelf-life stability under different storage conditions, assess the benefits of micronutrient fortification, and explore natural preservatives like ginger, lemon, or Moringa extracts to enhance safety. Broader consumer acceptability studies across various Ethiopian regions and demographic groups are also recommended.

6. REFERENCES

AACC. (2000). *Approved Methods of the American Association of Cereal Chemists: Vol. 10th ed*. https://doi.org/10.4236/als.2023.114025

Abong, G. O., Okoth, M. W., Karuri, E. G., Kabira, J. N., & Mathooko, F. M. (2009). Nutrient contents of raw and processed products from Kenyan potato cultivars. *Journal of Applied Biosciences*, *16*, 877–886.

Abou, E. T., & Ahmed, S. (2021). Potential Effects of cooking conditions and substitution with carrot and pumpkin on quality attributes of orange sweet potato jam. *The Scientific Journal of Specific Education and Applied Scienc Es*, 140–162.

Adam, C. L., Williams, P. A., Garden, K. E., Thomson, L. M., & Ross, A. W. (2015). Dose-dependent effects of a soluble dietary fibre (pectin) on food intake, adiposity, gut hypertrophy and gut satiety hormone secretion in rats. *PLoS ONE*, *10*(1), 1–14. https://doi.org/10.1371/journal.pone.0115438

Afoakwah, N. A., Amagloh, F. K., Mahunu, G. K., Ayyub, S. W., Tchabo, W., & Owusu-Ansah, P. (2023a). Quality evaluation of orange-fleshed sweet potato-pineapple blended jam. *Journal of Agriculture and Food Research*, *12*(December 2022), 100540. https://doi.org/10.1016/j.jafr.2023.100540

Afoakwah, N. A., Amagloh, F. K., Mahunu, G. K., Ayyub, S. W., Tchabo, W., & Owusu-Ansah, P. (2023b). Quality evaluation of orange-fleshed sweet potato-pineapple blended jam. *Journal of Agriculture and Food Research*, *12*(March), 100540. https://doi.org/10.1016/j.jafr.2023.100540

Ahmed, N. H. and, & Alrhum, H. A. A. (2016). *Optimization of physicochemical, textural, and rheological properties of sour cherry jam containing stevioside by using response surface methodology. Received: 16 October 2020.doi: 10.1002/fsn3.2192*

Allen, And, E. I., & J, E.-E. (2019). Physicochemical, Sensory Properties and Bacteria Load of Jam Produced from Squash (Cucurbita) Fruit. *Food Science & Nutrition Technology*, *4*(3), 1–7. https://doi.org/10.23880/fsnt-16000187

Anderson, P., Kapinga, R., Zhang, D., & Hermann, M. (2007). Vitamin A for Africa (VITAA): An entry point for promoting orange-fleshed sweetpotato to combat vitamin A-deficiency in sub-Saharan Africa. *Proceedings of the 13th ISTRC Symposium*, 711–720. http://www.istrc.org/Symposiums/2003_Tanzania/vitaa_anderson.pdf

Anuar, N. A., & Salleh, R. M. (2019). Development of fruit jam from Averrhoa bilimbi L. *Journal of Food Processing and Preservation*, *43*(4), 1–7. https://doi.org/10.1111/jfpp.13904

AOAC. (2005). Official Methods of Analysis of the Association of Official Agricultural Chemists. In *American Journal of Public Health and the Nations Health* (Vol. 18). https://doi.org/10.2105/ajph.46.7.916-a

AOAC. (2010). Association of OfficialAnalytical Chemists. *Official Methods of Analysis*, *17*. https://doi.org/10.1007/978-1-4684-7086-4_3

Awulachew, M. T. (2021). Fruit Jam Production. *International Journal of Food Science, Nutrition and Dietetics*, *June*, 532–537. https://doi.org/10.19070/2326-3350-2100092

Babatunde, R. O., Omoniwa, A. E., & Adeniyi, A. E. (2019). Orange fleshed sweet potatoes (OFSP) and productivity: the case of smallholders in Kwara State, Nigeria. *Agricultura Tropica et Subtropica*, *52*(3–4), 105–111. https://doi.org/10.2478/ats-2019-0012

Bao, B. M., & Fweja, L. W. T. (2020). Evaluation of the Potential of Freshly Bred Orange-Fleshed Sweet Potato Varieties in Combating Vitamin A Deficiency. *Tanzania Journal of Science*, *46*(1), 1–8.

Behera, S., Chauhan, V. B. S., Pati, K., Bansode, V., Nedunchezhiyan, M., Verma, A. K., Monalisa, K., Naik, P. K., & Naik, S. K. (2022). Biology and biotechnological aspect of sweet potato (Ipomoea batatas L.): a commercially important tuber crop. *Planta*, *256*(2), 1–15. https://doi.org/10.1007/s00425-022-03938-8

Bhadoriya, S. S., Ganeshpurkar, A., Narwaria, J., Rai, G., & Jain, A. P. (2011). Tamarindus indica : Extent of explored potential. *Pharmacognosy Reviews*, *5*(9), 73–81. https://doi.org/10.4103/0973-7847.79102

Bhuyan, S., Mishra, S., Mallick, S. N., Biswal, S., & Chauhan, V. B. S. (2022). Sweet Potato: Its Nutritional Factor and Health Benefits. *Biotica Research Today*, *4*(6), 450–452. https://biospub.com/index.php/biorestoday/article/view/1501

Blokhina, O., Virolainen, E., & Fagerstedt, K. V. (2003). Antioxidants, oxidative damage and oxygen deprivation stress: A review. *Annals of Botany*, *91*, 179–194. https://doi.org/10.1093/aob/mcf118

Cartabiano-Leite, C. E., Porcu, O. M., & de Casas, A. F. (2020). Sweet potato (Ipomoea batatas L. Lam) nutritional potential and social relevance: a review. *International Journal of Engineering Research and Applications Www.Ijera.Com*, *10*(June), 23–40. https://doi.org/10.9790/9622-1006082340

CODEX. (2009). CODEX STAN 296 Page 1 of 10. *Codex standard for jams, jellies and marmalades (codex stan 296-2009)*, 1–10.

Dako, E., Retta, N., & Desse, G. (2016). Comparison of three sweet potato (Ipomoea Batatas (L.) Lam) varieties on nutritional and anti-nutritional factors. *Global Journal of Science Frontier Research*, *16*(4), 62–72. https://pdfs.semanticscholar.org/61c8/0293d9cc811632c40ad096d0d59ebaa9433c.pdf

David, A. A., Adegbite, A., & Adeniyi, B. (2021). *Nutritional and health benefits of sweetpotato that make it consumers' choice Abiodun David Arowolo and Basiru Adeniyi Adegbite*. *2*(1), 52–60.

Dhingra, D., Michael, M., Rajput, H., & Patil, R. T. (2012). Dietary fibre in foods: A review. *Journal of Food Science and Technology*, *49*(3), 255–266. https://doi.org/10.1007/s13197-011-0365-5

Ebifa-Othieno, E., Mugisha, A., Nyeko, P., & Kabasa, J. D. (2017). Knowledge, attitudes and practices in tamarind (Tamarindus indica L) use and conservation in Eastern Uganda. *Journal of Ethnobiology and Ethnomedicine*, *13*(1), 1–13. https://doi.org/10.1186/s13002-016-0133-8

Feng, H. A. O., Ereifej, K., Kilani, I., & Ishmais, M. A. B. U. (2012). *Effect of jam processing*

and storage on phytochemicals and physiochemical properties of cherry at different temperatures. https://doi.org/10.1111/j.1745-4549.2012.00770.x

Fikre, T. (2010). *Nutritional, sensory and rehydration characteristics of solar-dried carrots as affected by blanching and osmosis* (issue October).

Food and Agriculture Organization of the United Nations. (2019). *FAOSTAT Statistical Database.* Rome, Italy: FAO. Retrieved December 9, 2025 from https://www.fao.org/faostat/en/#data

Food and Agriculture Organization of the United Nations. (2023). *FAOSTAT* [Statistical database]. Retrieved from https://www.fao.org/faostat/en/#home

Fügel, R., Carle, R., & Schieber, A. (2005). Quality and authenticity control of fruit purées, fruit preparations and jams—a review. *Trends in Food Science & Technology*, *16*(10), 433–441. https://doi.org/10.1016/J.TIFS.2005.07.001

Gałkowska, D., Fortuna, T., & Prochwicz-Zagórska, W. (2010). *p otravinárstvo physicochemical quality of selected strawberry jams with fructose Dorota Gałkowska , Teresa Fortuna , Weronika Prochwicz - Zagórska p otravinárstvo Table 1 Physicochemical properties of jams (mean values and standard deviations) Titratab*. 22–24.

Garg, S., Ghosh, P., Rana, S. S., & Pradhan, R. C. (2019). Preparation and Quality Evaluation of Nutritionally Enriched Jam Made from Blends of Indian Blackberry and Other Fruits. *International Journal of Fruit Science*, *19*(1), 29–44. https://doi.org/10.1080/15538362.2018.1536872

Gebru, A. M., Oduor, F., Lochetti, G., Kennedy, G., & Baye, K. (2019). *Ethiopia ' s Food Treasures : Revitalizing Ethiopia ' s underutilized fruits and vegetables for inclusion in the Food-Based Dietary Guidelines for improved diet diversity , nutrition and health of the population*. 2–36.

Groote, S. De, Caluwé, E. De, & Damme, P. Van. (2007). Tropentag 2007 University of Kassel-Witzenhausen and University of Göttingen , October 9-11 , 2007 Conference on

International Agricultural Research for Development Domestication and Development of Baobab and Tamarind (DADOBAT). *Energy*, *ii*, 1–4.

Gurmu, F. (2019). Sweetpotato Research and Development in Ethiopia: A Comprehensive Review. *Journal of Agricultural and Crop Research*, *7*(7), 106–118. https://doi.org/10.33495/jacr_v7i7.19.127

Gurmu, F., Hussein, S., & Laing, M. (2015). Diagnostic assessment of sweetpotato Production in ethiopia: Constraints, post-harvest handling and farmers' preferences. *Research on Crops*, *16*(1), 104–115. https://doi.org/10.5958/2348-7542.2015.00016.9

Hagenimana, V., Carey, E. E., Oyunga, M. A., Low, J., Turyamureeba, G., Smi, N. E. J. M., K'osambo, L., & P'Obwoya, C. O. (1999). Using orange-fleshed sweetpotato varieties to combat Vitamin a deficiency and enhance market opportunities for smallholder farmers in Sub- Saharan Africa. *Proceedings of the Scientific Workshop of the Southern African Root Crops Research Network (SARRNET), Held at Lusaka, Zambia, 1995*, 476.

Hermes, D., Dudek, D. N., Maria, M. D., Horta, L. P., Lima, E. N., De Fátima, Â., Sanches, A. C. C., & Modolo, L. V. (2013). In vivo wound healing and antiulcer properties of white sweet potato (Ipomoea batatas). *Journal of Advanced Research*, *4*(4), 411–415. https://doi.org/10.1016/j.jare.2012.06.001

Javanmard, M., & Endan, J. (2010). A Survey on Rheological Properties of Fruit Jams. *International Journal of Chemical Engineering and Applications*, *1*(2010–0221), 31_37.

Kidaha, M. L. (2022). *production, utilization, characterization and antimicrobial activity of tamarind (tamarindus indica) accessions from semi-arid eastern kenya mercy liharaka kidaha doctor of philosophy (horticulture)A Thesis Submitted in Partial Fulfilment of the Requirements for The Degree of Doctor of Philosophy in Horticulture of the Jomo Kenyatta University of Agriculture and Technology*

Kiranmai, E., Suneetha, A., & Sethi, N. (2017). Preparation of Tamarind Jam Blended with Mango. *International Journal of Current Microbiology and Applied Sciences*, *6*(12), 3365–3373. https://doi.org/10.20546/ijcmas.2017.612.392

Kiranmai, E., Suneetha, A., & Sethi, N. (2020). *Preparation of Tamarind Jam Blended with Mango*. *December 2017*. https://doi.org/10.20546/ijcmas.2017.612.392

Kourouma, V., Mu, T., Zhang, M., & Sun, H. (2019). Effects of cooking process on carotenoids and antioxidant activity of orange-fleshed sweet potato. https://doi.org/10.1016/j.lwt.2019.01.011

Kurabachew, H. (2015). The role of orange fleshed sweet potato (Ipomea batatas) for combating vitamin A deficiency in Ethiopia: A review. *International Journal of Food Science and Nutrition Engineering*, *5*(3), 141–146. https://doi.org/10.5923/j.food.20150503.05

Kuru, P. (2014). Tamarindus indica and its health related effects. *Asian Pacific Journal of Tropical Biomedicine*, *4*(9), 676–681. https://doi.org/10.12980/APJTB.4.2014APJTB-2014-0173

Lakhawat, S. (2018). International Conference on Food Security and Sustainable Agriculture (Thailand on 21-24 December, 2018) Review on orange fleshed sweet potato: A miracle crop to reduce Vitamin A deficiency. *~ 321 ~ Journal of Pharmacognosy and Phytochemistry*, *4*, 321–326.

Landi Librandi, A. P., Chrysóstomo, T. N., Azzolini, A. E. C. S., Recchia, C. G. V., Uyemura, S. A., & de Assis-Pandochi, A. I. (2007). Effect of the extract of the tamarind (Tamarindus indica) fruit on the complement system: Studies in vitro and in hamsters submitted to a cholesterol-enriched diet. *Food and Chemical Toxicology*, *45*(8), 1487–1495. https://doi.org/10.1016/j.fct.2007.02.008

Lola, K. F., Olamide, S.-O. H., Adebanke, B. M., & Odunayo, A. S. (2017). Physical and chemical characteristics of moringa - fortified orange sweet potato flour for complementary food. *Croatian Journal of Food Technology, Biotechnology, and Nutrition*, *12*(1–2), 37–43.

Low, J., Kapinga, R., Cole, D., Loechl, C., Lynam, J., & Andrade, M. (2009). Challenge theme paper 3: Nutritional impact with orange-fleshed sweetpotato (OFSP). *International Potato Center (CIP)*, 73–105.

Maceiras, R., Álvarez, E., & Cancela, M. A. (2007). Rheological properties of fruit purees: Effect of cooking. *Journal of Food Engineering*, *80*(3), 763–769. https://doi.org/10.1016/j.jfoodeng.2006.06.028

Mahmud, A. Al, Alam, M. J., Heck, S., Grüneberg, W. J., Chanda, D., Shofiur Rahaman, E. H. M., Molla, M. S. H., Anwar, M. M., Talukder, M. A. A. H., Ali, M. A., Amin, M. N., Alhomrani, M., Gaber, A., & Hossain, A. (2021). Assessing the productivity, quality and profitability of orange fleshed sweet potatoes grown in riverbank of the tista floodplain agro-ecological zone of Bangladesh. *Agronomy*, *11*(10), 1–17. https://doi.org/10.3390/agronomy11102046

Maiti, R., Das, U. K., & Ghosh, D. (2005). Attenuation of hyperglycemia and hyperlipidemia in streptozotocin-induced diabetic rats by aqueous extract of seed of Tamarindus indica. *Biological and Pharmaceutical Bulletin*, *28*(7), 1172–1176. https://doi.org/10.1248/bpb.28.1172

McClelland, W., J., Allen, And, J. C., & Zakir, S. (2007). Poster session : wellness and public health title : motivational influences for participating. *Journal of the American Diabetic Association*, 2.

Meena, V. S., Gora, J. S., Singh, A., Ram, C., Meena, N. K., Pratibha, A., Rouphael, Y., Basile, B., & Kumar, P. (2022). Underutilized Fruit Crops of Indian Arid and Semi-Arid Regions: Importance, Conservation and Utilization Strategies. *Horticulturae*, *8*(2), 1–29. https://doi.org/10.3390/horticulturae8020171

Meher, B., Kumar Dash, D., & Roy, A. (2014). a Review on: Phytochemistry, Pharmacology and Traditional Uses of Tamarindus Indica L. *Deepak et Al. World Journal of Pharmacy and Pharmaceutical Sciences*, *3*(January), 229. www.wjpps.com

Mergence, S. E. E. (2013). Effect of provenances on seed germination, early survival and growth performance of tamarindus indica l. In ethiopia: a key multipurpose species.Article *June 2017*, 823–832. t: https://www.researchgate.net/publication/317606999.

Mudege, N. N., Mayanja, S., & Muzhingi, T. (2017). Women and men farmer perceptions of economic and health benefits of orange fleshed sweet potato (OFSP) in Phalombe and Chikwawa districts in Malawi. *Food Security*, *9*(2), 387–400. https://doi.org/10.1007/s12571-017-0651-9

Muhammad, L., Aminah, Y., & Abbas, K. (2012). Development of Orange Fleshed Sweet Potato (OFSP) Based Juice Drink to Help Reduce On Vitamin A Deficiency. *International Journal of Science and Research (IJSR) ISSN (Online Impact Factor*, *3*(7), 2319–7064. www.ijsr.net

Naeem, N., Nadeem, F., Azeem, M. W., & Dharmadasa, R. M. (2017). Tamarindus indica-A Review of Explored Potentials. *Ijcbs*, *12*, 98–106. www.iscientific.org/Journal.html

Nagar, C. K., Dash, S. K., & Rayaguru, K. (2022). Tamarind seed: Composition, applications, and value addition: A comprehensive review. *Journal of Food Processing and Preservation*, *46*(10), 1–18. https://doi.org/10.1111/jfpp.16872

Neela, S., & Fanta, S. W. (2019). Review on nutritional composition of orange-fleshed sweet potato and its role in management of vitamin A deficiency. *Food Science and Nutrition*, *7*(6), 1920–1945. https://doi.org/10.1002/fsn3.1063

Ogasawara, N., Sasaki, M., & Itoh, Y. (2011). Rebamipide suppresses TLR?TBK1 signaling the Society for Free Radical Research Japan 1880 50860912-0009 10.3164/j9cb .10-69 JJCBN Kyj bn10-6 Original Article c oto, Japan ournal of Clinical Biochemistry and Nutrition pathway resulting in regulating IRF3/7. *J Clin Biochem Nutr*, *48*(2), 154–160. https://doi.org/10.3164/jcbn.10

Okudu, H. O., & Ene-Obong, H. N. (2015). The chemical and sensory properties of jam developed from two varieties of monkey kola (Cola parchycarpa , Cola lepidota). Department of Biochemistry (Nutrition and Dietetics Unit). Faculty of Basic Medical Science . *American Journal of Food Nad Nutrition*, *5*(1), 16–22. https://doi.org/10.5251/ajfn.2015.5.1.16.22

Okut, D., Devseren, E., Koç, M., Ocak, Ö. Ö., Karataş, H., & Kaymak-Ertekin, F. (2018). Developing a vacuum cooking equipment prototype to produce strawberry jam and

optimization of vacuum cooking conditions. *Journal of Food Science and Technology*, *55*(1), 90–100. https://doi.org/10.1007/s13197-017-2819-x

Oloniyo, R. O., Omoba, O. S., & Awolu, O. O. (2021). Biochemical and antioxidant properties of cream and orange-fleshed sweet potato. *Heliyon*, *7*(3), e06533. https://doi.org/10.1016/j.heliyon.2021.e06533

Omoikhoje, S. O., Aruna, M. B., & Bamgbose, A. M. (2009). Effect of cooking time on some nutrient and antinutrient components of bambaragroundnut seeds. *Animal Science Journal*, *80*(1), 52–56. https://doi.org/10.1111/j.1740-0929.2008.00599.x

Owade, J. O., Abong, G. O., & Okoth, M. W. (2018). Production, utilization and nutritional benefits of orangfleshed sweetpotato (OFSP) puree bread: A review. *Current Research in Nutrition and Food Science*, *6*(3), 644–655. https://doi.org/10.12944/CRNFSJ.6.3.06

Quindara, H., Gonzales, I., … E. B.-M. J. of, & 2020, undefined. (2020). Utilization of Orange-fleshed Sweetpotatoes to Enhance the ß-Carotene Content of Locally Consumed Food Products. *Portal.Bsu.Edu.Ph*. http://portal.bsu.edu.ph:8083/index.php/BRJ/article/view/269

Rababah, T. M., Al-u'datt, M. H., & Brewer, S. (2015). Jam Processing and Impact on Composition of Active Compounds. In *Processing and Impact on Active Components in Food*. Elsevier Inc. https://doi.org/10.1016/B978-0-12-404699-3.00082-2

Rahman, M., Patwary, M. A., Barua, H., Hossain, M., & Nahar, S. (2013). Evaluation of Orange Fleshed Sweet Potato (Ipomoea batatas L.) Genotypes for Higher Yield and Quality. *The Agriculturists*, *11*(2), 21–27. https://doi.org/10.3329/agric.v11i2.17483

Ramos, A., Visozo, A., Piloto, J., García, A., Rodríguez, C. A., & Rivero, R. (2003). Screening of antimutagenicity via antioxidant activity in Cuban medicinal plants. *Journal of Ethnopharmacology*, *87*(2–3), 241–246. https://doi.org/10.1016/S0378-8741(03)00156-9

Rana, M., Sharma , P., Mahima Rana, C., & Sharma, P. (2018). Proximate and phytochemical screening of the seed and pulp of Tamarind indica. *~ 111 ~ Journal of Medicinal Plants*

Studies, *6*(2), 111–115.

Rani, Pessu, P. O., *Abel, G. I., Akande, S. A., Ayanda, I. S., Adarabierin, I. G., Olagunju, O. D., Gbabe, E. K. (2020). Chemical and physico-chemical properties of orange fleshed sweet potatoes (OFSP) CHIPS DRIED USING SOLAR DYERS Pessu,. *Range Management and Agroforestry*, *4*(1), 1–15. https://doi.org/10.1016/j.fcr.2017.06.020

Rehab, H. S. B. (2018). *Utilization of Sweet Potato Roots in Jam Production*. A Dessertation Submitted to Sudan University of Science and Technology in Partial Fulfillment for the Requirements of Master Degree in Food Science and Technology

Rios-Romero, E. A., Ochoa-Martínez, L. A., Bello-Pérez, L. A., Morales-Castro, J., Quintero-Ramos, A., & Gallegos-Infante, J. A. (2021). Effect of ultrasound and steam treatments on bioaccessibility of β-carotene and physicochemical parameters in orange-fleshed sweet potato juice. *Heliyon*, *7*(4), 0–5. https://doi.org/10.1016/j.heliyon.2021.e06632

Rodrigues, N. da R., Barbosa, J. L., & Barbosa, M. I. M. J. (2016). Determination of physico-chemical composition, nutritional facts and technological quality of organic orange and purple-fleshed sweet potatoes and its flours. *International Food Research Journal*, *23*(5), 2071–2078.

Senanayake, S. A., Ranaweera, K. K. D. S., Gunaratne, A., & Bamunuarachchi, A. (2013). Comparative analysis of nutritional quality of five different cultivars of sweet potatoes (I pomea batatas (L) Lam) in S ri L anka . *Food Science & Nutrition*, *1*(4), 284–291. https://doi.org/10.1002/fsn3.38

Shonga, E., Gemu, M., Tadesse, T., & Urage, E. (2013). Review of Entomological Research on Sweet Potato in Ethiopia. *Discourse Journal of Agriculture and Food Sciences Www.Resjournals.Org/JAFS*, *1*(5), 83–92.

Singh, D., Wangchu, L., & Moond, S. K. (2007). Processed products of Tamarind. 1Department of Post Harvest Technology, Department of Floriculture College of Horticulture and Forestry, Maharana Pratap University of Agriculture and Technology Jhalawar *Natural Product Radiance*, *6*(4), 315–321.

Soetan, K. O., Olaiya, C. O., & Oyewole, O. E. (2010). The importance of mineral elements for humans , domestic animals and plants : A review. *African Journal of Food Science*, *4*(May), 200–222.

Stathers, T., Low, J., Mwanga, R., Carey, T., McEwan, M., David., S., Gibson, R., Namanda, S., McEwan, M., Malinga, J., Ackatia-Armah, R., Benjamin, M., Katcher, H., Blakenship, J., Andrade, M., Agili, S., Njoku, J., Sindi, K., Mulongo, G., Tumwegamire, S., Njoku, A., Abidin, E., Mbabu, A., Mkumbira, J., Ogero, K., Rajendran, S., Okello, J., Bechoff, A., & Ndyetabula, D., Grant, F., Maru, J., Munyua, H., Mudege, N. (2018). Everything you ever wanted to know about sweetpotato. Topic 4: Nutrition and orange-fleshed sweetpotato. Reaching agents of change ToT manual. In *Everything you ever wanted to know about sweetpotato. Topic 4: Nutrition and orange-fleshed sweetpotato. Reaching agents of change ToT manual.* (Issue October). https://doi.org/10.4160/9789290605027t4

Stathers, T., Benjamin, M., Katcher, H., Blakenship, J., & Low, J. (2013). Everything you ever wanted to know about sweetpotato: Reaching agent of change manual 2: orange fleshed sweetpotato and nutrition. In *International sweet potato center* (Vol. 2, Issue June). https://doi.org/10.4160/9789290604273.v2

Steed, L. E., & Truong, V. D. (2008). Anthocyanin content, antioxidant activity, and selected physical properties of flowable purple-fleshed sweetpotato purees. *Journal of Food Science*, *73*(5), 215–221. https://doi.org/10.1111/j.1750-3841.2008.00774.x

Sumonsiri, N., & Barringer, S. A. (2014). Fruits and Vegetables - Processing Technologies and Applications. *Food Processing: Principles and Applications: Second Edition*, *9780470671*, 363–381. https://doi.org/10.1002/9781118846315.ch16

Sur, R., Paik, C., Mitra, S., & Chakraborty, I. (2020). Standardization of recipes for preparation of sweet potato jam. *~ 580 ~ Journal of Pharmacognosy and Phytochemistry*, *9*(2), 580–584. www.phytojournal.com

Swami, S. B., Thakor, N. J., & Wagh, S. S. (2017). *Effect of temperature on viscosity of kokum , karonda , mango pulp and cashew apple syrup*. *January*. Article in Agricultural

Engineering International : The CIGR e-journal · November 2013 https://www.researchgate.net/publication/270898986

Swamy, S., Areefulla, sb shirsand, And, smitha gandra, & Prashanth. (2007). Indian Journal of Pharmaceutical Sciences Scienti fi c Publication of the Indian Pharmaceutical Association Cholesteryl Ester Transfer Protein : A Potential Target for the Orodispersible Tablets of Meloxicam using Disintegrant Blends for Improved Efficacy. *Indian Journal of Pharmacutical Sciences*, *69*(6), 836–840.

Syukri, D., Sylvi, D., & Ramadani, S. F. (2022). Effect of Various Cooking Methods on Quality and Sensory Characteristics of Tempeh Madefrom Soybeans and Corn. *Andalasian International Journal of Agriculture and Natural Sciences (AIJANS)*, *3*(02), 87–113. https://doi.org/10.25077/aijans.v3.i02.87-113.2022

Tabassum, R., Fazal, M. A., & Scholar, R. (2022). Health Benefits of Sweet Potatoes: a Scientific Review. *Peer Reviewed and Refereed Journal*, *816*(6), 4. http://ijmer.in.doi./2022/11.04.180

Toungos, M. D. (2019). Tamarind (Tamarindus indicus L) Fruit of Potential Value But Underutilized in Nigeria. *International Journal of Innovative Food*, *7*(1), 1–10. www.seahipaj.org

Truong, V. D., Avula, R. Y., Pecota, K. V, Yencho, G. C., & Lam, I. L. (2018). Sweetpotato Production , Processing , and Nutritional Quality. *Journal of Food Science*, *II*(5), 811–835.

Uzoaga, L. N., Mazi, E. A., & Kanu, A. N. (2020). Evaluation of Nutritional and Anti Nutrition Factors of Orange-fleshed Sweet Potato, Yellow Root Cassava and Plantain Flour Blends Fortified with Moringa oleifera Leaves. *Asian Journal of Advances in Agricultural Research*, *February 2020*, 7–19. https://doi.org/10.9734/ajaar/2020/v12i230075

Vikram, B., Gautam, D. K., Rahul, Yadav, H. C., Gaurha, A., Kumar, V., Omer, S., & Chawla, R. (2023). Tamarind Cultivation, Value-Added Products and Their Health Benefits: A Review. *International Journal of Plant & Soil Science*, *35*(21), 903–911.

https://doi.org/10.9734/ijpss/2023/v35i214060

Wang, Z., Li, J., Luo, Z., Huang, L., Chen, X., Fang, B., Li, Y., Chen, J., & Zhang, X. (2011). Characterization and development of EST-derived SSR markers in cultivated sweetpotato (Ipomoea batatas). *BMC Plant Biology, 11*(1), 139. https://doi.org/10.1186/1471-2229-11-139

Wanjala, O. simon. (2019). *Scaling Up the Production and Commercialization of Tamarind*. Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 26 April 2019*April*. https://doi.org/10.20944/preprints201904.0295.v1

Yao, Y., Zhang, R., Jia, R., Deng, Y., & Wang, Z. (2023). Impact of different cooking methods on the chemical profile of orange-fleshed sweet potato (Ipomoea batatas L.). *Lwt*, *173*(November 2022), 114288. https://doi.org/10.1016/j.lwt.2022.114288

7. APPENDIX

Appendix table 1. ANOVA Table for Moisture

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	554.3241	277.1620	147224.9000	<.0001
Cooking_method	2	596.9630	298.4815	158494.9000	<.0001
Cooking_time	2	177.5741	88.7870	47148.2000	<.0001
Cooking_m * Blending_r	4	20.3704	5.0926	2.7055	0.0826
Blending_r * Cooking_ti	4	1.3148	0.3287	0.1745	0.9927
Cooking_m * Cooking_ti	4	0.9259	0.2315	0.1229	0.9695
Cookin * Blendi * Cookin	8	3.7407	0.4676	0.2483	0.9989
Error	54	0.1017	0.0019		
Corrected Total	80	1.3277			

Appendix table 2. ANOVA Table for Crude Protein

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	0.4014	0.2007	106.5600	<.0001
Cooking_method	2	0.6585	0.3292	174.8600	<.0001
Cooking_time	2	0.0609	0.0305	16.1700	<.0001
Cooking_m * Blending_r	4	0.0823	0.0206	10.9300	<.0001
Blending_r * Cooking_ti	4	0.0063	0.0016	0.8400	0.6165
Cooking_m * Cooking_ti	4	0.0034	0.0008	0.4500	0.6655
Cookin * Blendi * Cookin	8	0.0133	0.0017	0.8800	0.6658
Error	54	0.1017	0.0019		
Corrected Total	80	1.3277			

Appendix table 3. ANOVA table for Crude Fat

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	0.0656	0.0328	2.8300	0.0649
Cooking_method	2	0.2429	0.1214	10.4800	<.0001
Cooking_time	2	0.0451	0.0225	1.9400	0.0818
Cooking_m * Blending_r	4	0.0049	0.0012	0.1100	0.9967
Blending_r * Cooking_ti	4	0.0009	0.0002	0.0200	1.0000
Cooking_m * Cooking_ti	4	0.0002	0.0000	0.0000	1.0000
Cookin * Blendi * Cookin	8	0.0020	0.0003	0.0200	1.0000
Error	54	0.6257	0.0116		

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Corrected Total	80	0.9873			

Appendix table 4. ANOVA for Fiber

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	10.4590	5.2295	729.7500	<.0001
Cooking_method	2	0.9391	0.4695	65.5300	<.0001
Cooking_time	2	0.0979	0.0489	6.8300	0.0003
Cooking_m * Blending_r	4	0.1055	0.0264	3.6800	0.0067
Blending_r * Cooking_ti	4	0.0021	0.0005	0.0700	0.9989
Cooking_m * Cooking_ti	4	0.0062	0.0016	0.2200	0.8839
Cookin * Blendi * Cookin	8	0.0020	0.0003	0.0400	1.0000
Error	54	0.3871	0.0072		
Corrected Total	80	11.9987			

Appendix table 5. ANOVA for Ash

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	0.2447	0.1223	26.7700	<.0001
Cooking_method	2	2.6461	1.3230	289.6100	<.0001
Cooking_time	2	0.0577	0.0289	6.3200	0.0005
Cooking_m * Blending_r	4	0.0089	0.0022	0.4800	0.8563
Blending_r * Cooking_ti	4	0.0010	0.0003	0.0600	0.9995
Cooking_m * Cooking_ti	4	0.0020	0.0005	0.1100	0.9655
Cookin * Blendi * Cookin	8	0.0011	0.0001	0.0300	1.0000
Error	54	0.2468	0.0046		
Corrected Total	80	3.2082			

Appendix table 6. ANOVA for Carbohydrate

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	361.2279	180.6139	82.2300	<.0001
Cooking_method	2	576.2358	288.1179	131.1400	<.0001
Cooking_time	2	205.2120	102.6060	46.7000	<.0001
Cooking_m*Blending_r	4	23.2539	5.8135	2.6500	0.0394
Blending_*Cooking_ti	4	1.1594	0.1932	0.1300	0.9941
Cooking_m*Cooking_ti	4	1.0353	0.2898	0.1200	0.9592

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Cookin*Blendi*Cookin	8	3.8472	0.4809	0.2200	0.9983
Error	54	118.6495	2.1972		
Corrected Total	80	1290.6211			

Appendix table 7. ANOVA for Total Energy

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	6526.9333	3263.4667	84.0000	<.0001
Cooking_method	2	9366.9292	4683.4646	120.5300	<.0001
Cooking_time	2	2961.9449	1480.9725	38.1400	<.0001
Cooking_m * Blending_r	4	348.7322	87.1831	2.2400	0.0775
Blending_r * Cooking_ti	4	19.0695	4.7674	0.1200	0.9951
Cooking_m * Cooking_ti	4	15.3136	3.8284	0.1000	0.9704
Cookin * Blendi * Cookin	8	60.3899	7.5487	0.1900	0.9991
Error	54	2097.5390	38.8433		
Corrected Total	80	21396.8517			

Appendix table 8. ANOVA for Beta Carotene

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	45136.0507	22568.0254	122.6900	<.0001
Cooking_method	2	1840.0419	920.0210	5.0000	0.0022
Cooking_time	2	4681.4516	2340.7258	12.7300	<.0001
Cooking_m*Blending_r	4	692.6330	173.1583	0.9400	0.5454
Blending_*Cooking_ti	4	242.3293	60.5823	0.3300	0.9385
Cooking_m*Cooking_ti	4	31.9695	7.9924	0.0400	0.9936
Cookin*Blendi*Cookin	8	263.6144	32.9518	0.1800	0.9994
Error	54	9929.1080	183.8724		
Corrected Total	80	62817.1985			

Appendix table 9. ANOVA for Vitamin C

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	24.8781	12.4391	9.3600	<.0001
Cooking_method	2	10.3717	5.1858	3.9000	0.0078
Cooking_time	2	3.1172	1.5586	1.1700	0.2164
Cooking_m * Blending_r	4	16.9224	4.2306	3.1800	0.0157

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending * Cooking_ti	4	3.1391	0.7848	0.5900	0.7876
Cooking_m * Cooking_ti	4	1.8778	0.4694	0.3500	0.7568
Cookin * Blendi * Cookin	8	7.0104	0.8763	0.6600	0.8464
Error	54	71.7600	1.3289		
Corrected Total	80	139.0767			

Appendix table 10. ANOVA for Iron

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	8.3703	4.1852	328.9000	<.0001
Cooking_method	2	2.1320	1.0660	83.7500	<.0001
Cooking_time	2	0.1575	0.0788	6.1900	0.0006
Cooking_m*Blending_r	4	0.0686	0.0171	1.3500	0.3175
Cooking_t*Blending_r	4	0.0578	0.0144	1.1400	0.4262
Cooking_m*Cooking_ti	4	0.0361	0.0090	0.7100	0.4428
Cookin*Cookin*Blendi	8	0.1061	0.0133	1.0400	0.5255
Error	54	0.6871	0.0127		
Corrected Total	80	11.6156			

Appendix table 11. ANOVA for Zinc

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	0.0086	0.0043	9.2700	<.0001
Cooking_method	2	0.0131	0.0065	14.0700	<.0001
Cooking_time	2	0.0313	0.0157	33.6700	<.0001
Cooking_m*Blending_r	4	0.0015	0.0004	0.8200	0.6253
Cooking_t*Blending_r	4	0.0004	0.0001	0.1900	0.9847
Cooking_m*Cooking_ti	4	0.0006	0.0002	0.3300	0.7752
Cookin*Cookin*Blendi	8	0.0015	0.0002	0.3900	0.9760
Error	54	0.0251	0.0005		
Corrected Total	80	0.0822			

Appendix table 12. ANOVA for Calcium

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	4655.9884	2327.9942	1196.2000	<.0001
Cooking_method	2	37.3118	18.6559	9.5800	<.0001
Cooking_time	2	14.2493	7.1246	3.6600	0.0103
Cooking_m*Blending_r	4	10.9090	2.7273	1.4000	0.2935
Cooking_t*Blending_r	4	4.6778	1.1694	0.6000	0.7805
Cooking_m*Cooking_ti	4	6.8940	1.7235	0.8900	0.3265
Cookin*Cookin*Blendi	8	10.3933	1.2992	0.6700	0.8406
Error	54	105.0855	1.9460		
Corrected Total	80	4845.5091			

Appendix table 13. ANOVA for Magnesium

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	10983.1573	5491.5787	5143.0000	<.0001
Cooking_method	2	0.8919	0.4459	0.4170	0.5755
Cooking_time	2	20.0613	10.0307	9.3900	<.0001
Cooking_m*Blending_r	4	7.9252	1.9813	1.8500	0.1462
Cooking_t*Blending_r	4	7.5513	1.8878	1.7700	0.1680
Cooking_m*Cooking_ti	4	2.8576	0.7144	0.6690	0.4734
Cookin*Cookin*Blendi	8	11.5320	1.4415	1.3500	0.3002
Error	54	57.6733	1.0680		
Corrected Total	80	11091.6499			

Appendix table 14. ANOVA for PH

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	98.1836	49.0918	10920.2000	<.0001
Cooking_method	2	1.1301	0.5651	125.7000	<.0001
Cooking_time	2	0.4365	0.2182	48.5500	<.0001
Blending_*Cooking_me	4	0.7301	0.1825	40.6000	<.0001
Blending_*Cooking_ti	4	0.1220	0.0305	6.7800	<.0001
Cooking_m*Cooking_ti	4	0.0387	0.0097	2.1500	0.0290
Blendi*Cookin*Cookin	8	0.0997	0.0125	2.7700	0.0094
Error	54	0.2429	0.0045		
Corrected Total	80	100.9835			

Appendix table 15. ANOVA for TSS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	880.2500	440.1250	294.5000	<.0001
Cooking_method	2	60.7963	30.3981	20.3400	<.0001
Cooking_time	2	122.7407	61.3704	41.1000	<.0001
Blending_*Cooking_me	4	26.8333	6.7083	4.4900	0.0017
Blending_*Cooking_ti	4	6.4444	1.6111	1.0800	0.4594
Cooking_m*Cooking_ti	4	1.0926	0.2731	0.1830	0.9125
Blendi*Cookin*Cookin	8	5.0556	0.6319	0.4230	0.9680
Error	54	80.6667	1.4938		
Corrected Total	80	1183.8796			

Appendix table 16. ANOVA for Color

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	25.0855	12.5427	122.7000	<.0001
Cooking_method	2	0.2252	0.1126	1.1000	0.2371
Cooking_time	2	0.0452	0.0226	0.2210	0.7457
Cooking_m*Blending_r	4	0.1881	0.0470	0.4600	0.8708
Cooking_t*Blending_r	4	0.0615	0.0102	0.1000	0.9915
Cooking_m*Cooking_ti	4	0.1309	0.0327	0.3200	0.7887
Cookin*Cookin*Blendi	8	0.3157	0.0395	0.3860	0.9779
Error	54	5.5200	0.1022		
Corrected Total	80	31.5721			

Appendix table17. ANOVA for Texture

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	22.5929	11.2964	89.3000	<.0001
Cooking_method	2	4.5706	2.2853	18.0600	<.0001
Cooking_time	2	0.4689	0.2344	1.8500	0.0917
Cooking_m*Blending_r	4	1.1991	0.2998	2.3700	0.0629
Cooking_t*Blending_r	4	0.1030	0.0257	0.2030	0.9813
Cooking_m*Cooking_ti	4	0.0556	0.0139	0.1100	0.9641
Cookin*Cookin*Blendi	8	0.1793	0.0224	0.1770	0.9994
Error	54	6.8333	0.1265		
Corrected Total	80	36.0025			

Appendix table 18. ANOVA for Aroma

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	0.0685	0.0343	0.8700	0.5127
Cooking_method	2	0.5569	0.2784	7.0700	0.0002
Cooking_time	2	0.0080	0.0040	0.1010	0.8741
Cooking_m*Blending	4	0.4476	0.1119	2.8400	0.0283
Cooking_t*Blending_r	4	0.0387	0.0097	0.2460	0.9697
Cooking_m*Cooking_ti	4	0.0893	0.0223	0.5670	0.5577
Cookin*Cookin*Blend	8	0.3285	0.0411	1.0400	0.5254
Error	54	2.1267	0.0394		
Corrected Total	80	3.6641			

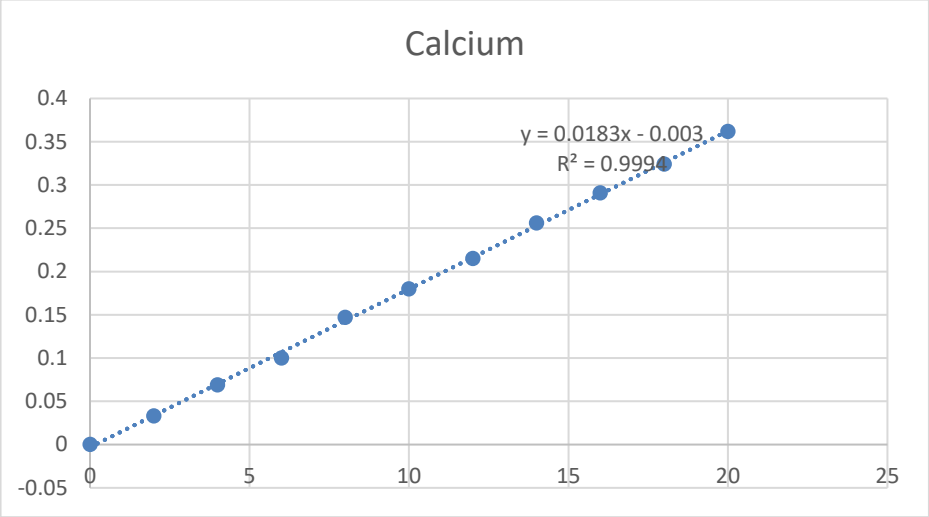
Appendix table19. ANOVA for Taste

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	12.0299	6.0150	78.9600	<.0001
Cooking_method	2	1.9717	0.9858	12.9500	<.0001
Cooking_time	2	0.4067	0.2033	2.6700	0.0336
Cooking_m*Blending_r	4	0.2787	0.0697	0.9140	0.5633
Cooking_t*Blending_r	4	0.2570	0.0643	0.8440	0.6115
Cooking_m*Cooking_ti	4	0.0917	0.0229	0.3010	0.8072
Cookin*Cookin*Blendi	8	0.1802	0.0225	0.2960	0.9931
Error	54	4.1133	0.0762		
Corrected Total	80	19.3292			

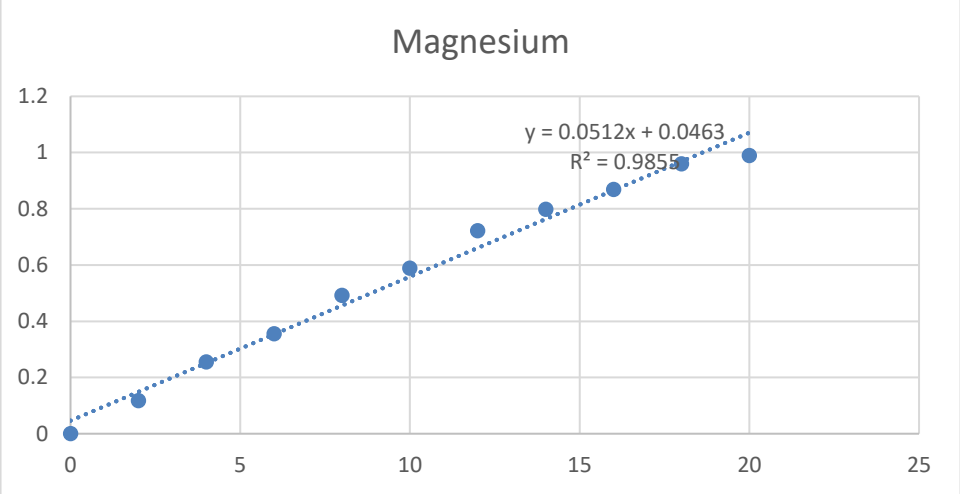
Appendix table 20. ANOVA for Overall Acceptability

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Blending_ratio	2	1.5192	0.7596	29.3000	<.0001
Cooking_method	2	1.1632	0.5816	22.4200	<.0001
Cooking_time	2	0.0888	0.0444	1.7100	0.1094
Cooking_m*Blending_r	4	0.2162	0.0541	2.0800	0.1009
Cooking_t*Blending_r	4	0.0327	0.0082	0.3160	0.9444
Cooking_m*Cooking_ti	4	0.0090	0.0023	0.0870	0.9764
Cookin*Cookin*Blendi	8	0.0572	0.0072	0.2760	0.9950
Error	54	1.4004	0.0259		
Corrected Total	80	4.4868			

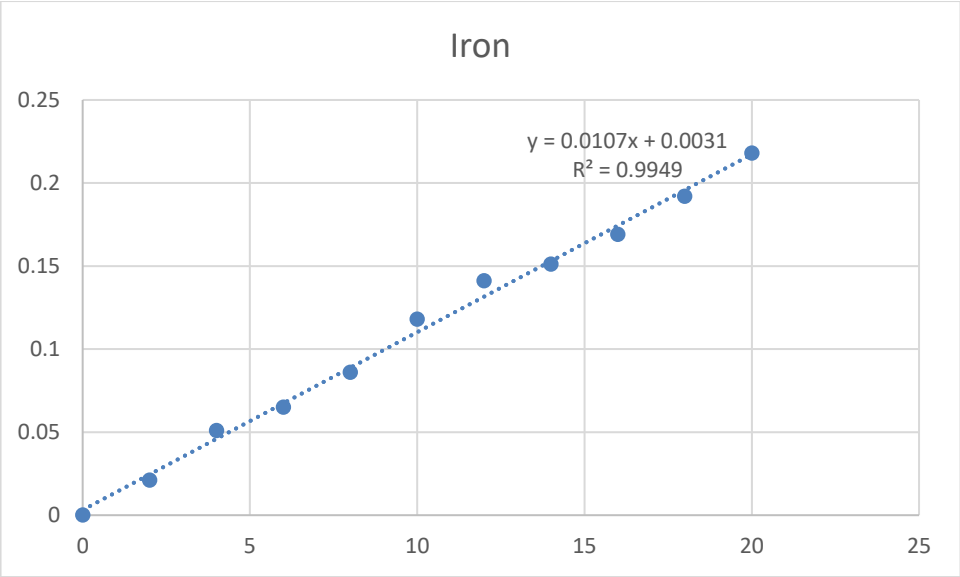
Appendix figure 1. Calibration curve for Calcium



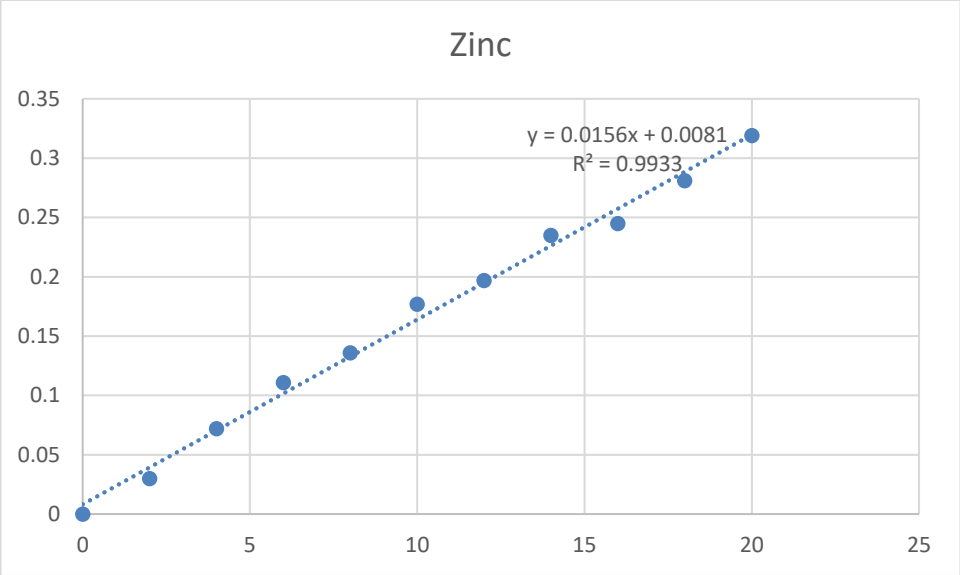
Appendix figure 2. Calibration curve for Magnesium



Appendix figure 3. Calibration curve for Iron



Appendix figure 4 Calibration curve for Zinc



Pictures


dreamstime.com
ID 10787422 © Somyot Sutprattanatawin


Orange Jam