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Effect of Different Processing Methods on the Microbiological, Mineral and Phytochemical Composition of Tamarind Seed Flour

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ABSTRACT

This study investigated the effect of different processing methods on the microbiological, mineral and phytochemical composition of tamarind seed flour. Fresh tamarind fruits were purchased from Wukari main market in Taraba State and were processed into flour using different methods (soaking, cooking, roasting and sprouting). The flour was then analysed for microbiological, mineral and phytochemical composition using standard methods. The result showed that roasted, cooked, soaked, sprouted, and the control flour had total aerobic plate count of 3.45x104, 4.6x104, 2.1x104, 1.65x104 and 3.2x104 cfu/g, for bacteria respectively. The result showed that roasted, cooked, soaked, sprouted and the control flour had yeast count of 1.1x104, 9x104, 1.3x104, 2.3x104 2.4x104 cfu/g, for yeast respectively. The study also revealed the following species of organisms such as streptococcus, lactococcus, staphylococcus, clostridium spp, enterobacter and neiserra. Phosphorous, iron and magnesium ranged from 0.68 to 0.80, 0.03 to 0.07 and 0.03 to 0.07 mg/100g, respectively. Tannin, alkaloid, flavonoid and saponin contents of the flour ranged from 9.45 to 19.36, 9.12 to 14.67, 4.30 to 17.61 and 2.57 to 4.92 µg/ml, respectively. The study concluded that treatment methods have significant impacts on the microbiological, mineral and phytochemical composition of tamarind seed flour. The cooking and sprouting methods is recommended due to its anti-nutrient detoxification and bioavailability of the nutritional composition of the processed flour and safety for consumption and these methods should be utilized in food processing of tamarind flour industrially.

1.0 INTRODUCTION

The Tamarind (*Tamarindus indica* L.) is a fruit plant that belongs to the Legume family, native to Equatorial Africa, India, and Southeast Asia. The plant is commonly referred to as “Saamia” in Hausa and “Yooyi” in Ga. It is also sometimes referred to as the “date of India”. The tamarind tree produces bean-like pods, filled with seeds and surrounded by a fibrous pulp as fruit. The fruit pulp possesses a sweet acidic taste that is attributed to the presence of high amounts of reducing sugars and tartaric acid. (Borquaye *et al*., 2020).

The tamarind plant is appreciated for the refreshing, acidic, and astringent flavor of its fruit is used in the manufacture of candies, soft drinks, liqueurs, and ice cream and for the beauty and production of shade, being used in ornamentation, afforestation, and urbanization. Its industrialization has been largely in the form of juices and pastes prepared from pulp. (Barros *et al*., 2022)

In traditional medicine, the seeds of tamarind are used in the treatment of chronic diarrhea and dysentery. The roots and bark are used as remedies for treating ulcers, boils, rashes, eye and skin inflammation, and indigestion and to promote wound healing. (Borquaye *et al*., 2020).

Tamarind seeds, like many other agricultural products, may be susceptible to microbial contamination during harvesting, processing, and storage. The microbiological composition of tamarind seed flour is an essential aspect to consider, as it directly influences the product's safety and shelf life. Microbial load, including total bacterial count, yeast, and mold count, needs to be evaluated to ensure that the tamarind seed flour is safe for consumption and meets the regulatory standards for microbial limits in food products (Sharma *et al*., 2016).

Moreover, the nutrient value of food can be changed by the way it is processed, cooked, and stored. However, some food processing methods (soaking, boiling, roasting, sprouting, and fermentation) can enhance the quality of processed foods through detoxification of anti-nutrients, flavour and colour development, among others. Tamarind seed flour is rich in various phytochemicals, which are biologically active compounds derived from plants. These phytochemicals contribute to the flavor, color, and health-promoting properties of the flour. The primary phytochemicals found in tamarind seed flour include phenolic compounds, flavonoids, alkaloids, saponins, and sterols. Quantifying the total phenolic content and flavonoid content can provide valuable information about the potential health benefits associated with tamarind seed flour consumption. Additionally, high-performance liquid chromatography (HPLC) analysis can be used to identify and quantify specific bioactive compounds in the flour (Zade *et al*., 2017).

The limited comprehensive studies on the effect of processing methods on tamarind seed flour hinders its potential application as a functional ingredient in the food and pharmaceutical industries. Hence, the aim of this study was to determine the effect of sprouting, cooking, soaking, and roasting methods on the microbial, mineral and phytochemical composition of flours produced from tamarind seeds thereby improving the anti-nutrient

detoxification and bioavailability of their nutritional composition and safety for consumption.

MATERIALS AND METHODS

Source of Raw Materials

Fresh tamarind fruits were purchased from Wukari main market in Taraba state, Nigeria and transported to the Food Science and Technology Laboratory, Federal University Wukari for analyses.

Methods of Processing of Tamarind Seed Flour

Sprouting/germination

The preparation of tamarind seed flour was carried out by modifying the method of Okoronkwo *et al*., (2022). The tamarind pods were manually de-podded by carefully opening the pods to obtain the seeds. Whole un-infested seeds were sorted out for use. Cleaned tamarind seeds were boiled in water for about two hours. The seed coat were removed manually by pressing between fingers to obtain the cotyledons. The cotyledons were tightly wrapped with banana leaves (Musa sapientium) in different packets and the packets were placed in calabash trays, covered with jute bags, and water were continually sprinkled for three days for it to germinate. The samples were oven dried at 60^{o}C after germination and then milled into flour using an attrition mill. The milled flour were sifted through a 1 mm mesh size sieve, packaged in an airtight container, and stored at room temperature until analysed.

Cooking/boiling

The method as described by Akajiaku *et al*., (2014) were used. Five hundred gram (500g) of the seeds were cooked in boiling water at 100^{0}C for 30 min. The seeds were sun-dried and milled into flour. The flour was sifted through a 1-mm mesh size sieve, packaged in an airtight container, and stored at room temperature until needed for analyses.

Roasting

Method described by Akajiaku *et al*., (2014). After preliminary investigation (such as cleaning, sorting). 500g of tamarind seeds were roasted in an open pan and placed on an electric stove at a temperature of 120^{o}C for 15 min. The roasted seeds were de-hulled after breaking the cotyledons with the attrition mill and the seed coats removed by abrasion (rubbing in between palms) and winnowing. The cotyledons were sun-dried and milled into flour using an attrition mill and sifted through a 1-mm mesh size sieve, packaged in air-tight plastic containers, and stored at room temperature.

Soaking

The preparation of tamarind seed flour was carried out as described Okoronkwo *et al*., (2022) with little modification. 500g of the seeds were soaked in sufficient clean water for 12h, then the water was decanted and then the de-hulled seeds were oven dried at 60°C for 8h to a constant moisture content of 8.30% and milled into flour. The flour was sifted through a 1-mm mesh size sieve and packaged in an airtight container and stored at room temperature until analysed.

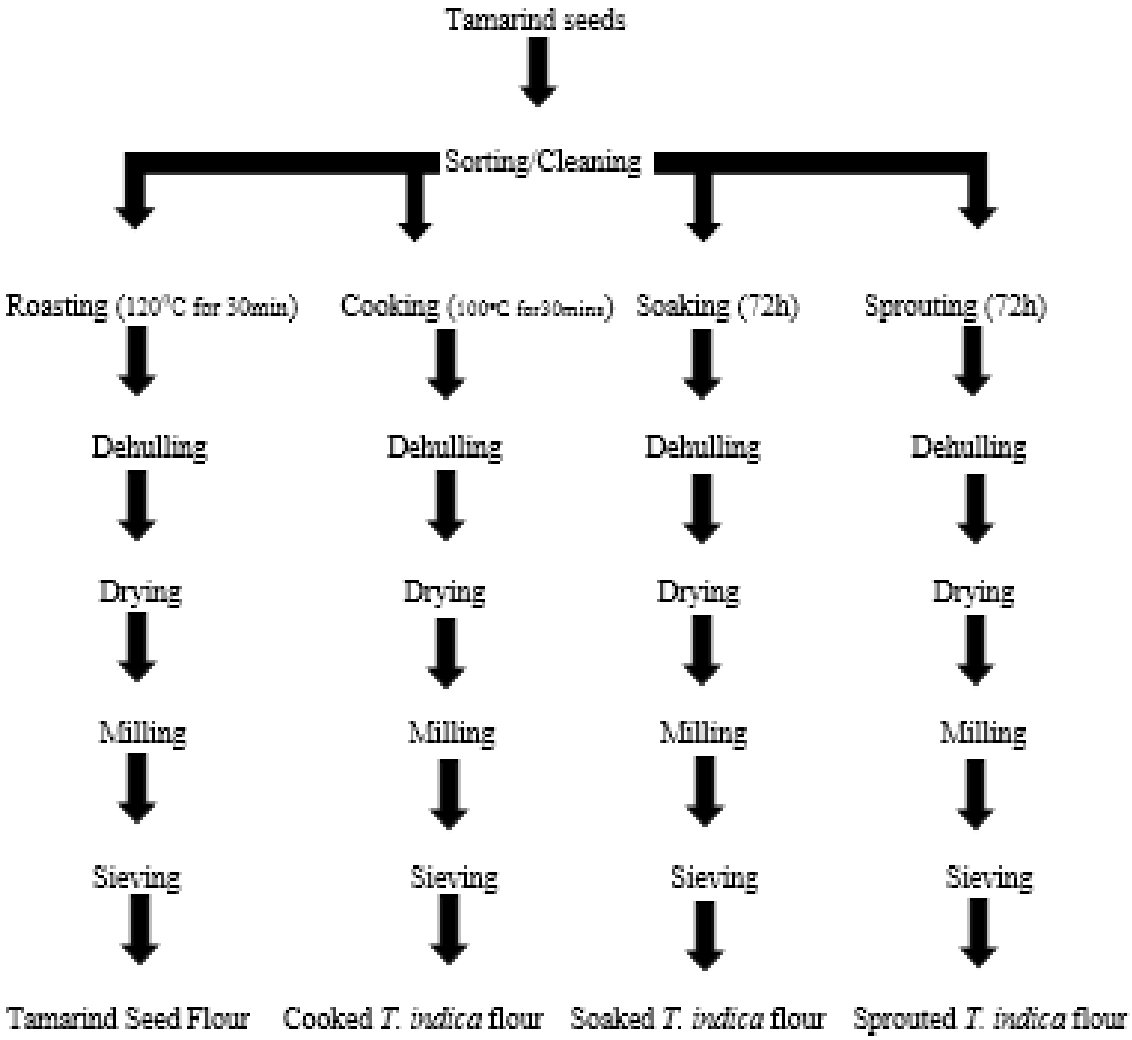

Figure 1: Production of Tamarind Seed Flour.
Source: Akajiaku *et al*. (2014)**.**

Microbiological Analysis

The method as described by Ijah *et al*., (2014),for total viable bacterial and fungi counts (yeast) were carried out on the tamarind samples to determine the microbial load of the samples as stated by American Public Health Association.

Preparation of Media

The following media were used for the enumeration of bacteria cells from the samples of tamarind flour nutrient agar, Macconkey agar, and potato dextrose agar. 2.8g of nutrient agar, 5.5g of Macconkey agar, and potato dextrose agar, 3.9g/100ml respectively were weighed and dissolved in distilled water and sterilized by autoclaving at 121^0C for 15 minutes at 15 pounds per square inch (PSI).

Isolation and Enumeration

The total bacterial count was determined using the method of Ijah *et al*., (2014). The stock solution were prepared by dissolving 1ml of the sample of tamarind flour in 9ml of sterile peptone water, serial dilution (10 fold) were carried out (1:10, 1: 100, 1:1000…10,0000). 1.0ml of appropriate dilutions (10-2 and 10-4) were placed on various agar plates using pour plate method and incubated at 37 ^{0}C for 18-24 hours for total bacteria, and coliform. For fungi 1.0ml amount of appropriate dilutions (10-2 and 10-4) were also poured into the plates of potato dextrose agar and incubated at room temperature 28±10c for 3 to 5 days. All enumerations were expressed as colony-forming unit (cfu/ml).

Purification and Maintenance of Microbial Isolate

Bacteria isolates were transferred into fresh agar medium of isolation and incubated at 37^{o}C for 24 hours. Pure colonies of bacteria were maintained and stored at 4^{0}C until needed.

Identification and Characteristics of the Isolates

Bacteria isolates were identified and characterized based on their morphology, structures cell shapes and appearance as described by Ijah *et al*., (2014).

Analytical Methods

Determination of Mineral Composition of Tamarind Seed Flour

Determination of phosphorous

Phosphorus in the samples was determined according to Onwuka (2005) by the molybdate method using hydroquinone as a reducing agent. Five milliliters (5 ml) of the test sodium was pipetted into 50 ml graduated flask. Then 10 ml of molybdate mixture was added and diluted to mark with water. It was allowed to stand for 30 minutes for colour development. The absorbance was measured at 660 nm against a blank.

Determination of iron

Iron was determined by the method described by Onwuka (2005). Three grammes of sample were placed in a crucible and put in a muffle furnace at 550^{o}C for 6 hours, after which it was allowed to cool for 1 hour in the furnace before being transferred to the dessicator. One gramme of ashed sample was weighed into a digestion flask and 20 ml of the acid mixture (650 ml Conc. HNO_3, 80 ml PCA and 20 ml Conc. H_2SO_4) were added. The digestion flask was heated until a clear digest was obtained. The digest was diluted with distilled water to 500 ml mark. Ten milliliters of the diluted digest were injected into atomic absorption spectrophotometer and the absorbance was read at the maximum wavelength (λ_{max}) of absorption of the respective element. Standard curves were plotted, from which the concentration of iron were extrapolated.

Determination of magnesium

Magnesium was determined using the method described by Bartram and Balance (1996). Ten milliliters of digested sample were pipetted into 250 ml conical flask and a small amount of Eriochrome Black T was added to the solution which, when buffered at pH 10.0. Then the solution was titrated with ethylenediaminetetraacetic acid (EDTA), the magnesium was complexed; at the end-point the solution changed from wine-red to blue.

Determination of zinc

Five milliliters (5 ml) of each of the samples was first digested with 20 ml of acid mixture (650 ml) of concentrated HNO_3; 80 ml percloric acid (PCA); 20 ml conc. H_2SO_4) and aliquot of the diluted clear digest was used for the measurement of absorbance with atomic absorption spectrophotometer using filters that match the element.

Determination of Phytochemical Compositions of the Tamarind Seed Flour

Determination of tannins

The method as described by (Uzodinma *et al*., 2020) was used for the determination of tannin contents of the differently processed samples. 0.2g of finely ground sample were measured into a 50 ml beaker. 20 ml of 50% methanol was added and covered with paraffin and placed in a water bath 77-80oC for 1h and stirred with a glass rod to prevent lumping. The extract was quantitatively filtered methanol to rinse. This was made up to mark with distilled water and thoroughly mixed. 1 ml of sample extract was pipette into 50ml volumetric flask, 20ml distilled water, 2.5 ml Folin Denis reagent and 10 ml of 17% Na_2C03 were added and mixed properly. The mixture was made up to mark distilled water, mixed well and allowed to stand for 20 min when a bluish – green colouration developed. Standard Tannic Acid solutions of range 0-10 ppm were treated similarly as 1 ml of sample above. The absorbances of the Tannic Acid Standard solutions as well as samples were read after colour development using Spectrophotometer at a wavelength of 760 mm.

Determination of alkaloids

The method of AOAC, (2012), was used by the alkaline precipitation gravimetric method. A measured weight of the sample was dispersed in 10% acetic acid solution in ethanol to form a ratio of 1.10 (10%). The mixture was allowed to stand for 4h at 28oC. It was later filtered via what man No 42 grade of filter paper. The filtrate was concentrated to one quarter of its original volume by evaporation and treated with drop wise addition of cone aqueous NH4OH until the alkaloid was precipitated. The alkaloid precipitated was received in a weighted filter paper, washed with 1% ammonia solution dried in the oven at 80^{o}C. Alkaloid content was calculated and expressed as a percentage of the weight of sample analyzed.

Determination of Flavonoids

One gram (1 g) of the sample was weighed and repeatedly extracted with 100 cm^3 of 80% methanol at room temperature. The mixture was then filtered through filter paper into a 250 cm^3 beaker and the filtrate was

transferred into a water bath and allowed to evaporate to dryness and weighed. The % flavonoid were calculated as described by (Krishnaiah *et al*., 2009).

Determination of Saponins

The method of (AOAC, 2012), was used .The saponin content of the samples were determined by double extraction gravimetric method. 5g of the powered sample was mixed with 50 ml of 20% aqueous ethanol solution in a flask. The mixture was heated with periodic agitation in water bath for 90 minutes at 55^{o}C; it was then filtered through a filter paper. The residue was extracted with 50 ml of 20% ethanol and both extract reduced to about 40 ml at 90oC and transferred to a separating funnel where 40 ml of diethyl either was added and shaken vigorously. Separation was by partition during which the ether layer were discarded and the aqueous layer reserved. Re extraction by partitioning was done repeatedly until the aqueous layer become clear in colour. The sapinions were extracted, with 60 ml of normal butanol. The combined extracts were washed with 5% aqueous sodium chloride (Na CI) solution and evaporated to dryness in a reweighted evaporation dish. It was dried at 60^{o}C in the oven and reweighted after cooling in a desiccator. The process was repeated two more times to get an average. Saponin content was determined by difference and calculated as a percentage of the original sample.

Experimental design and data analysis

All experiments were conducted in a completely randomized design (CRD). Data generated was subjected to the analysis of variance (ANOVA) at 0.05 probability level. Duncan multiple range tests (DNMRT) were used to compare means using the statistical package for social sciences (SPSS) version 22.0 and significance was accepted at p≤0.05.

RESULTS AND DISCUSSION

Effect of Processing Methods on Microbial Load of Tamarind Seed Flours

Table 1 shows the total aerobic plate count (TAPC) for bacteria and yeast cells for roasted, cooked, soaked and sprouted tamarind seed flour. The tamarind seed flour samples had total aerobic plate count for bacteria cells of $3.45x10^4$, $4.6x10^4$, $2.1x10^4$, $1.65x10^4$ and $3.2x10^4$ cfu/ml for the roasted, cooked, soaked, sprouted, and control flour, respectively. The fungi count (yeast) ranged from $1.1x10^4$ – $2.4x10^4$. The highest count $4.6x10^4$ cfu/ml was observed for cooked tamarind flour and the least count $1.65x10^4$ cfu/ml for bacteria was obtained from the sprouted flour. The high microbial count observed in the roasted and cooked tamarind flour for bacteria suggests that certain microorganisms were able to survive the heat treatment. This result obtained in this study is in agreement with the report of Adams *et al*., 2019) who also obtained a similar result. The lower microbial count observed in the sprouted sample indicates that sprouting contributed to a reduction in microbial populations compared to other processing methods (Jeddi *et al*., 2014).

Table.1: Total Aerobic Plate count of bacteria and fungi (yeast) cells obtained from roasted, cooked, soaked and sprouted tamarind flours.

Sample	Total aerobic plate count (cfu/ml)	Yeast Cell (cfu/ml)
Roasted	$3.45x10^4$	$1.1x10^4$
Cooked	$4.6x10^4$	$1.3x10^4$
Soaked	$2.1x10^4$	$2.4x10^4$
Sprouted	$1.65x10^4$	$1.4x10^4$
Control	$3.2x10^4$	$1.7x10^4$

Morphological Characteristics Bacterial Isolates from Roasted, Cooked, Soaked and Sprouted Tamarind Seed Flours.

Table 2 shows the morphological characteristics of bacteria species from roasted, cooked, soaked and sprouted tamarind seed flours. The following microbial floral included : *Streptococcus, lactococcus*, *Staphylococcus*, *Clostridium spp*, *Enterobacter* and *Neiserra* were the suspected organisms identified in the flour samples The presence of *Streptococcus* or *lactococcus*, in the roasted flour indicates the possibility of lactic acid bacteria, which are commonly found in fermented or acidic environments and could contribute to flavor development or preservation. The cooked flour has a milky dry appearance and positive cocci in clusters which suggest the presence of *Staphylococcus*. *Staphylococcus* is commonly associated with cocci in clusters and is often found in cooked foods (Kadariya *et al*., 2014). The study suspected the organism present in the soaked flour to be *Clostridium spp*. based on the morphological features. This result also agrees with the report of some researchers who also isolated *Clostridium spp*. in a similar study (Maslanka *et al*., 2013). The sprouted flour has a yellowish/milky colour. It also has a positive rod and was suspected to result from *Enterobacter* organism. *Enterobacter* is a rod-shaped bacteria and is commonly associated with environmental contamination. *Enterobacter spp.* are opportunistic pathogens and can be found in soil, water, and plants. The presence of this organism in the sprouted flour shows that there may be environmental contamination during the sprouting process (Perri *et al*., 2020).

Table 2: Morphological Characteristics of Bacterial Isolates from Roasted, Cooked, Soaked and Sprouted Tamarind seed Flours.

Sample	Medium of growth	Morphological appearance	Gram Reaction	Suspected Organism
Roasted	NA	Mucoid, smoothy whitish colour	Positive rod and cocci in chain	*Streptococcus, lactococcus*
Cooked	NA	Milky colour	Positive cocci in clusters	*Staphylococcus*
Soaked	NA	Yellowish/milky colour smooth	Positive cocci in clusters and rod	*Clostridium spp*
Sprouted	NA	Yellowish/milky colour	Positive rod	*Enterobacter*
Control	NA	Milky mucoid and smooth edge	Positive cocci	*Neiserra*

Effect of Processing Methods on Mineral Composition of Tamarind Seed Flours

Table 3 shows the minerals composition of roasted, cooked, soaked and sprouted tamarind seed flours. The phosphorous content of the tamarind flour samples ranged from 0.68 to 0.80 mg/100g and was significantly different ($p<0.05$). The highest phosphorous (0.80 mg/100g) was observed in the roasted tamarind flour and was lowest (0.68 mg/100g) in the control sample (untreated). The higher phosphorous in the roasted tamarind flour may be as a result of higher exposure of the flour to direct heat which caused an elevation in the phosphorous content compared to other flours. The result obtained from this study is in line with that of Adelakun *et al*. (2012) who reported high phosphorus in a roasted seed flour sample which increased in roasting temperature and time. Phosphorus is an essential nutrient for all living organisms and is involved in energy production, DNA and RNA synthesis, cell signaling, and bone formation (Michigami *et al*., 2018).

The iron content of the tamarind flour samples ranged from 0.03 to 0.07 mg/100g and were significantly different ($p<0.05$). The control, cooked and sprouted tamarind flours were observed to have the highest iron content (0.07 mg/100g). The lowest iron (0.03 mg/100g) was recorded for the roasted tamarind flour. This indicates that iron bioavailability was increased through reduction of anti-nutrients by cooking and sprouting. However the lower iron reported for the roasted flour may have reduced due to decrease in iron bioavailability.

Olanipekun *et al*. (2015) reported iron of 23.02 ppm in raw kidney bean seed flours when compared to the boiled and roasted samples. Adelakun *et al*. (2012) reported that roasted okra seed (Abelmoschus esculentus Moench) flour had iron of 1.11–1.92%. Iron is essential for the development of baby's brain, it helps in neurological and cognitive development. Iron deficiency may hinder the development of the central nervous system (Oluseyi *et al*., 2019).

The magnesium content of the tamarind flour samples ranged from 0.03 to 0.07 mg/100g. The control, cooked and sprouted tamarind flours had the highest magnesium content (0.07 mg/100g) and were significantly different ($p<0.05$). The roasted and soaked tamarind flours recorded lowest magnesium (0.03 mg/100g). The increase in magnesium content of the sprouted flour may result from increase in magnesium bioavailability through enzymatic processes. Magnesium is important for the proper functioning of the cardiovascular system, as it helps regulate the contraction and relaxation of muscles, including the heart muscle (Faryadi, 2012).

Table 3. Mineral composition of roasted, cooked, soaked and sprouted tamarind flours

Samples	Phosphorous (mg/100g)	Iron (mg/100g)	Magnesium (mg/100g)
Roasted	$0.80^{a} \pm 0.01$	$0.03^{b} \pm 0.04$	$0.03^{c} \pm 0.00$
Cooked	$0.78^{a} \pm 0.01$	$0.07^{a} \pm 0.00$	$0.07^{b} \pm 0.00$
Soaked	$0.71^{b} \pm 0.01$	$0.04^{b} \pm 0.01$	$0.03^{c} \pm 0.00$
Sprouted	$0.69^{b} \pm 0.02$	$0.07^{a} \pm 0.00$	$0.07^{a} \pm 0.00$
Control	$0.68^{b} \pm 0.01$	$0.07^{a} \pm 0.00$	$0.07^{ab} \pm 0.00$

Values are means ± standard deviation of duplicate determinations. Means in the same column with different superscripts are significantly ($p<0.05$) different.

Effect of Processing Methods on Phytochemicals Composition of Tamarind Seed Flours

Table 4 shows the phytochemical composition of roasted, cooked, soaked and sprouted tamarind seed flours.Tannins ranged from 9.45 to 19.36 µg/g in the tamarind flour samples and were significantly different ($p<0.05$). The cooked tamarind flour had the highest tannin (19.36 µg/g) and was lowest in the soaked tamarind flour (9.45 µg/g). Olanipekun *et al*. (2015)

reported tannins ranging from 0.10 to 0.21 % and was highest in the raw sample. The high tannin observed in the cooked flour shows that the tannins present were water-insoluble and were unable to leach into the cooking water (Takekawa and Matsumoto, 2012). The alkaloid content of the tamarind flour samples ranged from 9.12 to 14.67 µg/g and was highest (14.67 µg/g) in the cooked flour. The soaked tamarind flour had the lowest alkaloid (9.12 µg/g) and was significantly different ($p<0.05$). Egbuonu *et al*. (2014) reported alkaloid of 0.91 to 1.75 % in soaked bitter (trifoliate) yam flour and observed a decrease in the alkaloid content as soaking time was increased. High alkaloids may cause adverse effects such as nausea, vomiting, dizziness, or even more severe symptoms depending on the individual's sensitivity and the amount ingested (Koleva *et al*., 2012).

Flavonoid ranged from 4.30 to 17.61 µg/ml and was significantly different ($p<0.05$). The highest flavonoid (17.61 µg/ml) was observed in the cooked tamarind flour and was lowest (4.30 µg/ml) in the soaked tamarind flour. Flavonoids are often heat-stable compounds and resulted to higher amounts in during cooking. Flavonoids help protect cells from oxidative damage and can help modulate the body's inflammatory response (Al-Khayri *et al*., 2022).

Saponin ranged from 2.57 to 4.92 µg/ml and was highest in the sprouted tamarind flour (4.92 µg/ml). The saponin of the flour samples were significantly different ($p<0.05$). Soaked tamarind flour had the lowest saponin (2.57 µg/ml). Olanipekun *et al*. (2015) reported saponins ranging from 0.03 to 0.05 % and was highest in the raw and boiled sample. Saponins have been shown to lower cholesterol levels by interfering with the absorption of dietary cholesterol in the intestines (del Hierro *et al*., 2018).

Table 4 .Phytochemical composition of roasted, cooked, soaked and sprouted tamarind seed flours

Samples	Tannin (µg/g)	Alkaloid (µg/g)	Flavonoid (µg/ml)	Saponin (mg/ml)
Roasted	$12.56^{c} \pm 0.67$	$9.93^{c} \pm 0.26$	$7.39^{c} \pm 0.40$	$4.38^{ab} \pm 0.39$
Cooked	$19.36^{a} \pm 0.43$	$14.67^{a} \pm 0.90$	$17.61^{a} \pm 0.85$	$3.60^{bc} \pm 0.54$
Soaked	$9.45^{d} \pm 0.42$	$9.12^{c} \pm 0.12$	$4.30^{d} \pm 0.35$	$2.57^{c} \pm 0.54$
Sprouted	$14.93^{b} \pm 0.40$	$12.35^{b} \pm 0.21$	$9.33^{b} \pm 0.35$	$4.92^{a} \pm 0.23$
Control	$12.22^{c} \pm 0.23$	$7.07^{d} \pm 0.06$	$6.11^{c} \pm 1.00$	$3.46^{bc} \pm 0.56$

Values are means ± standard deviation of duplicate determinations. Means in the same column with different superscripts are significantly ($p<0.05$) different.

CONCLUSION AND RECOMMENDATION

The treatment of tamarind seed by soaking, cooking, roasting and sprouting has significant impacts on the microbiological, mineral and phytochemical composition of tamarind seed flour. The processing methods especially cooking and sprouting produced flour with a better proportion of mineral composition. The cooking and sprouting methods is recommended due to its anti-nutrient detoxification and bioavailability of the nutritional composition of the processed flour which makes it safe for consumption and these methods should be utilized in food processing of tamarind seed flour industrially.

Disclosure of Conflict of Interest

No conflict of interest to disclosure

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