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NUTRITIONAL ASSESSMENT OF FERMENTED AND ROASTED *Tamarindus indica* SEEDS FROM LAPAI, NIGERIA

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ABSTRACT

This work studied the proximate, mineral and phytochemical content of fermented and roasted Tamarind (Tamarindus indica) seed nuts, using standard analytical methods. The seeds were divided into two; one portion was roasted at temperature 85 - 100 ^oC for 15 mins while the second portion was fermented for 48 hours in the presence of yeast. The proximate analysis of the roasted and fermented samples revealed the values of moisture, ash, crude lipid, Crude protein, crude fibre, carbohydrate and calorific values of the fermented sample were 10.70±0.21 %, 3.06±0.71 %, 2.30±0.19 %, 19.25±0.16 %, 5.75±0.33 %, 58.94±0.23% and 301.29±0.31kcal/100g while values for the roasted sample were 2.00±0.82 %, 3.34±0.53 %, 7.60±0.43 %, 23.63±0.11 %, 5.22±0.74 %, 58.21±0.17 % and 329.08±0.92 kcal/100g respectively. Mineral elements present were K (336.75±0.31 mg/100g), Mg (166.90±0.37 mg/100g), P (106.42±0.65 mg/100g), Na (186.52±0.09 mg/100g) and Ca (10.33±0.15 mg/100g) for the fermented sample and values obtained for K, Mg, P, Na and Ca in roasted sample were 784.95±0.43, 187.65±0.17, 122.38±0.29, 54.36±0.13 and 12.65±0.11 mg/100g respectively. Results of phytochemical content showed that fermented Tamarindus indica contained tannin (64.61±0.43 mg/100 g), saponnins (127.33±0.79 mg/100 g), flavonoid (3.53±0.18 mg/100 g) and alkaloid (23.56±0.37 mg/100 g) while phytochemicals in the roasted sample were 40.97±0.21, 94.69±0.29, 1.96±0.51 and 14.33±0.12 mg/100g for tannins, saponins, flavonoid and alkaloids respectively, and were significantly lower than those in the fermented sample. Correlation analysis indicate a correlation exist between nutritional content of fermented and roasted samples of T. indica. The high crude protein, carbohydrate, calorific value and mineral content in fermented and roasted T. indica seeds indicate that the seeds could be good source of nutrient.

KEYWORDS: Tamarind, nutrition, carbohydrate, minerals, phytochemicals

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INTRODUCTION

Several fermented and roasted food products are known to exist, which are very useful in meeting the large dietary needs of the rapidly growing global population (Beveridge *et al.,* 2013). Present studies have well documented the availability of several shrubs and trees in Nigeria. Most of these plants produce fruits; some which have pods and seeds that can be investigated in other to promote nutrient availability and formulations of drugs (Mathew *et al*., 2021; Franzo *et al.,* 2013). There is need for effective promotion of most underutilized crops including seeds, pods and other portions that are mostly disposed due to

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their under assessment in terms of nutritional compositions (Bello, 2014).

Tamarindus indica is a member of the *Caesalpinaceae* subfamily of *Fabaceae* family. It is a slow growing but long lived that leguminous tree grows to 20-25 m in height with an average life span of 80-200 years (Panara *et al*. 2014; Dash and Maher 2014). It grows well in both semi-arid and humid monsoon climates and can tolerate temperatures up to 47 ºC but is very sensitive to frost. It is mainly grown in areas with 500-1500 mm rain/year but tolerates down to 350 mm if irrigated at the time of establishment. In the wet tropics with over 4000 mm rain, flowering and fruit settling is significantly reduced (Iman *et al*., 2007).

Tamarindus indica is valued for its fruit, especially the pulp, which is used for a wide variety of domestic and industrial purposes (Khandza and Kabir, 2008).The pulp is used as a beverage and its seeds are discarded as waste (Singh *et al*., 2007). Tamarind pulp is reported to be used in the treatment of a number of ailments, including the alleviation of sunstroke and the intoxicating effects of alcohol and cannabis. It can be gargled for sore throats, dressing of wounds and is said to aid the restoration of sensation in cases of paralysis. Tamarind pulp is also said to aid in the cure of malarial fever (Caluwe *et al*., 2010; Garba *et al*., 2003). The fruit pulp is used as digestive, a remedy in bile disorders, to alleviate sunstroke. The acidic pulp is used as an ingredient in culinary preparations, such as curries, chutneys, sauce, ice cream, and sherbet in countries where the tree grows naturally (Caluwe *et al*., 2010).

Tamarind (*Tamarindius indica*) seed is a by-product in the tamarind pulp industry. It is considered as waste and discarded after processing. Not much has been reported on the nutritional composition of *Tamarindus indica* seed. This study seeks to assess the proximate, mineral and phytochemical content of fermented and roasted tamarind (*Tamarindus indica*) seed and determine the correlation between factors.

MATERIALS AND METHODS

Sample Collection

Fresh fruit of *Tamarindus indica* used for this research were obtained from Gulu town in Lapai local Government Area, Niger State, Nigeria. They were dried under sun and the seeds were carefully removed from their hulls and stored in plastic containers.

Sample Preparation

Tamarindus indica fruit were soaked (5000 g) in water for few hours to soften the fruits then hand crushed to remove the seeds. The seeds were sundried then sorted to remove dirt and bad seeds before they were divided into two (2) portions (1000 g each for roasting and fermentation). The experiments were carried out in the laboratory in Department of chemistry, Ibrahim Badamasi Babangida University, Lapai Niger state, Nigeria.

Fermentation

The seeds of *Tamarindus indica* about 1000 g were crushed and dehulled, then ground to powder and sieved with a 1 mm mesh sieve. About 100 g of powder was weighed into 250 cm^3 conical flask, 30 cm^3 of distilled water was added and 1.0 g of yeast (*Saccharomyces cerevisiae*) was added to the mixture and thoroughly mixed, covered and fermented for 48 h. The fermentation was ended using freeze dryer and this was kept for further analysis (Mathew *et al*., 2020).

Roasting

The open pan roasting method described by Makinde *et al*. (2016) was used.About 100 g of *Tamarindus indica* seeds were roasted in an open pan at a temperature of 85- 100ºC for 15 minutes then left to cool in a dessicator before the seeds were dehulled. The dehulled roasted seeds were milled into flour using

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attrition mill (SK-30-SS) then oven dried at a temperature of 60ºC. The milled sample was sieved to obtain fine flour and kept in an air tight plastic container ready for analysis.

Proximate Composition

Moisture content was determined by drying 5 g of the powdered sample to constant weight in an oven at 105 ºC. The difference in weight before and after drying was recorded as the moisture content of the seed (AOAC, 2006). Ash content was quantified according the method described by Ceirwyn (1998), which involves dry ashing in muffle furnace at 600 ºC until grayish white ash was obtained. Crude lipid content was determined using soxhlet apparatus and n-hexane as solvent according to the AOAC (2006) method. Crude protein of the sample was determined by multiplying (the value obtained from Kjeldahl's nitrogen analysis) by a protein factor of 6.25, (AOAC, 2006). Carbohydrate content was estimated using the method where the sum of the percentage ash, crude lipid, crude protein, and crude fiber was subtracted from 100 % (AOAC, 2006):

$$Carbohydrate(\%) = 100 - (\%\ ash + \%\ protein + \%\ lipid\ \%\ fibre) \quad (1)$$

Calorific value was calculated using expression described by Asibey-Berko and Taye (1999):

$$Energy(kcal/100g) = (gcrudeproteinx\ 2.44) + (gcrudelipidx\ 8.37) + (gavailablecarbohydratex\ 3.57) \quad (2)$$

Mineral Determination

Six (6) g of oven dried powdered sample was weighed into dry crucible and ignited in a muffle furnace at 600 ºC until grayish white ash was obtained. The sample was removed and cooled in a desiccator. 5 cm^3 of 1.0 $moldm^{-3}$ HNO_3 was added and the sample was evaporated to dryness on a steam bath and then re-heated in a muffle furnace until the formation of grayish white ash was observed. The samples were removed, cooled in a desiccator and 10 cm^3 of 1.0 $moldm^3$ HCl was added to each ash and filtered into a 100 cm^3 volumetric flasks. Concentrations of magnesium and calcium were determined using Atomic Absorption Spectrophotometer (AAS Model SP9) while sodium and potassium were evaluated using flame photometer. Phosphorus concentration was quantified using Jenway 6100 spectrophotometer at 420 nm (Ceirwyn, 1998).

The contribution of fermented and roasted tamarind seedsto dietary intake of essential elements was evaluated as follows (Hassan *et al*., 2005):

$$Contribution\ to\ RDA\ (\%) = \frac{Concentration\ (\frac{mg}{100g})}{RDA} \times 100$$

Where RDA = recommended dietary allowance.

Determination of Phytochemical Content

Determination of total flavonoids: The method is based on the formation of the flavonoids - aluminium complex which has an absorptivity maximum at 415nm. 100µl of the sample extracts in methanol (10 mg/ml) was mixed with 100 µl of 20 % aluminum trichloride in methanol and a drop of acetic acid, and then diluted with methanol to 5ml. The absorption at 415 nm was read after 40 minutes. Blank samples were prepared from 100 ml of sample extracts and a drop of acetic acid, and then diluted to 5ml with methanol. The absorption of standard rutin solution (0.5 mg/ml) in methanol was measured under the same conditions. All determinations were carried out in triplicates (Sofowora, 1993; Abubakar et al., 2015a).

Determination of total alkaloids: 5 g of the sample was weighed into a 250 ml beaker and 200 ml of 10% acetic acid in ethanol was added and covered and allowed to stand for 4

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h. This was filtered and the extract was concentrated on a water bath to one-quarter of the original volume. Concentrated ammonium hydroxide was added drop wise to the extract until the precipitation was complete. The whole solution was allowed to settle and the precipitated was collected and washed with dilute ammonium hydroxide and then filtered. The residue is the alkaloid, which was dried and weighed (Trease and Evans, 1996; Abubakar et al., 2015b)

Determination of total tannins: 500 mg of the sample was weighed into a 50 ml plastic bottle. 50 ml of distilled water was added and shaken for 1 h in a mechanical shaker. This was filtered into a 50 ml volumetric flask and made up to the mark. Then 5 ml of the filtered was pipetted out into a test tube and mixed with 2 ml of 0.1 M $FeCl_3$ in 0.I N HCl and 0.008 M potassium ferrocyanide. The absorbance was measured at 120 nm within 10 min (AOAC; 2006; Abubakar et al., 2015b).

Determination of total saponins: The samples were ground and 20 g of each were put into a conical flask and 100 ml of 20% aqueous ethanol were added. The samples were heated over a hot water bath for 4 h with continuous stirring at about 55°C. The mixture was filtered and the residue reextracted with another 200 ml 20% ethanol. The combined extracts were reduced to 40 ml over water bath at about 90°C. The concentrate was transferred into a 250 ml separator funnel and 20 ml of diethyl ether was added and shaken vigorously. The aqueous layer was recovered while the ether layer was discarded. The purification process was repeated. 60 ml of n-butanol was added. The combined n-butanol extracts were washed twice with 10 ml of 5% aqueous sodium chloride. The remaining solution was heated in a water bath. After evaporation the samples were dried in the oven to a constant weight; the saponin content was calculated (AOAC; 2006; Tsado et al., 2018).

Correlation Analysis

Correlation quantifies the extent to which two quantitative variables go together (Gogtay and Thatte, 2017).The scatter plot was employed to determine the correlation between the nutritional factors studied. The scatter plot or scatter diagram is a plot of x and y variables and the correlation coefficients were obtained using the 'add trendline' in spreadsheet to determine correlation between factors. Table 1 present a 6-way guide for interpreting correlation coefficient (r value) (Gogtay and Thatte, 2017; Nworgu, 2015).

RESULTS AND DISCUSSION

Results of proximate, mineral and phytochemical compositions of Fermented and Roasted *Tamarindus indica* Seeds and correlation between factors are presented in Tables 2-5 and figures 3-5.

Table 2 present the proximate composition of fermented and roasted *Tamarindus indica* seeds. Values obtained for the mean moisture content were 10.70±0.21 and 2.00±0.82 % for fermented and roasted samples respectively. Moisture content of the fermented was lower than the 11.50±0.71 % obtained for fermented *Glycine max* seed but higher than 7.50±0.71 % reported for *Parkia biglobosa* seed (Ndamitso *et al*., 2020) and is significantly higher than that of roasted sample. Low moisture content is necessary for increased shelf life, as high moisture content can result in the growth of molds (Musah *et al*., 2021a); hence the roasted sample is expected to have high shelf life during storage than the fermented sample. Ash content is important in determining mineral content of a sample. The ash contents of fermented and roasted samples were 3.06±0.71 and 3.3411±0.53 % respectively. These values were lower than the 5.11±0.61 and 4.82±0.22 % reported for *Vigna unguiculata sub spp. Sesquipedalis* and roasted sunflower seeds (Musah *et al*., 2020; Anjum *et al*., 2006) indicating a low level

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presence of inorganic components in both fermented and roasted samples. Values of crude fibre were 5.75±0.33 and 5.22±0.74 % for fermented and roasted *Tamarindus indica* seeds respectively. The slight difference in crude fibre value could be due to the action of heat on the roasted sample. Crude fibres aid in digestion and nutrient absorption in the body. Values obtained are higher than 1.48±0.05 and 3.86±0.05 % reported for fermented *Glycine max* and roasted sesame seeds (Ndamitso *et al*., 2020; Makinde *et al*., 2016).

Mean protein values of the roasted sample (23.63±0.11 %) was higher than the 19.25±0.16 % obtained for the fermented sample. The high crude protein in roasted sample could be due the removal of moisture leading to increased concentration of crude protein, and some protein may have been lost during fermentation. However, both values were higher than 8.12±0.02 % reported for *Artoarpus altilis* seed (Tukura and Obliva, 2015). The crude protein content is an indication the samples could be good source of protein. Crude lipid content of roasted sample (7.60±0.43 %) was significantly ($p>0.05$) higher than the fermented sample (2.30±0.19 %) and both values were higher than 1.70 % obtained for *Parkia biglobasa* fermented seeds (Ndamitso *et al*., 2020). Carbohydrate values obtained for fermented and roasted sample were 58.94±0.23 and 58.21±0.17 % respectively. These values were lower than 72.66±0.01 % reported *Artocarpus altilis* seed (Nzekwe *et al*., 2016). The low carbohydrate in the samples is an indication of decreased chance of rancidity thereby increasing the shelf life of the samples (Abiodun and Umeonuorah, 2013). Mean calorific value of the roasted sample (329.08±0.92 kcal/100g) was higher than 301.29±0.31 kcal/100g obtained for the fermented sample; and were higher than 185.79±0.03 kcal/100g reported for *Vigna susterranea* (L) verdc (Musah *et al*., 2021b).

Mean concentrations of mineral content of fermented and roasted *Tamarindus indica* seeds are presented in Table 3. Results indicate high concentrations of potassium (784.95±0.43 mg/100g), phosphorus (122.38±0.29 mg/100g), magnesium (187.65±0.17 mg/100g) and calcium (12.65±0.11 mg/100g) in roasted seed sample when compared to values obtained for fermented sample. Only sodium content (186.52±0.09 mg/100g) was higher in the fermented sample. Values obtained in this study were higher than 19.17±0.02 mg/100g (potassium), 12.19±0.12 mg/100g (phosphorus) and 18.17±0.02 mg/100g (magnesium) reported for *Parkia biglobosa* fermented seed (Ndamitso *et al*., 2020).

Potassium helps to protect from rise in blood pressure and is essential for the synthesis of tissue protein in protein depleted animals (Dzemeku *et al*., 2006). The high concentration of potassium in both samples indicates their consumption could help to prevent rise in blood pressure. Potassium and sodium ions co-function to maintain body electrolytic balance (Eddy *et al*., 2012). Calcium is essential for strong bone formation and for nerves to function properly (Bell *et al*., 1996). The low calcium content of fermented (10.33±0.15 mg/100g) and roasted (12.65±0.11 mg/100mg) *Tamarindus indica* seeds compared to 1130.00±0.00 mg/100g for *Caesalpina pulcherrima* seed (Musah *et al*., 2014) does not make *Tamarindus indica* seeds very good source of calcium. The relatively high concentration of magnesium in fermented (166.90±0.37 mg/100g) and roasted (187.65±0.17 mg/100g) samples makes them good supplement for magnesium.

The contribution of fermented and roasted *Tamarindus indica* seeds to the recommended dietary allowance (RDA) of the studied minerals is presented in Table 4. Results revealed the contributions of sodium (37.30 mg), phosphorus (8.87 mg) were higher for

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fermented sample while potassium (39.25 mg), magnesium (3753 mg) and calcium (1.05 mg) were for the roasted sample. These values were higher than those reported for *Bombax buonopozense* calyx (Musah *et al*., 2021b) but lower than values obtained for *Vernonia amagdslins* (Idris and Yisa, 2009)

Mean concentrations of phytochemicals of fermented and roasted *Tamarindus indica* seeds are presented in Table 5. Tannin concentrations were 64.61±0.43 mg/100g and 40.97±021 mg/100g for fermented and roasted samples respectively. These values were significantly ($p>0.05$) higher than those reported water melon seed (6.83 mg/100g) and pear seed (5.64 mg/100g) (Olorode *et al*., 2014). Tannins are plant soluble polyphenols and have been reported to cause decrease in the intake of feed, rate of growth and digestibility of protein (Chuk *et al*., 1998). Tannins also have some health benefits which include anti-allergic, anti-oxidant, anti-inflammatory, anti-cancer and anti-microbial activities; they also enhance the uptake of glucose thereby lowering the level of blood sugar and reduce the risk of diabetes. The daily intake of tannin below the range of 1500 – 2500 mg is considered safe (Sharma *et al*., 2019).

Saponin content was 127.33±0.79 mg/100g in fermented sample and was significantly ($p>0.05$) higher than 94.69±0.29 mg/100g in roasted sample. The difference in saponin concentration could be due to the effect of heat on the roasted sample. Onning *et al*. (1994) reported degradation of saponin during heating. Values obtained were lower than 2160 mg/100g in *Adenantheral povonina* seed (Ogbuabu *et al*., 2014). Saponin is useful in the treatment of cardiovascular diseases, lowering cancer risk and decreasing blood lipid (Del-Rio *et al*., 1997). Concentrations of flavonoid in the fermented and roasted *Tamarindus indica* seeds were 3.53±0.18 and 1.96±0.51mg/100g respectively. These values were lower than 3.91±0.08 mg/100g reported for *Avena fatna* (Abbas *et al*., 2012) but higher than 1.28±0.03 mg/100g for *V. unguiculata sub spp sesquipedalis* seed (Musah *et al*., 2020). Flavonoid acts as free radical scavenger and exhibit anti-inflammatory properties (Ruiz-Cruz *et al*., 2017). Alkaloid values were 23.56±0.37 mg/100g and 14.33±0.12 mg/100g in fermented and roasted samples respectively. These concentrations were higher than 12.28 and 13.30 mg/100g obtained for Benoil seed (Olorode *et al*., 2014). Alkaoloid is known to act as stimulant or depressants on the central nervous system (Victor, 2014).

Correlation coefficients that depict the relationship between different nutritional factors are presented in figures 3-5. Figure 3-5 shows correlation between nutritional factors of fermented and roasted *Tamarindus indica* seeds. The correlation coefficient of the relationship between proximate compositions of fermented and roasted *Tamarindus indica* seeds (figure 3) shows a very high positive correlation coefficient (0.9981) indicating that increase in value of factors in fermented sample is accompanied by a corresponding increase in similar factors of the roasted sample. This trend was observed in figures 4 and 5 with correlation coefficient of 0.7552 and 0.994 for minerals and phytochemicals respectively. Figure 4 shows high positive correlation between the mineral content of fermented and roasted sample but lower than the very high positive correlation of phytochemical content that exist between fermented and roasted *Tamarindus indica* seeds (figure 5).

CONCLUSION

From the results obtained in this study, it has shown that there is reduction with proximate constituents of roasted sample when compared to fermented sample except that of crude protein which is a little bit higher than the later. Assessment of the phytochemical

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compositions of the samples further showed the suitability of the seeds for the formulation of drugs especially in the roasted portion of the sample. The samples studied have been found to have good contribution on the dietary intake of selected mineral by fermented and roasted *Tamarindus indica* seeds. From the findings of this study, it can be deduced that the flours investigated have unique mineral compositions hence can be incorporated into food as dietary protein supplements for humans. There needs to further promote researches and food processing techniques targeted towards the utilization of flours from underutilized plants.

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APPENDICES

Plate 1: *Tamarindus indica* Fruit *Tamarindus indica* Seeds *Tamarindus indica* Flour

Table 1: Guide for interpreting correlation (r) value

Value of r		Interpretation	
Positive	**Negative**	**Positive**	**Negative**
+0.80 to +1	-0.80 to -1	Very high positive correlation	Very high negative correlation
+0.60 to +0.80	-0.60 to -0.80	High positive correlation	High negative correlation
+0.40 to +0.60	-0.40 to -0.60	Moderate positive correlation	Moderate negative correlation
+0.20 to +0.40	-0.20 to -0.40	Low positive correlation	Low negative correlation
+0.00 to +0.20	-0.00 to -0.20	Very low positive correlation	Very low negative correlation
0.00	0.00	Absence of correlation	Absence of correlation

Table 2: Proximate composition of fermented and roasted *Tamarindus indica* seeds

Parameter	Percentage (% Dry weight)	
	Fermented	**Roasted**
Moisture	10.70±0.21	2.00±0.82
Ash	3.06±0.71	3.34±0.53
Crude fibre	5.75±0.33	5.22±0.74
Crude protein	19.25±0.16	23.63±0.11
Crude lipid	2.30±0.19	7.60±0.43
Carbohydrate	58.94±0.23	58.21±0.17
Ca1orific value (Kcal/100g)	301.29±0.31	329.08±0.92

Values are means of triplicate determination ± standard deviations

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Table 3: Mineral compositions of fermented and roasted *Tamarindus indica* seeds

Minerals	Concentration (mg/100g)	
	Fermented	Roasted
Sodium	186.52±0.09	54.36±0.13
Potassium	336.75±0.31	784.95±0.43
Phosphorus	106.42±0.65	122.38±0.29
Magnesium	166.90±0.37	187.65±0.17
Calcium	10.33±0.15	12.65±0.11

Values are means of triplicate determination ± standard deviations

Table 4: Contribution on the dietary intake of selected mineral by Fermented and Roasted *Tamarindus indica* Seeds

Minerals	RDA (mg)	Contribution to RDA	
		Fermented	Roasted
Sodium	500	37.30	10.87
Potassium	2000	16.84	39.25
Phosphorus	1200	8.87	1.19
Manganese	5.00	3338	3753
Calcium	1200	0.86	1.05

Table 5: Phytochemical Contents of Fermented and Roasted *Tamarindus indica* Seeds

Phytochemicals	Concentration (mg/100g)	
	Fermented	Roasted
Tannins	64.61±0.43	40.97±0.21
Saponins	127.33±0.79	94.69±0.29
Flavoloid	3.53±0.18	1.96±0.51
Alkaloid	23.56±0.37	14.33±0.12

Values are means of triplicate determination ± standard deviations

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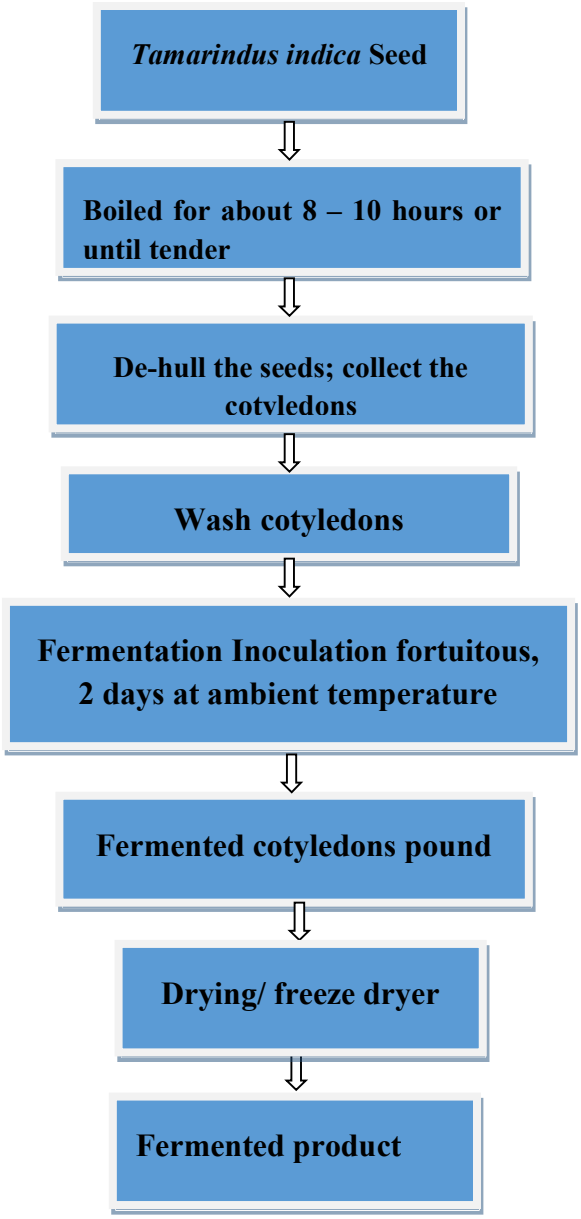

Fig. 1, Flow chart diagram for the fermentation production of *Tamarindus indica* seeds flour

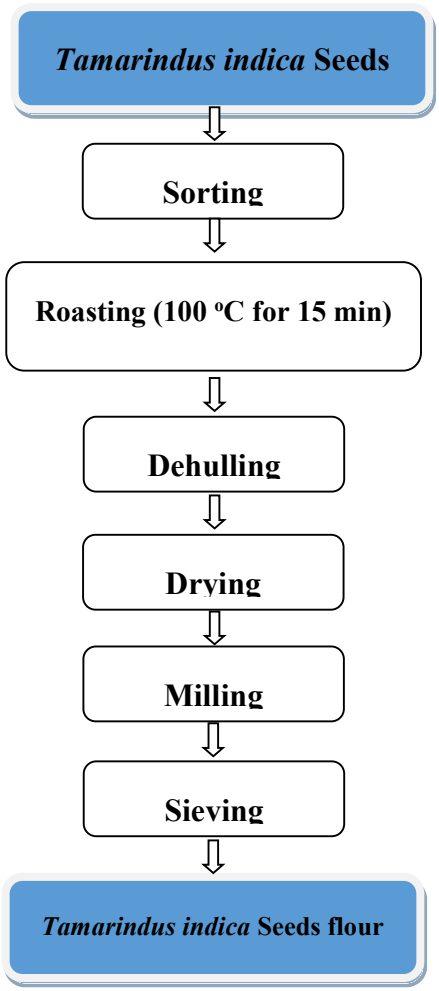

Fig. 2, Flow chart diagram for the roasting production of *Tamarindus indica* seeds flour

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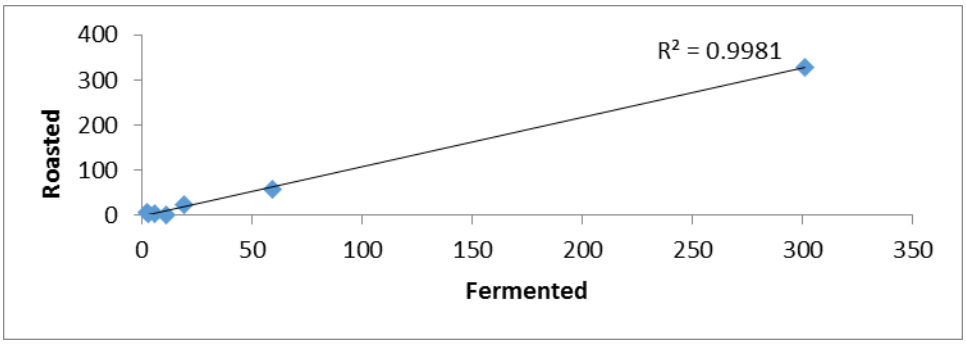

Figure 3: Correlation between proximate composition of fermented and roasted *Tamarindus indica* seeds

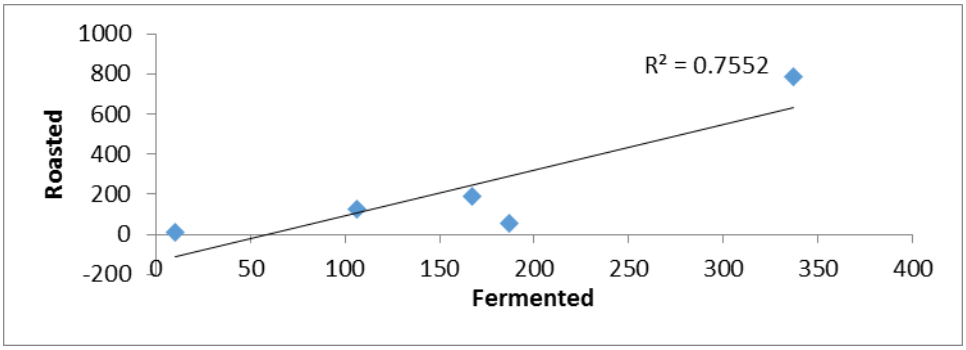

Figure 4: Correlation between the mineral content of fermented and roasted *Tamarindus indica* seeds

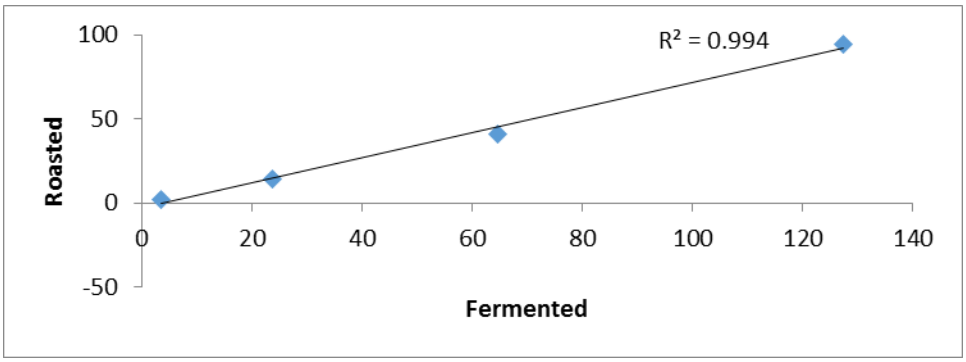

Figure 5: Correlation of phytochemical content between fermented and roasted *Tamarindus indica* seeds