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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(9): 1625-1630

www.thepharmajournal.com
Received: 13-07-2021
Accepted: 24-08-2021

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Studies on effects of different drying techniques on proximate and mineral composition of dried jackfruit seed powder

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Abstract
Present investigation were carried out to study the effect of different drying techniques on physic-chemical and mineral composition of dried jackfruit seed powder. Jackfruit are catogarized in under utilized fruit but it contain infinite numbers of health benefits for human being. In present investigation fresh jackfruit seed were dried by sun dying and tray drying methods. It was observed that the tray dried jackfruit seed powder contain higer amount of ash, fat, fiber and protein as compare to sun dried jackfruit seed powder. The mineral composition of jackfruit seed powder revealed that the tray drying was found signifacantly superior over sun drying with respect to all minerals. From the research it was concluded that the dried jackfruit seed powder prapred by tray drying was found significantly superior over sun drying method with respect to proximate and mineral composition.

Keywords: Jackfruit seed powder, minerals composition, proximate composition, sun drying, tray drying

Introduction
Jackfruit (*Artocarpus heterophyllus*) belongs to the family *Moraceae* and is widely grown in Southeast Asia including Bangladesh, India and Thailand. It is the national fruit of Bangladesh (Kirtikar. 2003) [8]. The ripe fruit contains well flavoured yellow sweet bulbs and seeds. The edible bulbs of ripe fruits are consumed fresh or processed into canned products (Kumar *et a*l., 1988) [9] Seeds usually make up 10-15 percent of the total fruit weight and they are light brown in colour, oval, or oblong ellipsoid or round in shape, 2-3 cm in length and 1-1.5cm in diameter. Up to 500 seeds can be found in each fruit. They are recalcitrant and can be stored in cool, humid conditions up to a month (Prakash *et al.*, 2009) [16]. A single seed is enclosed in a white aril encircling a thin brown endosperm, which covers the fleshy white cotyledons. In India, often the seeds are boiled in sugar and eaten as dessert or used in some local dishes. A fresh seed cannot be kept for a long time, whereas seed flour can be an alternative product, which can be used in some food varieties. Jackfruit seeds are usually eaten after boiling or roasting and they are not so popular as a vegetable (Sirisha *et al.*, 2014) [17].
On an average, in ripe jackfruit, the bulb, seeds and rind form 29 percent, 12 percent and 59 percent respectively (Jagadeesh *et al*., 2007) [7]. Major areas of cultivation in India are the eastern and southern parts of the country. These include the states of Jharkhand, Bihar, West Bengal, Uttar Pradesh, Orissa, Chhattisgarh, Andhra Pradesh, Tamil Nadu, Kerala and Karnataka. Among the tropical fruits, Jackfruit is an important underutilized fruit and often called the poor man's fruit because of its affordability and availability in large quantities during the fruiting season. Jackfruit trees are mostly gown in the homestead garden without any management practices. The jackfruit trees are highly productive and bear regularly. Production of 300-500 kg fruits per tree depending on the age of the tree and conditions under which grown has been reported. The individual fruit weight generally varies from 0.98-57.80 kg at maturity (Nath *et al*., 2001) [14]. India has annual production of jackfruit as 1.436 million tons from an area of 0.102 million hectors (Baruah 2014) [4]. India is the second largest producer of jackfruit in the world (Nandkule *et al*., 2015) [3].
After harvesting due to content of high moisture, the jackfruit gradually started to spoil due to some chemical and microbiological activities. To retain the nutritional quality of jackfurit and increase their storability different processing techniques must be apllied. The drying is one of the oldest method of food preservation. The drying of fruit and vegetables resulted in drawing back the moisture contents to desirable stage where microbial growth get stoped.

In present investigation different drying methods such as sun drying and tray drying were comparatively applied for determining the effects of drying on physico-chemical and mineral composition of prepared dried jackfruit powder.

2. Materials and Methods

2.1 Materials

The raw material such as jackfruit were purchased from local market of Parhani.

2.2 Methods

2.2.2.1 Proximate composition of jackfruit

Jackfruit analyzed for proximate composition including moisture, fat, protein, total carbohydrate, crude fiber, ash and mineral content will be determined.

2.2.2.1a Determination of moisture content of jackfruit

Moisture content was determined by accurately weighing the 5 g of ground sample, and then subjected to drying at 105 ^{0}C for 4 hr in hot air drier. After completion of drying process it was kept in desiccators for cooling. Weighed the cooled sample and calculate the moisture contents. The loss in weight of sample is regarded as moisture contents of the sample. The moisture content of the sample was calculated by formula given by (AOAC, 1990) [1].

$$\text{Moisture (\%)} = \frac{\text{Initial weight – final weight}}{\text{Total weight of sample}} \text{ X } 100$$

2.2.2.1b Determination of fat content of jackfruit

5g pulverized and moisture free sample weighed property in thimble and fat is removed with non polar organic solvents like petroleum ether or acetone or hexane etc. in Soxhlet apparatus for period of about 6 to 8 hrs at 60 ^{0}C. Hexane is most commonly used food grade solvent. After completion of the siphoning procedure the excess of solvent removed by evaporation under drier and lipid percentage was calculated (AOAC, 1990) [1].

$$\text{Fat \%} = \frac{\text{Final weight of flask – Empty weight of flask}}{\text{Weight of sample}} \text{ X } 100$$

2.2.2.1c Determination of protein content of jackfruit

Protein contents of jackfruit determined by using Micro-Kjeldhal method. The protocol is described by AOAC (1990) [1].

- **Process of digestion**

Defatted and moisture free powderd sample was weighed around 200 mg which was added with a pinch of catalyst mixture made up of potassium sulphate, copper sulphate and mercuric oxide in the ration of K_2So_4:$CuSo_4$:HgO red (91:8.2:0.8g), which is then feed in the digestion flask. The process of digestion was carried out with addition of 5 ml concentrated sulphuric acid (H_2SO_4) for 2 to 3hr at 45 ^{o}C until the mixture become colorless.

- **Neutralization and distillation process**

The digested colorless sample diluted to the 50 ml by distilled water in volumetric flask and made final quantity made to 50 ml. Then the 5 ml of digested and diluted aliquot was neutralized with 40 percent sodium hydroxide containing 5g of sodium thi-osulphtate solution. The process of distillation was carried out and then liberated ammonia was trapped in 2 percent solution of boric acid which contains methyl red indicator.

- **Titration**

The trapped ammonia was titrated against 0.01N H_2SO_4 Solution. The titre value was measured and percent nitrogen was calculated by using following formula and then percent protein was calculated by multiplying with nitrogen factor 6.25. carry out the same procedure for blank sample.

$$\text{\% N} = \frac{\text{CBR X Normality of } H_2SO_4 \text{ X Moles of Nitrogen X D.F}}{\text{Wt. of sample (g)}} \text{ X } 100$$

Where,

CBR=Sample burette reading (SBR) - Blank burette reading (BBR)
Normality of acid (H_2SO_4) = 0.01N
Moles of Nitrogen =14/1000
% Protein = % Nitrogen X 6.25

2.2.2.1d Determination of carbohydrate of jackfruit

The carbohydrate content of jackfruit was determined by using the phenol sulphuric acid method**.** Accurately weigh 200 mg of dried and defatted jackfruit sample in test tube and kept in refrigerated condition, add 2 ml of 70 percent hydrochloric acid and prepare its paste with glass rod in cold condition. Slowly transfer the same in 500 ml conical flask by using 23 ml of distilled water and reflux in to boiling water bath for 3 hours to ease in hydrolysis. Cool the resultant hydrolysate and then centrifuge or filter through Whatman No. 42 filter paper and by adding distilled water make final volume of 100 ml. Take a 0.2 ml of volume of aliquot for determination. Add 0.2 ml of 80 percent phenol in test tube followed by adding 5 ml of 96 percent concentrated H_2So_4. Vigorously shake the content of test tube on vertex mix or by manually after 10 min. Then read the optical density at 480 nm on a spectrophotometer.

- **Standard Curve Prepartion**

D-glucose (100 mg) used in 100 ml volumetric flask. Volume was made to 100 ml by distilled water. One ml from stock solution contained 1000 mg glucose. A standard calibration curve was made by using D-glucose as a standard sugar. Prepare a standard curve by taking 0,0.2,0.4,0.6,0.8 and 1.0 ml of standard glucose in the series of test tube with respect to 0,20,40,60,80 and 100 microgram respectively. Make up the volume of every test tube with distill water. Add 0.2 ml of 80 percent phenol in every test tube followed by 5 ml of 96 percent concentrated H_2So_4. Vigorously shake the content of test tube on vertex mix at last of 10 min record the optical density at 480 nm on a spectrophotometer and then prepare standard graph.

Calculate the percentage of carbohydrate in the sample using the standard graph.

$$\text{Total carbohydrate in sample (\%)} = \frac{\text{Sugar value from graph (mg) x total vol. of extract (ml)}}{\text{Aliquot sample used (0.2) x weight of sample}} \text{ X } 100$$

2.2.2.1e Total ash content of jackfruit

Weigh the 5 g jackfruit into silica crucible, which was heated at low flame till all the material was completely burned and charred (smokeless) and cooled. The Procedure was preceded by keeping the crucible in muffle furnace for about 4 hr at 550

^{0}C. The sample was cooled in desiccators and weighted after cooling. Repeat the process until two repeated weights were same. The percent ash was calculated by calculating the difference between the initial and final weight (AOAC, 2005) [2].

$$\text{Ash (\%)} = \frac{\text{Weight before heating} - \text{Weight after heating}}{\text{Weight of sample}} \times 100$$

2.2.2.1f Determination of fiber contents of jackfruit

About 2g of the jackfruit sample were weighed into a 600 ml long beaker. 200ml of hot 1.25 percent H_2SO4 was added. Beaker was then kept on digestion apparatus with preheated plates, boiled, refluxed for 30 min and then filtered through Whiteman filter paper by gravity. The beaker was washed with distilled water. The residual part was washed on the paper with distilled water until the filtrate was become neutral. The residual contents were then transferred from the filter paper to the beaker which contains 200 ml of hot 1.25% sodium hydroxide solution. The chemically treated sample was then filter through filter paper. The paper with residue was placed into a crucible, which was then dried at 100 ^{0}C overnight, cooled in a dessicator and weight was recorded (weight A). The samples were placed in furnace at 600 ^{0}C for 6 hrs, which was then cooled in a dessicator and again take the weight (weight B). The loss in weight during burning represents the weight of crude fiber (AOAC, 2005) [2].

$$\text{\% Fibre} = \frac{(\text{weight A}) - (\text{weight B})}{\text{Sample weight 1}} \times 100$$

2.2.2.2 Determination of minerals

Analysis of minerals was performed to estimate the macro and micro-elements available in jackfruit and prepared value added food products.

Preparation of mineral solution

In a boiling water bath, the ash obtained by the above procedure was moisture with glass distilled water (0.5-1 ml), and concentrated hydrochloric acid was added and evaporated to dryness. Again 5 ml of concentrated hydrochloric acid was applied to dryness and evaporated as before. Finally 4 ml of distilled water and 5 ml of hydrochloric acid were added. This solution was heated over a boiling bath of water and filtered into the 100 ml volumetric flask using which man filter paper No.4. After the volume was cooled and made to 100 ml using distilled water and the correct aliquot was used for calcium and iron estimation.

2.2.2.2a Procedure for determination of calcium

25 ml of mineral solution was diluted to 150 ml with distilled water and then ammonia solution was neutralized using methyl red as an indicator before the pink color shifts to yellow. The solution was then heated and added with 10 ml of 6 percent ammonium oxalate. This mixture was boiled for a sometime, and then combined with concentrated glacial acetic acid (99.9 percent) until the change of color was clearly pink. The mixture was held aside in a warm place (overnight), and the supernatant was measured with a drop of ammonium oxalate when precipitate settled to ensure precipitation was completed. The testing content was filtered through filter paper, and washed with distilled water. The precipitate was transferred to a beaker by making a hole in the filter paper center and twice rinsed by 5 ml of 2N H_2SO_4 solution. Then solution was heated to 70 ^{0}C and titrated against 0.01N potassium per magnet (KMNO4), and blank sample was also run simultaneously.

1ml of 0.01N $KMNO_4$ = 0.2004 mg of calcium

2.2.2.2b Procedure for determination of phosphorus

The contents of phosphorus were calculated using the colorimetric test. In this order 1 ml of hydroquinone and 1 ml of sodium carbonate solutions were applied to an aliquot (0.1 ml) of the ammonium molybdate mineral solution. The amount was then made with distilled water up to 15 ml, and the solution was thoroughly mixed. After 30 min the optical density (OD) of this solution was calculated in a photoelectric colorimeter, using a red filter (660 nm) against a blank reagent (Made in the same way as the test except that the test solution was omitted). After following the same procedure as mentioned above, the phosphorus content of the sample was read from a standard curve prepared with standard phosphate solution (range 0.01-0.1 mg of phosphorus).

2.2.2.2c Procedure for determination of magnesium

Colorimeteric method was employed for determinations of magnesium content of jackfruit. Take 10 ml of jackfruit ash solution into a 15 ml graduated centrifuge tube. Add 1 drop of indicator (Methyl red). Neutralize the jackfruit ash solution with NH_4OH and ammonium oxalate and finally make the solution of 13 ml volume. Mix well and kept aside for overnight. Centrifuge the mixture for 10 min. and then remove the precipitate obtained. Measure 1 ml of the collected supernatant liquid into centrifuge tube of capacity 15 ml. Add 3 ml of distilled water, ammonium phosphate (1 ml) and NH_4OH (2 ml). Mix and allow to stand stagnant for overnight. Centrifuge for 7 min, and remove the obtained supernatant liquid, mix with 5 ml diluted NH_4OH, again centrifuge for 7 minutes and remove supernatant. Remove the water of precipitate by keeping the tube to container of hot water. Add 1 ml of diluted hydrochloric acid and 5 ml of distilled water to dissolve the precipitate. Add molybdic acid solution (1 ml), hydroquinone solution (0.5 ml) and sodium sulphite solution (0.5 ml). Then mix and allow stand aside for 30 min. Transfer the colorimeter tube containing solution and read the absorbance in a colorimeter using filter. Calibrate the instrument scale to zero reading.

2.2.2.2d Procedure for determination of iron

Iron content of jackfruit was determined by using a-a, dipyridyl method AOAC (1990) [1]. Accurately take 10 ml of wet digested jackfruit sample solution into volumetric flask of 25 ml capacity by pippeting in triplicate. Hydroxylamine hydrochloride solution (1 ml), acetate buffer solution (5 ml) and a-a, dipyridyl solution (2 ml) were added into each volumetric flask. By using distilled water made up the volume to 25 ml and mix the content. The developed color intensity was read in spetronic 20 at 510 nm. Iron content of the digested jackfruit sample solution was read from the standard curve of known iron concentration.

Standard curve Preparation

Take 0.0, 0.5, 1.0, 1.5, 2.0, 3.0 and 4.0 ml of standard solution of iron in to a series of 25 ml volumetric flasks and add to each of them flask accurately 0.2 ml of concentrated hydrochloride solution. Dilute each sample with distilled

water to exactly 10 ml, then add chemicals in the same way as for the sample, Plot the quantity of iron in mg against the spectro photometeric absorbance (I.C.M.R., 1990) [6].

$$\text{Iron content} = \frac{\text{Quantity of Fe in aliquot (Calibration curve)}}{\text{Aliquot of ash solution taken}} \times \frac{\text{Total volume of ash solution}}{\text{Wt. of the sample}} \times 100$$

2.2.2.2e Procedure for determination of zinc

Zinc contents of jackfruit were estimated Atomic Absorption Spectrophotometer. By using wet digestion method the jackfruit sample was digested. Accurately 0.5g jackfruit sample was digested with 10 ml nitric acid (HNO_3) at 60-70 ^{0}C temperature for 20 minutes and subsequently digested with hydrochloric acid at190°C temperature until the color of solution become clear. The digested sample was transferred to a volumetric flask of 250 ml, and volume was created using distilled water and then filtered using filter paper. The solution was kept into the Atomic Absorption Spectrophotometer for estimation of zinc. The standard curve was made by running known strength of samples by using the atomic absorption spectrophotometer. The quantity of zinc of unknown samples was determined by using the respective standard curve AOAC (2005) [2].

2.3 Processing technology for preparation of dried jackfruit seeds

Fresh, disease free and sound quality jackfruit were selected. The fresh jackfruit were washed with clean water and subjected to the treatments like cutting followed by removal of seed and drying of seeds were carried out. The dried jackfruit seeds were passed through grinder to make fine powder, which was then packed and stored. (Lonkar *et al*., 2013) [11].

2.3.1 Sun drying

The jackfruit seeds were placed in a tray one layer deep on a table. Air was allowed to circulate below as well as above the leaves to speed up drying time. The pieces of jackfruit seeds in the tray on the table were placed in direct sun and turned occasionally. These seeds of jackfruits were placed in direct sun for several hrs and the weight of the dried jackfruit sees were being measured at intervals of 1 hr until the weight became constant.

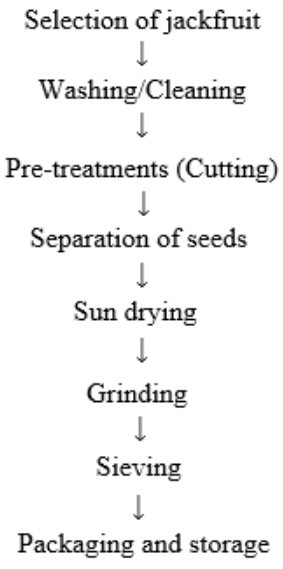

Fig 1: Drying of jackfruit seed by sun drying method

2.3.2 Tray drying

Tray drying was carried out in the Department of Food Engineering, College of Food Technology, VNMKV, Parbhnai. It consists of a 0.8 kW axial flow fan blowing at air velocity of 3.5 m/s over the heating elements into a drying chamber with perforated trays. The dryer casing is lagged with cushion to give it a compact look. A door was provided to suite the design for loading and unloading the dryer. The pieces of jackfruit seeds were spread on the tray and placed into the cabinet tray drier at 45 ^{0}C temperature and the weight was being measured at interval of 30 min until a constant weight was being recorded.

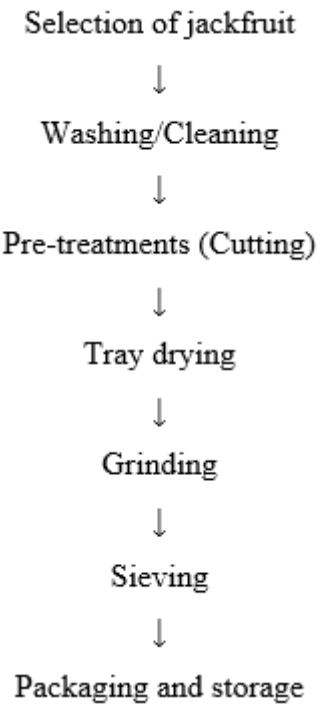

Fig 2: Drying of jackfruit seeds by tray drying method

3. Results and Discussion

3.1 Proximate composition of fresh jackfruit (*Artocarpus heterophyllus*)

Proximate composition generally represents the nutritional quality of product. It is necessary to determine the proximate composition of jackfruit so as to judge its impact on prepared value added food product after utilization as a novel ingredient. The proximate composition of jackfruit was determined and presented in Table 1.

Table 1: Proximate composition of jackfruit (*Artocarpus heterophyllus*)

Parameters	Jackfruit (%)
Moisture	74.86
Ash	1.40
Crude fat	0.70
Crude protein	1.69
Crude fiber	1.63
Carbohydrate	19.72

*Each value is average of three determinations

The data presented in Table 1 showed jackfruit contain 74.86 percent of moisture. This is expected since the sample has been subjected to drying to reduce the moisture content. Ash content of jackfruit contained about 1.40 percent. Ash content is an indication of the level of minerals present in food

material this suggests that jackfruit can help in boosting the mineral content of prepared value added food products. Crude fat, crude protein, crude fiber and carbohydrate of jackfruit were observed 0.70 percent, 1.69 percent, 1.63percent and 19.72 percent respectively. The obtained results for the proximate composition of jackfruit were found similar to that of results of Waghmar *et al*. (2019) [18] investigate the Jackfruit seed: an accompaniment to functional foods.

3.2 Mineral composition of jackfruit (*Artocarpus heterophyllus*)

Mineral content of jackfruit is essential in justifying its food value. Calcium, iron, manganese, phosphorus, and zinc are the minerals of interest in current study. Minerals play a key role in various physiological functions of the body especially in the building and regulation processes. The data pertaining to mineral content is presented in Table 2.

Table 2: Mineral composition of jackfruit (*Artocarpus heterophyllus*) (mg/100g)

Parameters (mg/100g)	Jackfruit
Calcium	26
Phosphorus	23
Magnesium	32
Iron	0.21
Zinc	0.11

*Each value is average of three determinations

The data presented in table 2 showed the mineral composition of jackfruit. The macro minerals like calcium, phosphorus and magnesium were 26, 23 and 32 mg/100g respectively. Minerals especially calcium and phosphorus are required in human body in large amounts. Their deficiency results in arthritis, bone and tooth related disorders. The iron, zinc was 0.21, 0.11 mg/100g respectively. Iron is essential for blood formation owing to a major constituent of hemoglobin while zinc is required for fertility, insulin working as well as mental and body growth. The similar results were obtained by finding of Gupta *et al.* (2011) [5]. phytochemical, nutritional and antioxidant activity evaluation of seeds of jackfruit (*artocarpous heterolphyllus lam*).

3.3 Effects of processing on chemical composition of dried jackfruit seed

The chemical composition of processed dried jackfruit seed was analyzed by standard technique. The effects of different processing methods on chemical composition of dried jackfruit seed are presented in table 3.

Table 3: Effects of processing on chemical composition of dried jackfruit seed

Chemical composition	Sun drying	Tray drying	SE±	CD at 5%
Moisture content	5.16	4.79	0.057	0.121
Ash content	2.60	2.69	0.070	0.208
Crude fat	1.71	1.86	0.043	0.166
Crude protein	20.71	21.49	0.469	1.699
Crude fiber	2.46	2.47	0.097	0.279
Carbohydrate content	67.70	66.70	1.082	3.921

*Each value is average of three determinations

The data presented in table 3 showed that maximum percent of moisture was present in dried seed sample which was dried by sun drying method i.e. 5.16 percent. The dried seed processed by tray drying method contained moisture content 4.79 percent respectively. The seed sample dried by tray drying method observed good percentage of ash content i.e. 2.69 percent than other samples. The ash contents of dried jackfruit seed processed by sun drying and tray drying method was 2.60 and 2.69 percent respectively. Ash is the inorganic residue remaining after the water and organic matter have been removed by heating a food. The ash content is a measure of amount of mineral present within a food. Minerals are not destroyed by heating and they have a low volatility compared to other food components. The result showed that jackfruit seed processing by tray drying method was significant with seed processed by sun drying method with respect to moisture and ash content. The increase in ash content observed in this study could be due to the removal of moisture which tends to increase the concentration of nutrients (Morris *et al*., 2004).

The fat content of dried jackfruit seed was increased after drying. The jackfruit seed processed by tray drying method retained the good percentage of fat content i.e. 1.86 per cent. The jackfruit seed processed by sun drying and tray drying method had fat content 1.71 percent and 1.86 percent. It shows that jackfruit seed sample dried by tray drying method was significant sun drying method. It represents a good index of storability as it reduces the susceptibility of the powder to lipid oxidation. The seed sample dried by tray method founded the highest percentage of protein i.e. 21.49 percentage. The jackfruit seed sample dried by tray and sun drying method founded protein content 21.49 and 20.71 percent respectively.

The fiber content of dried samples was found in the range of 2.46 to 2.47 per cent. The seed sample dried by tray drying method method had good percentage of fiber i.e. 2.47 percent. The carbohydrate content of dried samples was found in the range of 67.36 to 66.70 per cent.

Similar results were by research outcome of Ocloo *et al.* (2010) [15] Physicochemical, functional and pasting characteristics of flour produced from jackfruits (*Artocarpus heterophyllus*) seeds.

3.4 Effects of processing on mineral composition of dried jackfrui seed

Mineral content of dried jackfruit seed is essential in justifying its food value. Phosphorous, calcium, iron, magnesium, zinc, copper and manganese are the minerals of interest in current study. Minerals play a key role in various physiological functions of the body especially in the building and regulation processes. The results pertaining to mineral content of dried jackfruit seed are presented in Table 4.

Table 4: Effects of processing on mineral composition of dried jackfruit seed (mg/100g)

Mineral composition	Sun drying method	Tray drying method	SE±	CD at 5%
Calcium	39.78	41.20	0.817	2.531
Phosphorus	125.22	126.70	1.629	5.045
Magnesium	102.80	101.63	1.311	4.060
Iron	0.86	0.90	0.218	0.667
Zinc	1.08	1.13	0.065	0.201

*Each value is average of three determinations

The data presented in table 4 revealed the effects of different processing methods on mineral composition of dried jackfruit seed. It was observed that jackfruit seed sample dried by tray drying method is significantly superior over sample processed

by sun drying method. The calcium content of sample dried by tray drying method is more as compare to sun drying method samples i.e. 41.20 mg/100g. The calcium content of jackfruit seed sample dried by sun and tray drying method is 39.78 and 41.20 mg/100g respectively. The phosphorus contributes in bone formation, energy metabolism and nucleic acid metabolism. The sample processed by tray drying method got highest value for phosphorus i.e 126.70 mg/100g. The jackfruit seed processed by sun drying and tray dying method had phosphorus content 125.22 and 126.70 mg/100g respectively. The magnesium content of seed samples dried by sun drying, tray drying are 102.80, and 101.63 mg/100g respectively. The retention of good proportion of magnesium is observed by tray drying method. The increase in magnesium content is probably be due to the heating effect of the drying minerals which do not escape/vaporize and as such higher values in magnesium were seen (Liman *et al*., 2014) [10]. Albi, A. and Jayamuthunagai, J. (2014) [3]. An analytical study on jackfruit seed flour and its incorporation in pasta.

4. Conclusion

From the research it was concluded that the dried jackfruit seed powder prapred by tray drying was found significantly superior over sun drying method with respect to proximate and mineral composition.

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