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EFFECT OF PUFFING ON PHYSICO- CHEMICAL PROPERTIES OF CHICKPEA

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ABSTRACT

The Chickpea or Bengal gram or gram *(Cicer arietinum)* is an annual legume that belongs to the family *Fabaceae*. Chickpea is a remarkable legume known for its potent phenolic compounds, which offer strong antioxidant, anti-mutagenic, and anti-genotoxic benefits, It is consumed due to abundance of carbohydrates, proteins, essential amino acids, minerals, and dietary fiber. puffing leads to a higher puffing index, improved crispiness and volume and enhanced texture of Chickpea. For preparation of Puffed Chickpea, grains were preheated at 150^{0}C for 30 sec, the preheated grains were tempered for 7 hrs of tempering time, after tempering the grains were dipped in water for 20 sec and then the grains were puffed at 160^{0}C. The physical (*viz.*, length, width, thickness, AMD, GMD, SMD, EQD, Surface Area of Single Grain (S), Unit Volume of Single Grain (V) and Bulk Density (BD)) and chemical composition (*viz.*, Moisture, Protein, Fat, Crude fibre, Carbohydrate and Ash content) of raw and puffed Chickpea (Cicer arietinum L.) were analyzed and it was found that physical properties viz., length, width, thickness, AMD, GMD, SMD, EQD, Surface Area of Single Grain (S) and Unit Volume of Single Grain (V) of puffed Chickpea was greater than that of raw Chickpea and proximate composition *viz.*, Moisture, Protein, Fat and Ash content of raw chickpea grains were more than that of puffed Chickpea Grains.

INTRODUCTION

The Chickpea or Bengal gram or gram *(Cicer arietinum)* is an annual legume that belongs to the family *Fabaceae*. It is said to be one of the oldest pulses known and cultivated in Asia and Europe. In India, Chickpea is commonly enjoyed as a roasted snack or incorporated into curries following steam cooking, with roasting being a quick and efficient dry heat cooking method. It is consumed daily due the abundance of carbohydrates, proteins, essential amino acids, minerals, and dietary fiber. It is used for the preparation of *sattu* (roasted grain powder), fortified extruded foods, sweets, etc. Chickpea is a remarkable legume known for its potent phenolic compounds, which offer strong antioxidant, anti-mutagenic, and anti-genotoxic benefits. Beyond its culinary uses, Chickpea seeds have a medical role, serving as a tonic, stimulant, and aphrodisiac in the treatment of various conditions, including bronchitis, leprosy, skin diseases, blood disorders, and biliousness. Packed with dietary phenolics like flavonoids, these compounds have the potential to counteract aging and shield against degenerative diseases such as cancer, cardiovascular issues, and cerebral dysfunctions. Notably, these healthful phytochemicals are most concentrated in the outermost layers of the seeds, and their levels can be influenced by processes like dehulling, soaking, and heating. Puffing leads to faster dehydration, distinctive thermal and chemical reactions and a reduction in the water content of Chickpea. The puffing process, enhances digestibility by transforming micro and macronutrients into more easily digestible forms through rapid starch gelatinization, the simultaneous drying of gelatinized starch, and the denaturation of proteins. As a result, puffing leads to a higher puffing index, improved crispiness and volume and enhanced texture of Chickpea. It also enriches the color, aroma, flavor, shelf life, and consumer appeal, while reducing the bulk density and the presence of anti-nutrients in Chickpea grains. The research envisages that the effect of puffing on the physical properties and chemical composition of Puffed Chickpea.

MATERIALS AND METHODS

1. Procurement of raw materials

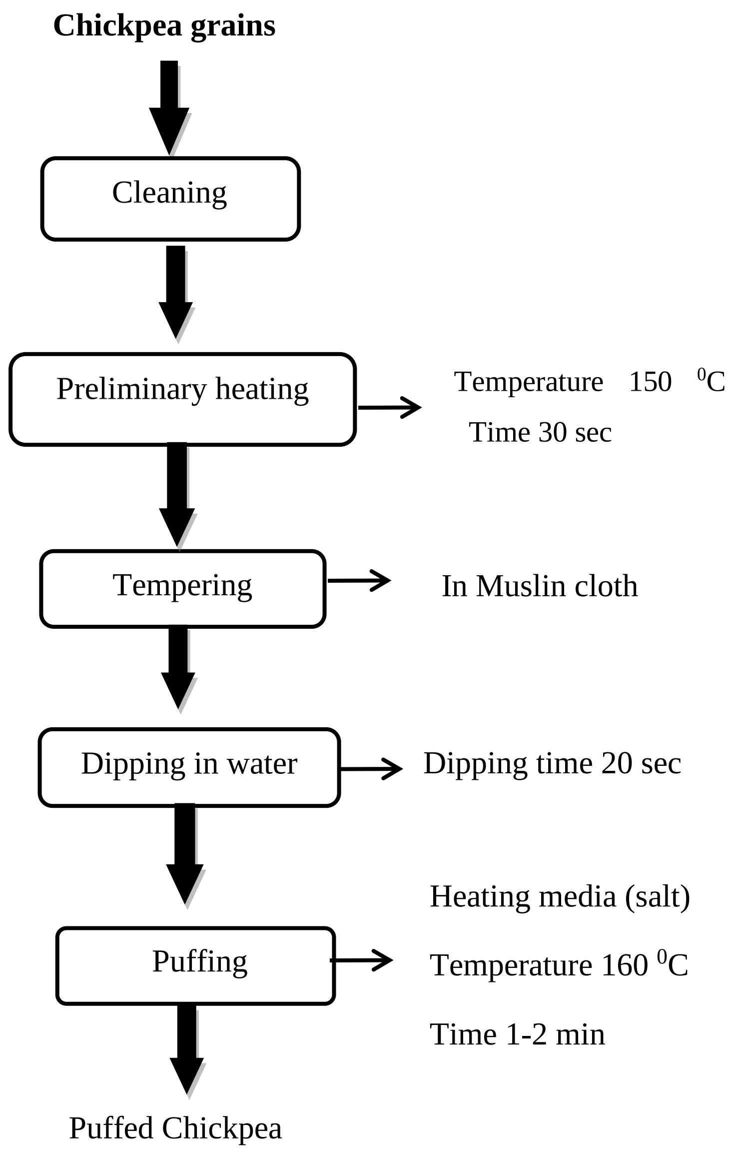
The Chickpea sample were procured from Pulses Research Center, Badnapur, VNMKV, Parbhani, the grains were cleaned, destoned and other impurities were also removed and stored.

The table salt was purchased from local market which was used as heating media for preparation of puffed chickpea.

2. Preparation of Puffed Chickpea sample

Puffed chickpea sample were prepared by using following sequence of steps

Flowchart for the production of puffed Chickpea:



Process flow chart for production of puffed Chickpea.

3. Physical Properties of Chickpea Grains

The physical properties of Chickpea varieties were important to design the equipment and machines for sorting, separation, transportation, processing and storage.

3.1 Thousand grain weight of Chickpea of different varieties

1 kg of Chickpea grains were roughly divided into 10 equal portions and then 1000 numbers of different Chickpea varieties of grains were randomly picked from each portion and weighed using a digital electronic balance having an accuracy of 0.001g. Three replications were carried out to determine the mean value of the weight of different Chickpea varieties.

3.2 Determination of length (L), width (W) and thickness (T) of Chickpea of different varieties

Length, width and thickness of Chickpeas were determined. In order to determine dimensions, one hundred of Chickpea grains were randomly selected. For each Chickpea grain, three principal dimensions namely length, width and thickness were determined using a Vernier Calliper (Model: CD-15CPX, Mitutoyo Corp Made in Japan) having the least count of 0.001 mm.

The length (L) was defined as the distance from the tip cap to kernel crown. Width (W) was defined as the widest point to point measurement taken parallel to the face of the kernel. Thickness (T) was defined as the measured distance between the two kernels faces (Nakade, 2020).

The values of Arithmetic Mean Diameter (AMD), Geometric Mean Diameter (GMD), Square Mean Diameter (SMD), Equivalent Diameter (EQD), Sphericity (Sp) of Chickpea were computed by using the following equations (Mohsenin,1980 and Deshmukh, 2016).

$$\text{AMD} = \frac{L+W+T}{3}$$

$$\text{GMD} = (\text{L} \times \text{W} \times \text{T})^{1/3}$$

$$\text{EQD} = \frac{\text{AMD} + \text{GMD} + \text{SMD}}{3}$$

$$\text{SMD} = \sqrt{\text{LW} + \text{WT} + \text{TL}}$$

$$\text{Sphericity} = \frac{\text{GMD}}{\text{L}}$$

where,

L, W and T : length, width and thickness (mm)

AMD : Arithmetic Mean Diameter

GMD : Geometric Mean Diameter

SMD : Square Mean Diameter

EQD : Equivalent Diameter

Sp : Sphericity

The values of Surface area (S) and grain volume (V) of Chickpea were determine by using following equations. (Jogihalli, 2017 and Sayar, 2016)

$$\text{S (mm}^2\text{)} = \pi\,(\text{GMD})^2$$

$$\text{V (mm}^3\text{)} = \frac{4}{3}\pi\,(\text{GMD}/2)^3$$

3.4 Bulk density of Chickpea of different varieties

Bulk density and true density of raw grain were determined. The bulk density was determined by filling a 100 ml measuring cylinder with grains randomly and then determining the volume and weight of the grains. (Jogihalli, 2017).

$$\text{Bulk Density (g/ml)} = \frac{Mass\ of Chickpea}{Volume\ of\ Chickpea}$$

4. Proximate composition

Proximate composition represents the gross content of important chemical constituents such as Moisture, Protein, Fat, Crude fibre, Carbohydrate and Ash content. The study of the proximate composition serves as an important base to study the nutritive quality of raw and puffed chickpea samples. The standard methods have been used for the proximate analysis.

4.1 Determination of Moisture content

The moisture content of raw and puffed chickpea was determined by using standard method.

4.2 Determination of protein content (Micro Kejdahl Method)

The protein content of raw and puffed chickpea samples were determined by Micro- Kjeldahl's apparatus (AOAC, 2005).

Reagents

N- free sulphuric acid, hydrogen peroxide (30 %), boric acid (4 %), sodium hydroxide (50 %) containing sodium thio- sulphate (5 %), catalyst mixture (potassium sulphate 9.9 g, mercuric oxide 0.41 g, copper sulphate 0.8 g), mixed indicator (Dissolved separately 0.2 % each of bromo-cresol green and methyl red indicators in 95 % ethyl alcohol and mixed together in 5:1, respectively and transferred to bottle provided with stopper), Standard hydrochloric acid (Diluted 0.17 ml conc. HCL to 100 ml with water and checked the concentration against 0.02 N sodium hydroxide).

Procedure

About 0.2 g of raw and puffed chickpea sample were taken and transferred to the digestion flask. The catalyst mixture 2 g and 5 ml of conc. H_2SO_4 were added carefully. The sample was digested until it became colourless by frequent rotating flask. The flask was cooled and 5 ml portion of water was slowly added with mixing. After cooling, the content was transferred to 50 ml volumetric flask with 2-3 rinsing, and the volume was made up with distilled water and mixed thoroughly. Blank digestion was carried out simultaneously. The distillation unit was cleaned by water. The beaker of 100 ml capacity containing 10 ml boric acid, four drops of indicator was dropped and placed under condenser with its tip dipped in solution the digest (5 ml) with rinsing was transferred to distillation flask, 5 ml NaOH was added and

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closed with stop cork. The digest was allowed to boil and about 50 ml distillate of ammonia liberated in boric acid was collected. The distillate was titrated with hydrochloric acid until blue color disappeared. Blank titration was carried out simultaneously. Protein content was calculated using following formula.

$$\text{Nitrogen, \%} = \frac{\text{Titre value} \times \text{Normality of HCL} \times \text{Volume made up of digest} \times 100}{\text{Aliquot of the sample} \times \text{weight of the sample} \times 1000}$$

$$\text{Protein (\%)} = \text{Nitrogen (\%)} \times 6.25$$

4.3 Determination of fat content

Fat analysis of samples was carried out using Soxtec 2045 (Foss instrument, Sweden). Extraction cups were dried in oven at 130°C for 15 min and the weight of empty cups was noted. Weighed sample (3 g) was taken in thimble. Dried empty cups were cooled and 70 ml of petroleum ether was added. Switched on and preheated the instrument, When temperature was attained, the extraction cups were attached to the instrument and left it boiling for 30 minutes, followed by rinsing for 20 minutes and last of all recovery of the solvent was done for 10 minutes. The recovered ether was collected and the fat contained in extraction cups was estimated.

$$\text{Fat \%} = \frac{\text{Weight of ether soluble material}}{\text{Weight of sample}} \times 100$$

4.4 Determination of Crude fibre

Crude fibre of raw and puffed chickpea were estimated using Fibertec (Foss instrument, Sweden). Switch on the instrument to pre-heat the hot plate. Capsules were kept in hot air oven at 100°C for 20 minutes for drying. Cooled pre-weighed and noted down the weight of dried empty capsules and weighed (1 g) sample in capsules (Defatting of samples was done if necessary). Fixed the capsules in the rotating stand, added 250-275 ml of 1.25 per cent H_2SO_4 to the large extraction cup and immersed the stand into the beaker. Acid extraction was done by boiling it for 30-40 minutes followed by its washing with hot water. Then alkali washing was done with 1.25 per cent NaOH for the same time duration followed by hot water washing. Finally, capsules were dried in oven for 2 hours at 130 °C and then placed at 550 °C for 5 hours. Cooled and weighed for crude fibre estimation (AOAC 2000).

4.5 Determination of ash content

For the determination of ash content of raw and puffed sample, method of AOAC (2005) was followed. According to this method, 10 g raw and puffed chickpea were weighed in a silica crucible. The crucible was heated in a muffle furnace for about 4 to 5 hrs at 525°C. It was cooled in desiccators and weighed. To ensure formation of ash, it was reheated again in the furnace for half an hour more, cooled and weighed. This was repeated consequently till the weight became constant (ash became white or greyish white). Weight of ash is a measure of ash content and was calculated by the following formula.

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample taken}} \times 100$$

4.6 Determination of Carbohydrate Per cent

Carbohydrate was determined by subtracting other constituents.

Carbohydrates = 100 - (Moisture + Protein + Fat + Ash + Fibre).

3. RESULT AND DISCUSSION

3.1 Physical properties

Puffing results in formation of space in the starchy endosperm leads to grain expansion resulting in variations in physical properties such as length, width, thickness, surface area and bulk density (Jogihalli et al, 2017, Chandrasekhar and Chattopadhyay, 1990). The length, width and thickness of raw Chickpea grains were 8.46 mm, 6.4 mm and 6.05 mm respectively. It was reported that the puffing increases the length (9.84mm), width (8.61mm) and thickness (7.56mm).

Table 3.1: Physico-chemical characteristics of raw and puffed Chickpea

Sr. No.	Component	Raw chickpea	Puffed chickpea
	Physical properties		
1.	Length (mm)	8.46	9.84
2.	Width (mm)	6.4	8.61
3.	Thickness (mm)	6.05	7.56
4.	AMD (mm)	6.97	8.67
5.	GMD (mm)	6.89	8.62
6.	SMD (mm)	12.00	14.97
7.	EQD (mm)	8.62	10.75
8.	Sphericity	0.81	0.88
9.	Surface Area of Single Grain ($mm^{2)}$	149.32	233.32
10.	Unit Volume of Single Grain (mm^3)	171.43	335.20

11	Bulk Density (kg/m^3)	880	406
	Proximate composition (%)		
1.	Moisture content	10.8	3.9
2.	Protein	21.36	20.28
3.	Fat	6.39	6.05
4.	Crude fibre	9.25	9.95
5.	Ash	3.8	3.2
6.	Carbohydrate	47.7	57.32

Furthermore puffing impact on AMD, GMD, SMD, EQD, Sphericity, Surface Area of Single Grain (S), Unit Volume of Single Grain (V). The arithmatic mean diameter of puffed Chickpea was 8.67 mm which was higher than raw chickpea (6.97 mm). The square mean diameter of puffed Chickpea was 8.62 mm which was higher than raw chickpea (6.89 mm). The equivalent diameter of puffed Chickpea was 10.75 mm which was higher than raw chickpea (8.62 mm).

The geometric mean diameter of puffed Chickpea was 8.62 mm which was higher than raw chickpea (6.89 mm). The increased geometric mean diameter due to puffing were also reported by Mridula et al. (2007) for soybean. The difference in grain length played a and the increase in geometrical mean diameter contributes in increasing sphericity of grain. The puffing exhibits a continuous increase in the sphericity of grain samples (0.88) than raw chickpea (0.81).

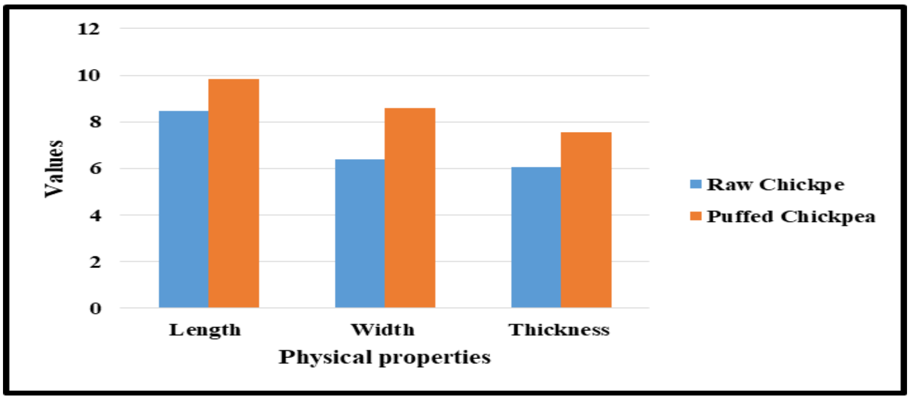

Fig 3.1: Physical properties of raw and puffed Chickpea

The expansion of puffed grain width and thickness, rather than its length, caused the increase in sphericity, Similar findings were observed by Qureshi et al, (2023). Puffing significantly increase the surface area from 149.32 to 233.32 (mm^2). The increase in surface area is also observed by Raigar et al. (2015) for roasted soybean. The unit volume of single grain of puffed Chickpea was 335.20 mm^3 which was higher than raw chickpea (171.43 mm^3).

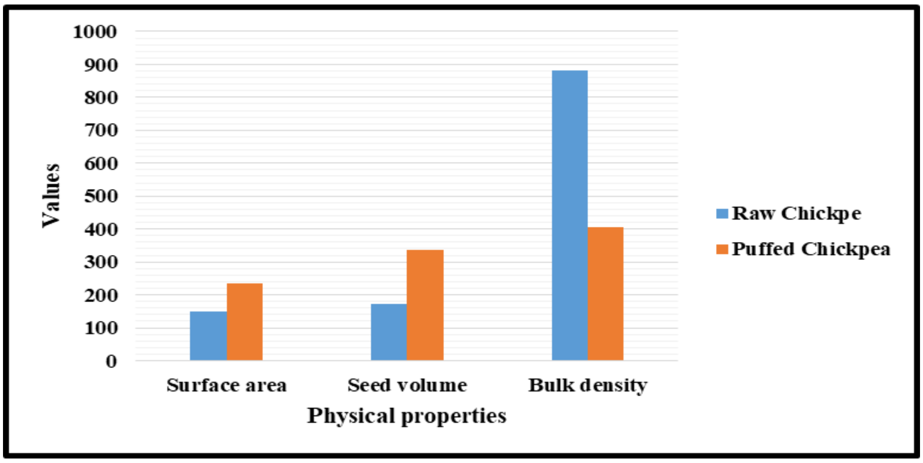

Fig 3.2: Surface area, Seed volume and bulk density of raw and puffed Chickpeas

It was observed from Table 3.1 and Fig 3.2. that the bulk density of raw Chickpea was 880 kg/ m3 and it decreased to 406 kg/m^3 after puffing. The decrease in bulk density of Chickpea may be due to the fact of creation of void spaces in the cellular matrix, which might have been allow the starchy endosperm to expand and resulting significant decrease of bulk density could explain the significant decrease in densities. The decrease in bulk density of Chickpea due to puffing is also observed by Mariotti *et al.* (2006) for puffing of brown rice.

4.3.2 Proximate composition

The results demonstrates significant impact of puffing on chemical composition. The considerable drop in moisture content was noticed. It was noted that the moisture content of the raw chickpea (10.8 %) was more than the puffed Chickpea (3.9 %) sample. This may be due to high pressure and temperatures during the explosion and the water might have changed into vapor and escaped from grains. The similar results were observed by Qureshi et al. (2023).

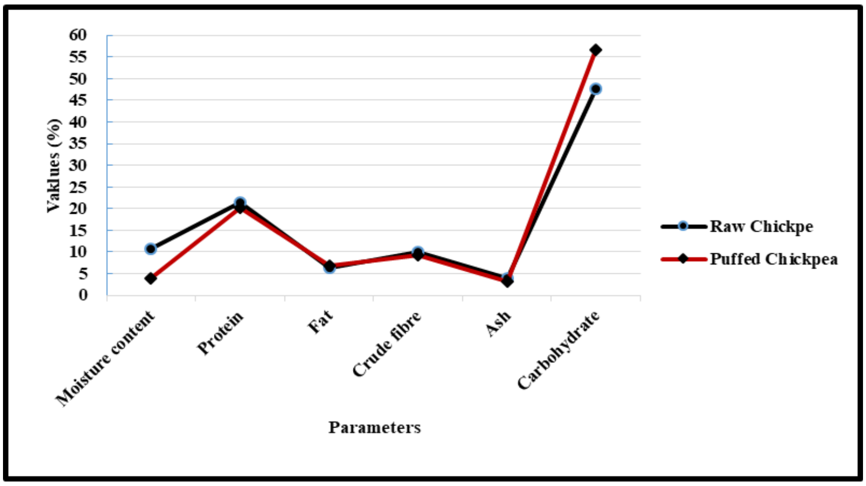

Fig 3.3: Proximate composition of raw and puffed Chickpea.

From Table 3.1 It was observed that the protein content of raw chickpea samples 21.36, which was reduced up to 20.28 due to heat treatment during puffing process. The protein content of the Chickpea decreased non significantly , may be due to the fact that heating and shearing during the expansion process might denature protein and change its structure. This might be expose the non-polar groups buried inside protein and increase the surface hydrophobicity and the formation of protein aggregates, resulting in a decline in protein content of chickpea. The similar results were observed by Huang *et al*. (2018).

It was observed from Table 3.1. that The fat content of raw chickpea grains was 6.39 % which was decreased up to 6.05 % after puffing. The decrease in fat content of Chickpea may be due to the fact that during puffing process, volatile oils are lost , which might account for the drop in the fat content. The similar results were observed by Huang *et al.* (2018).

The crude fibre content of a food sample is the amount of indigestible carbohydrates present. It was obsterved from Table 3.1, that the crude fibre content of the raw Chickpea was 9.25 %, which was increased upto 9.95 % after puffing. The fibre content of chickpea is increased after puffing due to, the concentration of components after heat treatment, which is induced by moisture loss, resulted in an increase in fibre content. The similar findings were observed by Qureshi *et al (*2023).

It was observed from Table 3.1, that the ash content of puffed chickpea sample (3.2 %) was less than raw chickpea sample (3.8 %) the same results were observed by Qureshi *et al* (2023).The ash content of Chickpea reduced after puffing, may be due to increase in carbohydrate content might be offset by decrease in ash content.

From Table 3.1, it was observed that, the total carbohydrate content of puffed chickpea sample (57.32 %) was higher than raw chickpea sample (47.7 %). The gelatinization of starch during puffing may be responsible in increase in carbohydrate content of chickpea. The same results were observed by Qureshi et al. (2023).

CONCLUSION

From the results of the present investigation, it is concluded that

1. After puffing the length, width and thickness of raw Chickpea grains were increased from 8.46 mm, 6.4 mm and 6.05 mm to 9.84mm, 8.61mm and 7.56mm respectively

2. The bulk density was decrease from 880 kg/ m^3 to 406 kg/m^3.

3. The moisture content of the raw chickpea (10.8 %) was more than the puffed Chickpea (3.9 %) sample.

4. The protein content of raw chickpea samples 21.36, which was reduced up to 20.28 due to heat treatment during puffing process.

5. The fat content of raw chickpea grains was 6.39 % which was decreased up to 6.05 % after puffing.

6. The crude fibre content of the raw Chickpea was 9.25 %, which was increased upto 9.95 % after puffing.

7. The ash content of puffed chickpea sample (3.2 %) was less than raw chickpea sample (3.8 %).

8. the total carbohydrate content of puffed chickpea sample (57.32 %) was higher than raw chickpea sample (47.7 %).

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