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Effect of Popping on Major Millets: Pearl Millet and Sorghum

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Abstract:

The consumption of millets, such as sorghum and pearl millet, has gained popularity due to their nutritional benefits and adaptability. Popping, a traditional food processing technique, significantly alters the physical properties of millets, making them expand and transform in texture, color, and aroma. This study investigates the effects of popping on sorghum and pearl millet, focusing on changes in their nutritional profiles.

The results show that popping increases the expansion ratio of sorghum and pearl millet, with sorghum experiencing a higher expansion ratio. This influences the texture and mouthfeel of popped grains. Moreover, popping leads to changes in the nutritional composition, reducing moisture content and increasing protein and carbohydrates in both millets. Additionally, the mineral content is affected, with slight increases in zinc, iron, magnesium, potassium, and phosphorus in popped sorghum. However, popped pearl millet experiences a decrease in calcium and an increase in iron content.

Anti-nutrients, such as tannin, oxalic acid, and phytic acid, are reduced in both millets after popping. These anti-nutrients can hinder mineral absorption in the body. Total phenolic content and antioxidant activity decrease after popping due to the high-temperature processing, which affects the health-promoting compounds in millets.
Keyword: Millets, Sorghum, Pearl millet, Popping, Anti-nutrients, Total phenolic content

Introduction:

The consumption of millets, which are a group of small-seeded grains, has gained considerable attention in recent years due to their nutritional benefits and adaptability to diverse agricultural environments. Among these millets, major varieties like sorghum and pearl millet are essential staples in many parts of the world. Popping, a traditional food processing technique, involves the application of heat to grains, resulting in their rapid expansion and the formation of edible snacks. While the effects of popping on the physical characteristics of millets have been extensively studied, there is a growing need to explore its impact on the nutritional and mineral composition of these grains. This research paper seeks to investigate the effects of popping on major millets, specifically sorghum and pearl millet, with a focus on changes in their nutritional profiles. Understanding these alterations is crucial for assessing the suitability of popped millets as a nutritious and convenient food source and for informing dietary choices in regions where millets are prevalent.

Popping major millets like sorghum and pearl millet has a profound effect on their physical properties. During the popping process, these grains undergo significant expansion, resulting in a remarkable increase in volume and a decrease in density. The texture of popped millets transforms from the original hardness to a crisp and crunchy consistency due to starch gelatinization and the development of a porous structure. Additionally, the grains often take on a lighter or golden-brown color through Maillard reactions and caramelization of sugars. Their shape and size become irregular and rounded, and they become much softer and more brittle. Popping also reduces the moisture content of millets, making them suitable for long-term storage. Moreover, the aroma and flavor of popped millets are enhanced, often acquiring a roasted or toasted note, which can be appealing to consumers. These changes in physical properties not only enable the development of new food products but also influence the sensory attributes and convenience of popped millets in various culinary applications, making them an important consideration for both the food industry and consumers, especially in regions where millets are dietary staples.

Nutritional importance of sorghumis 349 Kcalenergy, 9.6% protein, 3.8% fat, 73.2% percent carbohydrates, 2.4% ash and 11% moisture content. (Chavan et al.,2014) Grain sorghum protein contains albumin globulin (15%), prolamin (26%) and glutelin (44%). sorghum is gluten free and is a safe energy source forpeople allergic to gluten. Minimal amounts of flavan- 4-ols and phytic acid are present inwhitesorghum (Chavanand Patil, 2010).

The grain crop known as pearl millet, which is nutritious but rarely used, is used by those from lower socio economic levels to prepare traditional foods. The name of it is "pearl millet". It is not as pricey as pearl, but it does have pearl-like qualities that are healthy for the body. The following nutritional information applies to 100 % of bajra: energy 360 calories, moisture 12 %, protein 12 %, fat 5 %, mineral 2 %, fiber 1 %, carbohydrate 67 %, calcium 42 mg, phosphorus 242 mg, and iron 8 mg. The millet grains can therefore be used to create a variety of value-added and healthy food products with the help of processing methods that are suited for the task (Mal et al., 2010). This could lead to a high demand from huge urban populations and unconventional millet users.

Materials and Methods:
The grains were cleaned thoroughly. About 100 g each of pearl millet and sorghum were equilibrated to a moisture content of 18% by adding water and tempered for 6 h in a closed container. The tempered grains were popped by high temperature and short time (HTST) treatment in a domestic grain popper at 230+5 degree C .

Popping yield: Popping yield was determined as per the method given by Malleshi and Desikchar (1981).
Popping yield (%) = Weight of popped grain (g) /100 Weight of (popped × unpopped) grains (g)

Expansion ratio: Expansion ratio is the ratio of size of popped grain to the size of raw grain. The expansion ratio was determined according to the method of Hoke et al. (2007).
Expansion ratio = Breadth of popped grain / 100 Breadth of raw grain

The nutritional content: (protein, fat, crude fiber, ash) of the raw and popped grains were evaluated as suggested by AOAC (2000). The carbohydrate content was calculated by the difference method. The phytic acid was estimated by the method suggested by Sadasivam and Manickam (1991).

Minerals:
After dry washing of the sample an Atomic Absorption Spectrophotometer (Analyst 300 Perkin Elmer) was used to determine the mineral content of the popped sorghum sample. During the determination of Calcium content, a final concentration of 0.5% of the lanthanum chloride was used to reduce the phosphate effect (Llopart& Drago, 2016).

Determination of tannins:
The tannin content in the products was estimated using spectrophotometeric method (Sathasivam and Manicam, 2004)

Determination of phytates:
The phytates content in the products was estimated using spectrophotometeric method
(Sathasivam and Manicam, 2004)

Total phenolic content:
Folin-ciocalaetu method was used for the determination of phenolic compound (Singleton, Orthofer& Lamuela-Raventos,1999). Phenol react with phosphomolybdic acid in folin-ciocalaetu reagent in alkaline medium and produce blue colored complex. TPC expressed in gallic acid equivalents.

Antioxidant activity:
The antioxidant activity of popped sorghum was measured in terms of hydrogen donating

or radical scavenging ability using by antioxidant assays method such as DPPH free radical scavenging. 1,1 - Diphenyl 2-picrylhydrazyl (DPPH) is a stable free radical, with nitrogen bridge (Eklund et al., 2005). It is acommon colorimetric reagent that can be keptindefinitely with little decomposition, andneither dimerizes nor reacts with oxygen. Dueto its distinguishable color transition fromdeep -violet to yellow when reduced and coloris measured at 517 nm, it is often used for thedetermination of antioxidant properties inseveral compounds.

Result and discussion:

1. Effect on quality parameter after popping of millet:

The effect of popping on the quality of popped pearl millet and sorghum were analysed and the result were represented in the table 1 as below

Table 1. Effect on quality parameter after popping of millet

Parameter	**Pearl millet**	**Sorghum**
Expansion ratio	7.56	10
% popping	60.45	70.19

The volume increase that grains go through during the popping process is referred to as the expansion ratio. In this instance, sorghum has an expansion ratio of 10, which is marginally higher than the 7.56 expansion ratio of pearl millet. This is a result of the sorghum's hard kernel, which is larger than pearl millet. This implies that compared to pearl millet, sorghum grains tend to puff up more when they are popped, leading to a higher increase in volume. The mouthfeel and texture of popped grains in food products might be affected by this variation in expansion ratios.

The percentage of grains that actually pop during the popping process is an indicator of how effectively the operation is working. Sorghum has a greater percentage popping than pearl millet, with 70.19% compared to 60.45% for pearl millet. When compared to pearl millet, a higher percentage popping means that more sorghum grains successfully pop. similar finding observed by (Sharma et al.,2014).

2. Effect of popping on nutritional composition of raw material:

The effect of popping on the proximate composition of pearl millet and sorghum were analysed and the result were represented in the table 2 as below

Table 2. Effect of popping on nutritional composition of raw material.

Parameter	Sorghum	Popped sorghum	Pearl millet	Poppedpearl millet
Moisture(%)	8.31± 0.41	4.64± 0.41	10.08± 0.22	1.27± 0.22
Protein(%)	11.30± 0.23	11.60± 0.23	11.65± 0.31	11.73± 0.31
Fat(%)	2.56± 0.2	2.45± 0.2	5.74± 0.02	4.56± 0.02
Carbohydrate(%)	74.01 ± 0.51	77.31 ± 0.51	68.75± 0.24	79.34± 0.24
Crude Fiber(%)	2.42 ± 0.034	2.2± 0.034	1.92±0.03	1.16±0.03
Ash(%)	1.40 ± 0.02	1.80 ± 0.02	1.86± 0.03	1.94± 0.03

This table lists the nutritional value of two different grains, pearl millet and sorghum, in both their unpopped and popped forms. For each parameter, the values are shown as a proportion of the overall composition. Approximately 8.31% moisture, 11.30% protein, 2.56% fat, 74.01% carbs 2.42% crude fiber, and 1.40% ash are all present in sorghum in its usual form. In comparison to unpopped sorghum, popped sorghum has a slightly lower moisture content (4.64%), slightly greater protein content (11.60%), higher carbohydrate content (77.31%), and slightly lower fat content (2.45%). The numbers are roughly 10.08% moisture, 11.65% protein, 5.74% fat, 68.75% carbs, 1.92% crude fiber, and 1.86% ash for Pearl Millet in its usual form. When compared to normal Pearl Millet, popped Pearl Millet has slightly lower moisture (4.56%), greater carbs (79.34%), and noticeably less moisture (1.27%). due to the moisture being lost during popping, these nutrients were more concentrated. those readings aresimilar to (Nithya et al.,2007), (Anjitha et al.,2021), (Mishra et al., 2015), (Awadelkareem et al.,2009).

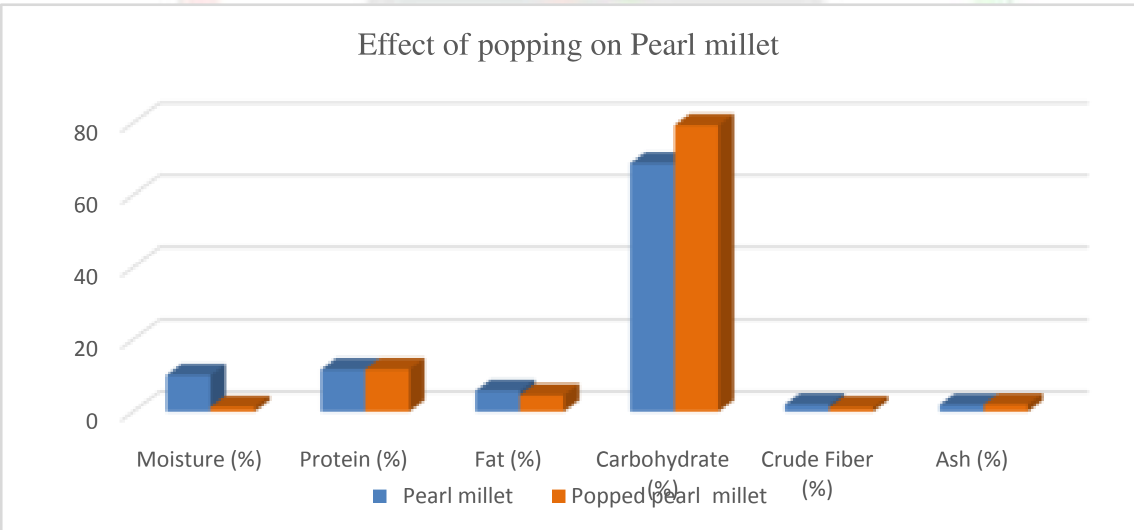

Fig 1.Effect of popping on Pearl millet

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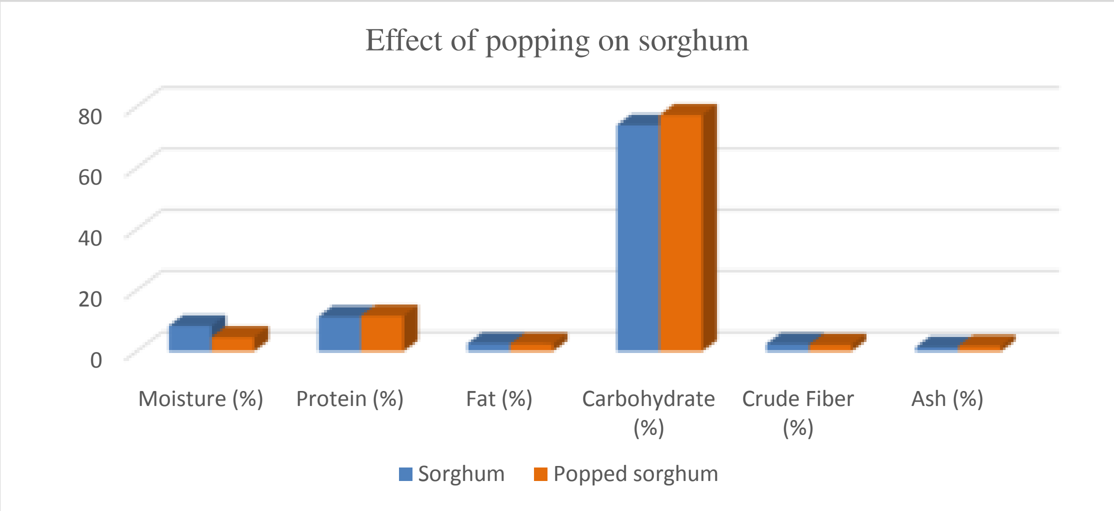

Fig 2.Effect of popping on sorghum

3. Effect of pre-treatment on mineral composition of raw material:

The levels of mineral concentration in millets after popping and beetroot after drying was determined by Atomic Absorption Spectroscopy (AAS). The present study has reported the profound minerals in sorghum pops, pearl millet pops, beetroot powder in Table 3 below.

Table 3. Effect of pre-treatment on mineral composition of raw material:

Mineral	Sorghum	Popped sorghum	Pearl millet	Popped pearl millet
Calcium	29±0.115	26.25±0.56	50.8±0.1	48.3± 0.49
Magnesium	125±0.22	120±0.22	90.26±0.22	85± 0.40
Iron	6.589±0.1	6.276±0.1	4.59±0.1	10.5± 0.33
Zinc	2.172±0.021	4.431±0.021	3.05±0.021	4.96±0.52
Phosphorous	351±0.01	250±0.09	236±0.02	238.3 ± 0.64
Potassium	175±0.54	196±0.73	375.45±0.5	380.5± 1.47

Zinc content in popped sorghum increased slightly (from 3.172 to 4.431 mg/100g), iron content increased slightly (from 6.589 to 7.276 mg/100g), magnesium content decreased (from 120 to 125 mg/100g), potassium content increased (from 180 to 196 mg/100g), and phosphorous content decreased (from 250 mg/100g). This is consistent with patterns observed by Ajintha et al. (2021), who also found related results. As for pearl millet, the mineral analysis, as shown in Table 2, revealed that the calcium content was 50.08 and 48.31.36 mg/100g, respectively, in raw and popped pearl millet, with a considerable drop during popping. Raw and popped pearl millet's iron contents were 4.59 and 10.5 mg/100g, respectively, showing a significant increase. During popping, the phosphorus content increased by a negligible amount (236 and 238mg/100g,results are similar toChauhan E. S, Sarita (2018).

4. Effect of popping on antinutrient in millet:

Table 4 depicts the anti-nutritional factors present in raw sorghum and pearl millet and popped sorghum and pearl millet. It is necessary to determine the anti-nutritional factors in cereal crops to know the activity in raw nature and on processing.

Table 4.Effect of popping on antinutrient in millet

Anti nutrients (mg/100g)	Millet	Raw grain	Popped grain
Tannin	Sorghum	113±0.31	67±0.21
	Pearl millet	349 ± 0.40	130±0.59
Oxalic acid	Sorghum	210 ± 0.72	129.3± 0.012
	Bajra	429 ± 0.08	386± 0.77
Phytic acid	Sorghum	130 ± 0.33	89.3±0.2
	Pearl millet	505 ± 2.51	365± 3.60

This table details the milligrams per 100 grams of anti-nutrients present in millet grains in both their raw and popped forms, notably tannin, oxalic acid, and phytic acid. When ingested in large quantities, these anti-nutrients might prevent the body from absorbing vital minerals and nutrients. When it comes to tannin, raw sorghum has 113 mg per 100 grams, while popped sorghum only includes 67 mg. Similar to pearl millet, which has a higher tannin concentration when consumed raw (349 mg per 100 grams), as opposed to 130 mg when consumed popped. Tannins are recognized for their astringent flavor and have been linked to potential health advantages, but consuming too much of them can prevent minerals from being absorbed. Results are in alignment with the findings reported (Jambunathan et al., 1981).

In terms of oxalic acid, raw sorghum has 210 mg per 100 grams, while popped sorghum has 129.3 mg. With 429 mg of oxalic acid per 100 grams in its raw form, Bajra (Pearl Millet) has even higher levels than the reasonably high 386 mg seen in its popped form. Oxalic acid can combine with calcium to produce insoluble crystals, which may interfere with the body's ability to absorb calcium. The present data was comparable to the concentration that had been reported by (Chauhan et al .,2015).

Another anti-nutrient found in millets is phytic acid. When popped, sorghum loses some of its 130 mg per 100 grams, falling to 89.3 mg. The phytic acid content of pearl millet, on the other hand, is significantly higher in its raw form, at 505 mg per 100 grams, and decreases to 365 mg when it is popped. Phytic acid can prevent the body from absorbing important minerals likeiron and zinc.

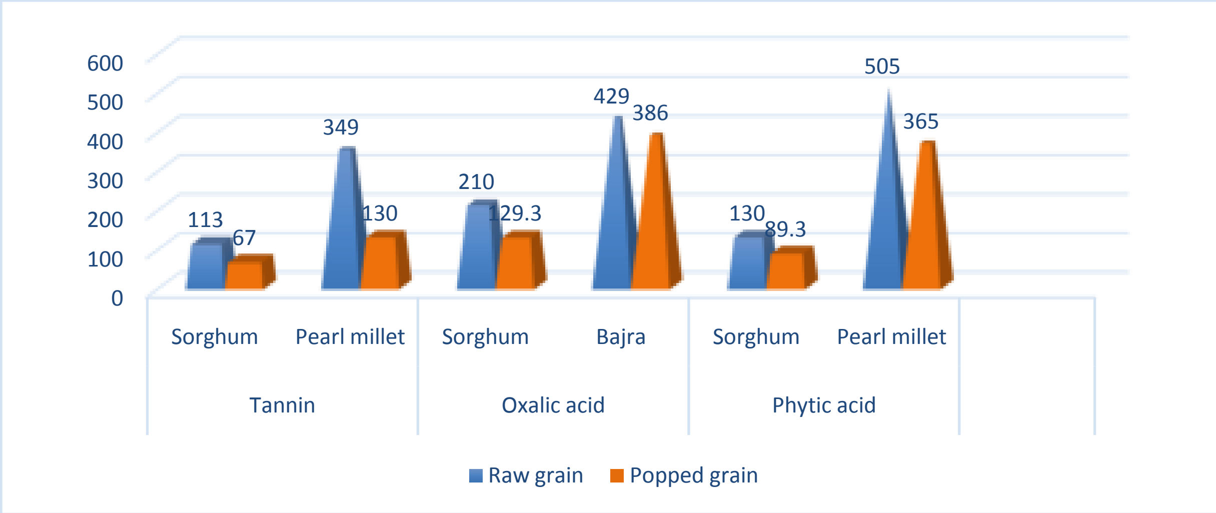

Fig 3.Effect of popping on antinutrient in millet

5. Effect of popping on Total phenolic content and antioxidant:

Parameter	Sorghum	Popped sorghum	Pearl millet	Popped pearl millet
TPC (mg GAE/g)	0.464±0.126	0.38±0.451	0.812 ± 0.22	0.741±0.56
Antioxidant activity %	70.5±0.163	65.8±0.364	60.78±0.97	56.3±0.37

Total phenolic content:

Sorghum's TPC content dropped after popping from 0.464 to 0.38 (mg GAE/g), whereas pearl millet's TPC content dropped from 0.812 to 0.741.According to Awadelkareem et al. (2005), bound phenol compounds exist. Choi et al. (2019) reported that TPC content in raw sorghum was greater than the level seen in Table 5 in other investigations.According to Mir et al. (2016), the total phenolic content of puffed brown rice decreases by 45 to 47% throughout the expanding process. According to Randhir et al. (2008), phenolic content is a heat-sensitive material, and oxidation and thermal degradation during high temperature processing result in a decrease in TPC.

Antioxidant activity:

Table 5 shows that sorghum's antioxidant activity reduced after being exposed to a high temperature. which falls from 70.5 to 65.8 and from 60.78 to 56.3% in pearl millet. According to Moraes et al. (2018), the antioxidant activity of raw sorghum ranges from 66.5 to 92.9%. In addition, the high temperature reduced the antioxidant content compared to the raw form. According to Pasha et al. (2015), untreated sorghum's antioxidant activity displayed a DPPH concentration that ranged from 88.4 to 94.2%. In our investigation, the antioxidant activity of the popped sorghum was lower than in earlier studies. The antioxidant activity of popped sorghum was impacted by a higher popping temperature. 2020 (Tasie & Gebreyes). claimed that the mineral content overall increased with the ash value of the types.This study shown that TPC content and antioxidant activity decreased during popping, and that the effect of high temperature on sorghum very slightly altered the quality of the popped grain. According to Sreerama et al. (2008), popping beans also demonstrated this.

Conclusion:

In summary, the popping process brings about significant changes in the physical properties and nutritional composition of sorghum and pearl millet. It enhances their volume and sensory attributes while reducing anti-nutrients, making them more suitable for consumption. However, the reduction in total phenolic content and antioxidant activity suggests a potential trade-off in terms of health benefits. These findings are essential for evaluating the use of popped millets as a nutritious food source and guiding dietary choices in millet-consuming regions. Further research could explore methods to mitigate the decline in health-promoting compounds during the popping process.

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