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Development and Quality Characterization of Pearl Millet Flakes

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ABSTRACT

This study presents the optimization of machine parameters, development and evaluation of Pearl millet (Pennisetum glaucum) flakes using various processing treatments and their effect on polyphenolic contents and sensory parameters. A roller flaking machine was used with a throughput capacity of 350 kg/h. As the roller clearance increased from 0.1 to 0.5 mm, the length and width of flakes decrease from 5.2 to 3.09 mm and 4.44 to 2.76 mm, respectively whereas the thickness of flakes increased from 0.50 to 1.50 mm. Bulk density of flakes was found proportional with the roller clearance ranged between 349.5– 590.7 kg/m3 at the mean moisture content of 8.11±0.07%. Soaking with steaming treatment produced flakes with least bulk density 355 kg/m3. Steaming of grains resulted in flakes with optimum bulk density and textural parameters. Pressure cooking method resulted in the highest loss of total polyphenolic content.

Keywords: Roller Flaking Machine, Throughput Capacity, Functional, Nutritional, Polyphenols

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INTRODUCTION

Millets, a group of small-seeded cereal crops belonging to the Gramineae family, are highly resilient and can thrive in adverse agro-climatic conditions such as arid soils and high temperatures. Pearl millet, finger millet, foxtail millet, and other varieties are emphasized for their nutritional superiority, earning them the title "nutri-cereals" or "super grain". The global scenario of millet production highlights India as a major producer, contributing to over 20% of the world's millet production. Pearl millet stands out for its nutritional benefits, being rich in energy, protein, fibre, and micronutrients like iron and zinc (Sumathi et al., 2007). Despite these advantages, challenges in the processing sector, such as small grain size and prolonged cooking times, limit millet's broader market potential. In the Europe and other regions, millets are gaining recognition as gluten-free alternatives, especially for individuals with celiac disease (Jones et al., 2000). Gluten-intolerant individuals face limited dietary options, but millets, particularly pearl millet, offer a nutritious substitute. Technological innovations, such as milling, puffing, and flaking, are being explored to make millet-based products more accessible and commercially viable (NRAA, 2012).

Flaking technology is one area of innovation with great potential for millets. It involves processes that enhance the nutritional value and shelf life of grains, making them suitable for ready-to-eat products (Narang et al., 2018). Studies on flaking other cereals like corn and rice serve as a basis for further research into millet processing. Moreover, recent advancements, such as the use of air plasma technology, show promising results in improving the quality of flaked and puffed millet products (Jaybhaye et al., 2014; Pittia et al., 2008). Millet-based convenience products, especially flaked ones, have significant potential for commercialization, benefiting both consumers and farmers. Public and private sector partnerships can help drive the large-scale adoption of millet processing technologies, ensuring these nutritious grains reach a wider audience and contribute to healthier dietary choices.

MATERIALS AND METHODS

A roller flaking machine was used to produce pearl millet flakes. The machine featured a feeding hopper made of mild steel (300 x 300 x 240 mm) for introducing the grains, which were agitated to ensure smooth and consistent feeding. Two horizontal rollers, crafted from hard chrome steel with a diameter of 140 mm and a length of 320 mm, compressed the softened grains into flakes. The rollers operated in opposite directions with the help of a gear set, and their clearance could be adjusted through a screw-pressing mechanism to regulate flake thickness. A 1.0 hp (0.746 kW) electric motor running at 1425 rpm powered the system, with a transmission assembly using V-pulleys to reduce the roller speed to 100 rpm, providing the ideal conditions for flaking (Fig. 1). This setup

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allowed for precise control over the flaking process, producing consistent and high-quality pearl millet flakes.tandard deviation, frequency, percentage, correlation, etc.

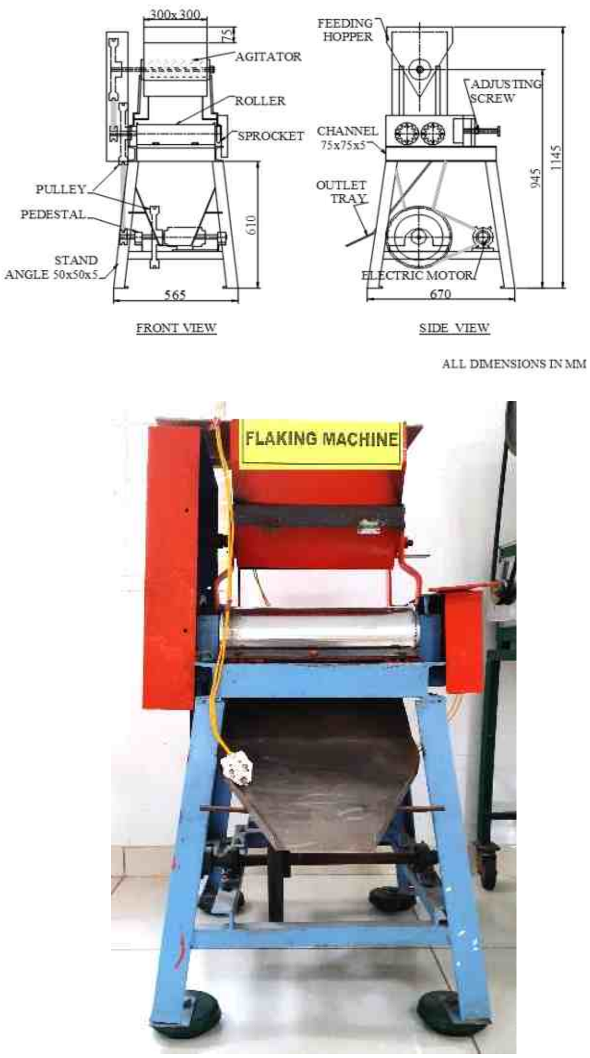

Fig. 1: Schematic view of flaking machine showing various components

Development of pearl millet flakes

The pearl millet variety HHB-67 was selected for flake preparation due to its early maturity, bold grains, and compact conical panicles. This variety is typically sown with the onset of the monsoon, either in the first or last fortnight of July, and harvested after 70-80 days, around October-November. The grains, stored in aluminium bins post-harvest, underwent an initial cleaning process and were then pearled using a grain pearler for 20 minutes in batches of 5 kg. This process removed the aleurone layer, which is critical for extending the grain's shelf life.

The grain pearler, manufactured by CIAE, Bhopal, had dimensions of 166×500×1000 mm and a capacity of 90 kg/h at 1000 rpm, powered by a 7.5 hp motor. The pearling process effectively peeled and cleared out the branny layers from the millet grains, which is vital since pearl millet has a relatively high fat content (5.5%), largely stored in the germ, pericarp, and aleurone layers. This lipid content, combined with the presence of lipase enzymes, reduces the shelf stability of the grain, making the removal of the aleurone layer essential.Seven different pre-treatments namely T1 (Soaking for 3.0 h only, no steaming/pressure cooking afterwards), T2 (5 min soaking + 15 min steaming), T3 (10 min soaking + 15 min steaming), T4 (20 min soaking + 15 min steaming), T5 (30 min soaking + 15 min steaming), T6 (10 min soaking + pressure cooking for 2 min at 15 psi), T7 (20 min soaking + pressure cooking for 2 min at 15 psi) were selected for preparation of grain for making flakes. T8 (control) consisted of hand pounding of whole pearl millet grain soaked in water for 5 h for production of flakes by traditional process.

A.Un-pearled grain
B. Pearled Grain (after removel of aleurone layer)
C. Pearl Millet Flakes (T4 sample)

Fig. 2: Satges of pearl millet flakes preparation

Bulk Density

Bulk density is defined as mass per unit volume of the grain including the pore space. It was calculated as the ratio of sample mass and its volume as per the method of Singh et al. (2010).

Phenol content

Phenol content of the flakes was measured by folin-coicalteau method (Singleton and Rossi, 1965).

Sensory quality

Flakes were stored by packaging in 200 μ gauge polyethylene pouches and stored at room temperature of 24 °C (42– 82 % RH) to 31 °C (61–98 % RH) for 180 days. Sensory quality of pearl millet flakes was assessed using 9-point hedonic scale (Amerine et al., 1965) by semi trained sensory panel.

RESULTS AND DISCUSSION

The performance of flaking machine was evaluated with the variable clearance ranged between 0.1 to 0.5 mm between flaking rolls. The length, width and thickness of flakes were measured by using veneer calliper and also bulk density was evaluated for the flakes obtained at different roller clearance. Figure 3 presents the physical parameters of pearl millet flakes as the function of roller clearances. As the roller clearance increased from 0.1 mm to 0.5 mm, the dimensions of the pearl millet flakes exhibited notable changes. The length of the flakes decreased from 5.2 mm to 3.09 mm, and the width reduced from 4.44 mm to 2.76 mm. However, the thickness of the flakes increased, ranging from 0.50 mm to 1.50 mm as the roller clearance widened. Additionally, the bulk density of the flakes was found to be directly proportional to the roller clearance, varying between 349.5 kg/m^3 and 590.7 kg/m^3 at an average moisture content of 8.11±0.07%.

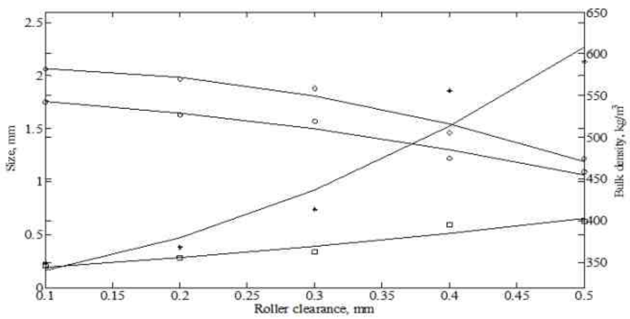

Fig. 3: Physical properties of pearl millet flakes as function of roller clearance (- ◊- Length, -o- width, -□- thickness, and -*- bulk density)

These variations highlight how the roller clearance significantly affects the physical characteristics of the flakes. It was also observed that at the lowest roller clearance of 0.1 mm around 50% grains were broken. Hence, based on the above finding, the rest of experiment on flaking was conducted at a roller clearance of 0.2 mm. Bulk density of flakes ranged from 355-430 kg/m3 with different pre-treatments. Soaking and steaming produced flakes with lower bulk density compared to pressure cooking. The lowest bulk density i.e. 355 kg/m3 were observed for samples T4. Highest bulk density was observed for flakes produced after pressure cooking of pearl millet as it was found 430 kg/m3. Lower bulk density is desirable criteria for producing good quality flakes.

Phenolic content

Pre-treatments before flaking caused significant changes in the total phenolic contents of flakes. Similar studies showed that concentration of phenolic content is highly dependent on the method used for cooking (Boari et al., 2013; Rafaella et al., 2017). The results indicated that polyphenolic compounds were very sensitive to heat treatment and cooking style affected total polyphenol content of samples. The phenolic content in flakes prepared by steaming was more than prepared after pressure cooking (Fig. 4). Increments of phenolic content of flakes by steaming have been attributed to improved extractability of phenolics from the food (Lim and Murtijaya, 2007; Tacouri et al., 2013; Van-Burden and Robinson, 1969).

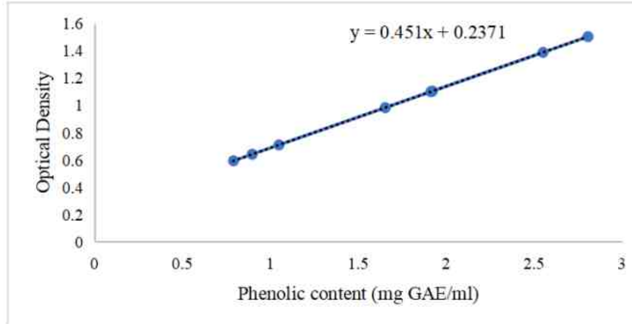

Fig. 4: Phenolic contents on pearl millet flakes

The steaming method seemed to preserve better the polyphenols content but the pressure-cooking method resulted in the highest loss of total polyphenolic content. Steaming caused an increase in total phenolic content but had a negative effect on microwave and boiling treatments. The study by Xu and Chang (2008) also showed similar findings that steaming treatments resulted in a greater retention of total phenolic content.

Organoleptic Quality of Pearl Millet Flakes

Organoleptic quality of pearl millet flakes was evaluated on 5-point hedonic scale (Fig. 5). Overall acceptability of sample T3 and T4 prepared by steaming method was found higher while the lowest was for samples T1 prepared after soaking only and T8 prepared by conventional process (control). The hedonic scores for the sample T3 and T4 were found almost similar.

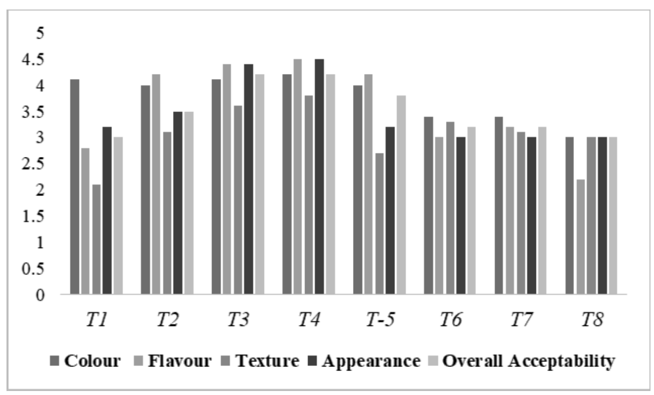

Fig. 5: Organoleptic quality of pearl millet flakes

Attributes such as colour, texture and appearance were found highest for sample T4. Samples T6 and T7 prepared by pressure cooking showed low hedonic scores for all the attributes including overall acceptability. The overall acceptability of T1 and T8 (control) were found least among all. The colour of sample T8 was significantly dark. Major difference in overall acceptability was found mainly due to the difference in colour, taste and texture of the products.

CONCLUSION

Flaking machine was used to prepare flakes of pearl millet.

Flake length, width and thickness were found 5.0 mm, 4.1 mm and 0.5 mm respectively. The increase in the roller clearance showed an inverse relation with flake length and width, while bulk density and thickness were increased consecutively. Soaking and steaming produced flakes with lower bulk density, higher water and fat absorption capacity compared to pressure cooking. The lowest bulk density was observed i.e. 355 kg/m3 for sample T4 (20 min soaking + 5 min steaming) followed by 358 kg/m3 for flakes samples T3 (15 min soaking + 5 min steaming) which is highly desirable property for flakes. Mean moisture content of the flakes was found 8.11% which in turn favoured its shelf life. Data revealed that phenols were decreased maximum by pressure cooking. Overall, it can be concluded that pre-treatment T4 produced best quality flakes with lower bulk density and desired functional characteristics at roller clearance of 0.2 mm. Flaking treatments is a better approach in improving the nutritional profile of pearl millet, which can be consumed directly or as one of the ingredients for formulations of processed products.

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