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Development and quality evaluation of millet based extruded product

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Abstract
This study was carried out to develop ready-to-eat snack products with composite formulations incorporating fine semolina of pearl millet, fine semolina of sorghum, corn, and rice grit blends in different proportions, employing extrusion technology. Extrusion cooking is a pioneering technique that improves the nutritional content of food items by employing elevated temperatures and brief cooking periods. The extrusion process was conducted with a twin-screw extruder, employing optimized parameters such as a temperature of 100 ºC, a die diameter of 2 mm, a screw speed of 26 Hz, cutter speed of 30 rpm, and feeder speed of 13 Hz. A panel of judges assessed the organoleptic qualities of the extruded samples on a 9-point hedonic scale. The outcomes highlighted that Formulation A3 (comprising ratios of 50:10:10:30) proved effective in producing high-quality extrudates with satisfactory sensory attributes.

Keywords: Sorghum, pearl millet, extrusion cooking, extrudates and extrusion

Introduction

Extrusion cooking is an innovative method that enhances the nutritional value of food products through high temperatures and short cooking durations. It involves introducing moist grains into an extruder, where the necessary temperature and pressure are attained without the use of external heat, generated instead through shear and friction. Globally, it's used for various products like expanded snacks, modified starches, cereals, baby foods, pasta, puff products, and pet foods (Deshpande and Poshadri, 2011) [8]. The technology offers versatility, cost-effectiveness, improved product's quality, and does not produce process effluents (Camire *et al.*, 1990) [5]. Cereals, favored for their functional properties and affordability, are traditionally used in extrusion for snacks. Millets, with their high protein content, show promise in enhancing the nutritional profile of extruded cereals snacks.

Pearl millet (*Pennisetum typhoides*), grown in semi-arid regions of Africa and Asia, is a significant source of energy and protein, with protein content ranging from 12.25% to 13.09% and fat content from 4.32% to 5.11% in different varieties (Abdalla *et al.*, 2009) [1]. Its sugar content includes total sugars (2.55% to 2.93%), reducing sugars (0.34% to 0.39%), and non-reducing sugars (2.15% to 2.57%) (Rekha *et al.*, 1997, and Poonam, 2002) [14, 12]. Abdalla *et al.*, (2009) [1] reported 4.31% to 5.30% crude fiber, 1.53% to 2.00% ash, and various minerals in their analysis, highlighting pearl millet's nutritional richness. This profile emphasizes its crucial role in supplying necessary nutrients for human health and overall well-being.

Sorghum (*Sorghum bicolor L. Moench*), commonly referred to as *jowar*, is acclaimed as the "king of millets" and holds the fifth position globally among major crops (Anglani, 1998; Awika and Rooney, 2004) [3, 4]. It's a crucial ingredient in various industrial products like pasta, vermicelli, semolina, malted foods, beverages, and beer (Dayakar and Singh, 2010) [7]. Dharmar *et al.*, (2021) analyzed sorghum grain's nutritional composition per 100g, revealing moisture (11.08g), protein (10.27g), crude fat (3.26g), ash (1.12g), carbohydrate (72.91g), crude fiber (1.65g), and energy (359.19 kcal). The mineral content per 100g includes calcium (21.40 mg), phosphorus (210.03 mg), iron (4.14 mg), and zinc (1.65 mg).

Millet possesses a starch composition characterized by a 25:75 ratio of amylose to amylopectin, and it serves as a notable lipid source, with lipid content ranging from 3-6%, featuring approximately 50% polyunsaturated fatty acids (Sridhar and Lakshminarayana, 1994) [15]. Despite amylase inhibitors, millet's carbohydrate digestibility remains unaffected due to the heat-labile nature of these inhibitors (Chandrasekher *et al.*, 1981) [6]. Although well-documented for its nutritional qualities (Hulse *et al.*, 1980) [10], millet consumption is mostly limited to traditional tribal populations due to the lack of convenient, ready-to-use products. Recently, there's a growing interest in millets, driven by their high fiber content, leading to efforts to make them more accessible in convenient forms for broader consumer adoption.

2. Materials and Methods

A. Locale of the study: This study was conducted in the Department of Food and Nutrition, College of Community Science, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan.

B. Raw material: The grains (pearl millet, sorghum, rice, and corn) and other materials for the research were obtained in bulk from the local market of Bikaner to ensure consistency. These materials were preprocessed (cleaning and washing), involving multiple washes with tap water to remove impurities. Subsequently, they were dried on a polythene sheet in the shade at room temperature for 2–3 days until they became brittle. The dried grains were then processed into grit using a domestic grain pulverizer. This methodology follows the procedure outlined by Agrahari and Dunkwal (2012) [2].

C. Formulation preparation: Three formulations (A1, A2, A3) were made using different proportions of sorghum, pearl millet, corn, and rice. A1 had 40% sorghum and 20% each of pearl millet, corn, and rice. A2 had 25% of each grain. A3 had 50% pearl millet, 30% rice, and 10% each of sorghum and corn. All formulations included 0.25 g of both oil and water.

Table 1: Samples employed in the creation of extruded products.

Ingredients	Formulation		
	A1	A2	A3
Pearl millet (g)	20	25	50
Sorghum (g)	40	25	10
Corn (g)	20	25	10
Rice (g)	20	25	30
Oil (ml)	0.25	0.25	0.25
Water (ml)	0.25	0.25	0.25

D. Extrusion cooking: Ready-to-eat (RTE) extruded products were produced through hot extrusion technology, utilizing a laboratory model twin screw extruder and various millet ratios. The extrusion parameters were established with the aim of attaining optimal product expansion stability and ensuring the extruder's overall stability (Deshpande and poshadri, 2011) [8]. Temperature settings for the two barrel zones of the extruder, measured from. the feeder end, were established at 90 °C and 140 °C. Samples were collected at the die's most stable temperature, which was approximately 100 °C. The screw speed was established at 26 Hz, and a 2-mm restriction die was employed during extrusion. Three replicate samples were extruded and subsequently dried. After drying, the samples were blended with spices and edible oil.

E. Organoleptic evaluation: A sensory assessment was conducted in the food laboratory through scorecard evaluation, employing a threshold test for the selection of panel members as per Potter (1987) [13]. The inclusion of panel members was based on considerations of convenience, experience, knowledge, willingness, interest, and sincerity. Consequently, a panel of ten members was formed, consisting of staff members from the College of Community Science, SKRAU, Bikaner. To maintain objectivity, samples were randomly coded, and their presentation order was counterbalanced. Panelists were given water to rinse and swallow between testing each sample. The evaluation by panelists encompassed sensory characteristics such as color, appearance, aroma, texture, taste, and overall acceptability, utilizing a nine-point hedonic scale (ranging from 1 = dislike extremely to 9 = like extremely; Swaminathan, 1987) [16].

F. Statistical Analysis: The investigations were carried out through three separate trials, and the results are conveyed as the mean value ± standard deviation (SD).

3. Results and Discussion

A sensory evaluation was carried out with a panel comprising ten staff members from the College of Community Science at Swami Keshwanand Rajasthan Agricultural University, Bikaner. The panelists were provided with extruded snack food samples to assess various organoleptic characteristics, including appearance, color, taste, aroma, texture, and overall acceptability. The samples were served to the judges on the day of preparation, and the recorded average scores were taken into consideration. The mean scores from the sensory evaluation indicated that all the prepared extruded products fell within the acceptable range. Notably, the extruded product derived from formulation A3 exhibited superior ratings in appearance (8.30±0.48), color (8.50±0.53), aroma (8.20±0.42), texture (8.20±0.42), taste (8.10±0.74), and overall acceptability (8.30±0.48). Similarly, Kaur *et al.*, (2020) [11] conducted an assessment of the organoleptic characteristics of extrudates by using a 9-point hedonic scale by following parameters such as color, texture, aroma, taste, appearance, and overall acceptability. Extrudates (SM1, SM2, and SM3) were produced from varying proportions of sorghum, maize, and rice. The average scores from sensory evaluations indicated that all extruded products (SM1, SM2, and SM3) made from composite flours fell within the acceptable range. Based on the overall acceptability scores (7.5 for SM1, 7.5 for SM2, and 8.3 for SM3), it was evident that blends with SM3 were well-received by the panel members.

Table 2: Average sensory score values for the extruded snack

Sample	Organoleptic Characteristics					
	Colour	Aroma	Taste	Texture	Appearance	Overall acceptability
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
A1	8.10±0.73	6.60±0.52	6.90±0.32	7.50±0.53	7.50±0.53	7.10±0.31
A2	8.20±0.78	7.70±0.48	7.30±0.48	7.60±0.51	7.70±0.48	7.60±0.52
A3	8.50±0.53	8.20±0.42	8.10±0.74	8.20±0.42	8.30±0.48	8.30±0.48

4. Conclusion

The findings indicated that, among all the samples, the A3 sample demonstrated higher acceptability compared to A1 and A2. The inclusion of corn and rice was observed to enhance the quality of the extruded product. Hence, it can be deduced that the extrusion process proves to be a proficient approach in crafting ready-to-eat food items incorporating millets, providing a combination of nutritional benefits and functional attributes.

5. References

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