



REVIEWER'S REPORT

Manuscript No.: IJAR-57374

Title: Optimization of twin-screw extruder operating parameters for millet-based ready-to-eat products and a comparative nutritional study.

Recommendation:

Accept as it is

Rating	Excel.	Good	Fair	Poor
Originality		√		
Techn. Quality		√		
Clarity			√	
Significance		√		

Reviewer's ID: JPR-006

Detailed Reviewer's Report

1. Abstract of the Study

This study focused on the development of pearl millet-based ready-to-eat (RTE) extruded food products. The primary objective was to optimize twin-screw extruder operating parameters for the production of nutritionally rich and consumer-acceptable products. Different pearl millet and maize formulations were tested under varying extrusion conditions. Physical, sensory, and nutritional properties of the developed products were evaluated. The results were compared with traditional millet-based foods. Findings revealed that appropriate extrusion technology can successfully produce high-quality, nutritious millet-based RTE foods. This research bridges the gap between traditional nutrition and modern convenience foods.

2. Objectives of the Research

The study had two major objectives. First, it aimed to optimize extrusion parameters such as barrel temperature and screw speed for pearl millet-based product development. Second, it compared the nutritional composition of processed RTE millet foods with traditional millet foods. The research also intended to assess consumer acceptability of these products. This comprehensive approach ensured evaluation of both technological efficiency and nutritional competitiveness. The outcomes support future millet product commercialization.

3. Nutritional Importance of Pearl Millet

Pearl millet is a traditional cereal grain rich in dietary fiber, calcium, iron, essential amino acids, and antioxidants. It is considered highly beneficial for health due to its gluten-free nature and

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mineral content. Pearl millet consumption can help address malnutrition, diabetes, and lifestyle-related diseases. The study utilized its nutritional strengths to develop value-added food products. Modern processing technologies like extrusion can enhance millet's commercial appeal while retaining nutritional quality.

4. Growing Demand for Ready-to-Eat Foods

Rapid urbanization, busy lifestyles, and changing consumer habits have significantly increased the demand for convenient RTE food products. Consumers increasingly seek foods that combine convenience with nutrition. Traditionally, processed foods were often viewed as nutritionally inferior. However, advanced food technologies such as extrusion have improved this perception. Millet-based RTE products offer a healthy alternative to conventional processed snacks. This growing market creates opportunities for millet-based innovations.

5. Raw Materials and Product Formulation

Three pearl millet-maize blends were developed for the study: BC1 (50:50), BC2 (60:40), and BC3 (70:30). Moisture content was standardized at 18% for all samples. These formulations were selected to determine the most suitable balance between nutritional quality and product acceptability. Varying millet proportions influenced expansion ratio, taste, and texture. Among all formulations, BC1 demonstrated the best overall performance. It provided an ideal balance between sensory quality and nutritional value.

6. Twin-Screw Extrusion Technology

Twin-screw extrusion is an advanced food processing method involving high temperature and short processing time. It improves texture, digestibility, and product stability. In this study, extrusion was performed at barrel temperatures of 100°C, 110°C, and 120°C, with screw speeds of 350, 400, and 450 rpm. A factorial design was used to analyze all combinations. This process significantly influenced product quality characteristics such as expansion, density, and sensory attributes.

7. Physical Property Analysis

The physical quality of the extruded products was assessed through expansion ratio, water absorption index (WAI), water solubility index (WSI), true density, and bulk density. These parameters are essential indicators of product quality and consumer appeal. Higher expansion ratio indicates improved crispness and texture. Density affects mouthfeel and product appearance. WAI and WSI provide insight into starch behavior during extrusion. These analyses helped identify optimal processing conditions.

REVIEWER'S REPORT***8. Significance of Expansion Ratio***

Expansion ratio is a critical quality parameter for extruded snack products. A higher expansion ratio generally indicates better texture, crispness, and consumer preference. In this study, the maximum expansion ratio (3.949) was achieved at 100°C barrel temperature and 450 rpm screw speed. This suggests that lower temperature combined with higher screw speed is optimal for product expansion. Such conditions improve product quality and marketability.

9. Water Absorption Index (WAI)

WAI measures the water-holding capacity of extruded products and reflects starch gelatinization. The observed WAI ranged from 5.420 to 9.445. Lower WAI values were associated with improved product structure and desirable air cell formation. This contributes to better texture and product acceptability. WAI is a crucial parameter for assessing extruded food quality and shelf stability.

10. Water Solubility Index (WSI)

WSI indicates the amount of soluble materials released from the product during processing. It reflects the degree of starch degradation and extrusion intensity. Balanced WSI values are essential for maintaining product structure and texture. Excessively high WSI may negatively impact product quality. The study showed that extrusion parameters significantly affected WSI values.

11. Sensory Evaluation Process

Sensory characteristics including color, texture, flavor, taste, crispness, and overall acceptability were evaluated. Sensory analysis is essential in determining consumer preference. Among the tested samples, BC1 achieved the highest acceptability scores. Its sensory performance was comparable to commercial control products. This demonstrates that pearl millet-based products can be successfully developed without compromising consumer satisfaction.

12. Selection of the Best Formulation

The 50:50 pearl millet-maize blend (BC1) was selected as the optimal formulation. It provided balanced flavor, reduced bitterness, and superior texture. Sensory scores for BC1 were closest to the control sample. This formulation offered the best compromise between millet nutrition and product palatability. Therefore, BC1 was chosen for further optimization studies.

13. Nutritional Comparison with Traditional Foods

Traditional millet foods such as ragi mudde and ragi roti were compared with commercial RTE millet products. This comparison was important for understanding the nutritional effects of modern processing. Traditional foods retained certain nutritional advantages, while RTE

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products excelled in other nutrients. Such comparisons help consumers make informed dietary choices.

14. Iron Content Comparison

Ragi roti showed the highest iron content among all tested products. Commercial RTE millet cereal had moderate iron levels, while ragi mudde had the lowest. These findings indicate that traditional preparation methods may preserve iron better than some processed alternatives. Future RTE products could be fortified with iron to enhance nutritional balance.

15. Calcium and Protein Comparison

Commercial RTE millet products exhibited the highest calcium and protein levels. This may be due to fortification and optimized formulation. Compared to traditional foods, RTE products offered improved protein density and calcium content. This makes them attractive for children, young adults, and health-conscious consumers.

16. Fat and Carbohydrate Levels

RTE millet products contained higher fat and carbohydrate levels than traditional foods. This provides greater energy density and convenience. However, higher fat content should be considered in balanced diet planning. Traditional foods generally offered lower fat levels, which may benefit specific consumer groups.

17. Consumer Perception Study

A survey involving 384 participants was conducted to understand consumer perceptions regarding millet foods. Participants included students and faculty members aged 18–50 years. Taste tests and questionnaires were used for evaluation. Consumers valued convenience, taste, and nutritional quality. RTE millet products received favorable responses, indicating strong market potential.

18. Statistical Analysis

Statistical tools such as ANOVA and T-tests were used to validate the experimental data. SPSS software was utilized for data analysis. These analyses confirmed the significance of processing parameters and product differences. Statistical validation strengthened the reliability of research conclusions.

19. Market Potential in India

India's health food sector is rapidly expanding due to increasing consumer awareness. Millet-based RTE and RTC products are gaining popularity among health-conscious urban populations. Rising incomes, lifestyle changes, and demand for functional foods contribute to this growth. The study highlights significant commercialization opportunities for millet-based food industries.

REVIEWER'S REPORT***20. Major Findings of the Study***

The optimal extrusion conditions were 100°C barrel temperature and 450 rpm screw speed. BC1 (50:50 pearl millet-maize) was identified as the best formulation. Developed RTE products demonstrated strong sensory and nutritional competitiveness. Traditional foods maintained superiority in certain nutrients such as iron. Overall, extrusion proved effective for producing high-quality millet snacks.

21. Future Research Opportunities

Future research can focus on fortifying millet-based RTE products with iron and micronutrients. Additional studies may explore alternative grain combinations and health-specific formulations. Product diversification can expand millet's role in modern diets. Such innovations could further strengthen the millet processing industry.

22. Conclusion

This study demonstrates that twin-screw extrusion technology can successfully develop high-quality pearl millet-based RTE food products. Appropriate operating parameters significantly improve physical, sensory, and nutritional quality. These products satisfy modern consumer demands for convenience and health. Traditional millet foods still retain certain nutritional advantages, especially in iron content. Therefore, both traditional and modern millet products can play important roles in balanced nutrition and sustainable food systems.