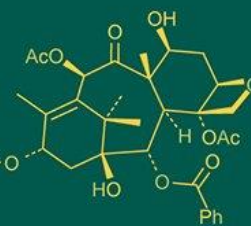
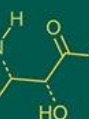
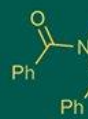


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Moisture stability of mango-enriched vermicelli prepared from wheat and sorghum flour

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Abstract

The increasing demand for functional and value-added food products has promoted the utilization of fruit-based ingredients and alternative cereal flours in traditional convenience foods. Mango pulp, despite its rich nutritional and phytochemical profile, has limited application in shelf-stable extruded products such as vermicelli. Moreover, information regarding the combined influence of flour composition, mango pulp incorporation, and storage on the moisture stability of mango-based vermicelli remains limited. Therefore, the present investigation was undertaken to develop mango-enriched vermicelli using wheat and sorghum flour blends and to evaluate the effect of different treatment combinations on moisture content during storage. Vermicelli was prepared using five flour blend combinations comprising wheat flour and sorghum flour [F1 (100:0), F2 (75:25), F3 (50:50), F4 (25:75), and F5 (0:100)] along with three levels of mango pulp incorporation [P1 (25%), P2 (30%), and P3 (35%)]. The products were stored under ambient conditions and analyzed at 0, 2, 4, and 6 months of storage. The experiment was conducted in a factorial Completely Randomized Design (CRD) with three replications. Moisture content ranged from 7.02 to 8.45% across treatments and storage intervals. Flour blend composition and mango pulp concentration significantly influenced moisture content, whereas storage duration showed a non-significant effect. The study demonstrated the potential of sorghum-based mango vermicelli as a nutritious and shelf-stable value-added product.

Keywords: Mango vermicelli, sorghum flour, mango pulp, moisture stability, value-added product

1. Introduction

Vermicelli is a widely consumed traditional cereal-based product known for its convenience, versatility, and ease of preparation. It is commonly prepared from wheat flour and is extensively used in several Asian and Middle Eastern countries as a staple or ready-to-cook food product (Yadav *et al.*, 2014) [12]. In recent years, increasing consumer preference for healthier and functional foods has encouraged the development of nutritionally enriched vermicelli through the incorporation of fruit ingredients and alternative cereal flours. Such modifications not only improve the nutritional profile of the product but also create opportunities for utilization of underexploited agricultural resources and value addition in food processing industries (Shaikh and Yadav, 2018) [10].

Mango (*Mangifera indica* L.) is one of the most important tropical fruits owing to its attractive flavour, rich nutrient composition, and abundance of bioactive compounds. It is a good source of carotenoids, vitamin C, dietary fibre, phenolic compounds, and natural antioxidants that contribute to several health-promoting properties (Masibo and He, 2008) [8]. Despite its nutritional importance and large-scale production, mango is highly perishable and prone to considerable post-harvest losses during peak harvesting seasons. Conversion of mango pulp into shelf-stable products can therefore serve as an effective approach for reducing post-harvest wastage while simultaneously enhancing the nutritional quality of processed foods.

Sorghum flour has gained attention as an alternative cereal ingredient because of its nutritional value, higher dietary fibre content, and suitability for development of functional food products. Incorporation of sorghum flour into vermicelli formulations may also influence the physicochemical and storage characteristics of the product, particularly moisture retention behaviour. Moisture content is considered a critical quality parameter in dried food products, as excessive moisture can accelerate microbial growth, enzymatic

activity, and textural deterioration, thereby affecting product safety and shelf life (Labuza and Altunakar, 2007) [7]. The moisture stability of vermicelli is largely dependent on flour composition, ingredient interactions, packaging conditions, and storage duration.

Although several studies have reported the development of cereal and fruit-based pasta products, information regarding the combined effect of wheat-sorghum flour blends and mango pulp incorporation on the moisture stability of vermicelli during storage is still limited. Therefore, the present investigation was undertaken to develop mango-based vermicelli using different wheat flour and sorghum flour combinations and to evaluate the influence of mango pulp incorporation and storage duration on its moisture content under ambient storage conditions.

2. Materials and Methods

2.1 Raw Materials

Refined wheat flour (maida) and sorghum flour were procured from a local commercial supplier. Fully ripe Kesar mango fruits were obtained from the local market during the peak harvesting season. The fruits were washed thoroughly with potable water, peeled manually, and the stones were removed. The pulp was extracted using a stainless-steel blender and filtered through a fine-mesh sieve to obtain a uniform consistency. The prepared pulp was stored at -18°C until further use. Food-grade salt and potable water were used during product preparation.

2.2 Experimental Design and Treatment Details

The experiment was conducted using a three-factor factorial Completely Randomized Design (CRD) with three replications. The treatments consisted of five flour blend combinations of wheat flour (W) and sorghum flour (S), namely F1 (100:0), F2 (75:25), F3 (50:50), F4 (25:75), and F5 (0:100). Mango pulp was incorporated at three levels: P1 (25%), P2 (30%), and P3 (35%) on flour weight basis. The prepared vermicelli samples were evaluated at four storage intervals, viz., S1 (0 month), S2 (2 months), S3 (4 months), and S4 (6 months).

2.3 Moisture Content Determination

Moisture content of vermicelli samples was determined by the standard hot-air oven method as described by AOAC (2000). Approximately 5 g of finely powdered sample was weighed into a pre-weighed moisture dish and dried in a hot-air oven at $105\pm 2^{\circ}\text{C}$ until constant weight was obtained. Moisture content was calculated on a wet weight basis using the following formula:

$$\text{Moisture (\%)} = \frac{\text{Fresh wt. of sample (g)} - \text{Dry wt. of sample (g)}}{\text{Fresh wt. of sample (g)}} \times 100$$

All analyses were carried out in triplicate.

2.4 Statistical Analysis

The experimental data were analyzed using analysis of variance (ANOVA) appropriate for factorial CRD. The significance of treatment effects and their interactions was tested at 5% probability level using the F-test. Critical difference (CD) values were calculated for significant effects, while non-significant differences were denoted as NS. The coefficient of variation (CV%) was also computed to assess the reliability and precision of the experimental data.

3. Results and Discussion

3.1 Moisture Content of Mango-Based Vermicelli During Storage

The moisture content of mango-based vermicelli was significantly influenced by flour blend composition and mango pulp incorporation, whereas storage duration did not show a significant effect on moisture changes during the six-month storage period. The moisture content of different treatment combinations ranged from 7.02 to 8.45% (Table 1).

Among the flour blend treatments, vermicelli prepared with 100% wheat flour (F1) recorded the highest mean moisture content (7.89%), while the lowest value was observed in vermicelli prepared with 100% sorghum flour (F5) (7.38%). A gradual reduction in moisture content was observed with increasing levels of sorghum flour incorporation. This may be attributed to the comparatively lower water absorption and moisture retention capacity of sorghum flour than refined wheat flour. Similar findings were reported by Aravind *et al.* (2012) [2] in sorghum-based pasta products.

Mango pulp concentration also showed a significant influence on moisture content. The mean moisture content increased from 7.26% in P1 (25% pulp) to 7.97% in P3 (35% pulp). The increase in moisture content with higher pulp incorporation could be due to the naturally high moisture content and hygroscopic sugars present in mango pulp, which tend to retain water within the product matrix during storage.

Storage duration showed a slight increase in moisture content from 7.51% at initial storage to 7.70% after six months; however, the variation was statistically non-significant. This indicates that the packaging material effectively minimized moisture absorption during storage under ambient conditions.

The interaction effect between flour blend and mango pulp concentration ($F \times P$) was found to be significant. The highest moisture content (8.35%) was recorded in F1P3, while the lowest value (7.10%) was observed in F5P1. Higher-order interactions involving storage period were non-significant, indicating relatively stable moisture behaviour of the product throughout storage.

Table 1: Effect of different treatment combinations on the moisture percent of mango based vermicelli during storage

Storage (S)	Flour mixture (F:w% + S%)	Moisture Content (%)						
		Mango pulp concentration (P)						
		P1-25%	P2-30%	P3-35%	Mean (F×S)	Grand Mean (F)		
S1: Initial	F1-(100:00)	7.35	7.79	8.26	7.80	7.89		
	F2-(75:25)	7.27	7.59	7.94	7.60	7.69		
	F3-(50:50)	7.15	7.43	7.81	7.46	7.56		
	F4-(25:75)	7.11	7.38	7.75	7.41	7.49		
	F5-(00:100)	7.02	7.26	7.59	7.29	7.38		
	Mean (P×S1)	7.18	7.49	7.87	7.51			
S2: 2 month	F1-(100:00)	7.41	7.83	8.32	7.85			
	F2-(75:25)	7.32	7.65	8.01	7.66			
	F3-(50:50)	7.19	7.49	7.89	7.52			
	F4-(25:75)	7.15	7.42	7.81	7.46			
	F5-(00:100)	7.06	7.31	7.65	7.34			
	Mean (P×S2)	7.23	7.54	7.94	7.57			
S3: 4 month	F1-(100:00)	7.46	7.89	8.37	7.91			
	F2-(75:25)	7.38	7.71	8.06	7.72			
	F3-(50:50)	7.25	7.54	7.95	7.58			
	F4-(25:75)	7.20	7.47	7.87	7.51			
	F5-(00:100)	7.12	7.37	7.71	7.40			
	Mean (P×S3)	7.28	7.60	7.99	7.62			
S4: 6 month	F1-(100:00)	7.54	7.97	8.45	7.99			
	F2-(75:25)	7.47	7.79	8.14	7.80			
	F3-(50:50)	7.32	7.63	8.02	7.66			
	F4-(25:75)	7.29	7.55	7.94	7.59			
	F5-(00:100)	7.20	7.45	7.79	7.48			
	Mean (P×S4)	7.36	7.68	8.07	7.70			
Grand Mean (P)		7.26	7.58	7.97				
F×P	F1-(100:00)	7.44	7.87	8.35				
	F2-(75:25)	7.36	7.69	8.04				
	F3-(50:50)	7.23	7.52	7.92				
	F4-(25:75)	7.19	7.46	7.84				
	F5-(00:100)	7.10	7.35	7.69				
S. Em.±	F	P	F×P	S	F×S	P× S	F×P× S	
CD at 5%	0.024	0.018	0.041	0.021	0.047	0.037	0.082	
	0.066	0.051	0.114	NS	NS	NS	NS	
CV (%)	1.86							

4. Conclusion

The present investigation revealed that flour blend composition and mango pulp incorporation significantly influenced the moisture content of mango-based vermicelli, whereas storage duration up to six months under ambient conditions had no significant effect on product moisture stability. An increase in sorghum flour proportion resulted in reduced moisture retention, while higher mango pulp incorporation increased moisture content due to the presence of hygroscopic sugars and soluble solids in the pulp. Among the treatment combinations, vermicelli prepared with 100% sorghum flour and 25% mango pulp incorporation exhibited the lowest moisture content and better storage stability. The findings indicate that sorghum flour can be effectively utilized in the preparation of mango-enriched vermicelli to develop a nutritious and shelf-stable value-added product. The study also highlights the potential of utilizing mango pulp in convenience food formulations as an approach for value addition and reduction of post-harvest losses. Further studies on sensory quality, texture, microbial safety, and consumer acceptability may provide additional scope for commercialization of the product.

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