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Research Article

Nutritional and Microbial Quality of Mango-based Cereal Flakes Stored at Different Temperatures

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Abstract*:* Malnutrition in young children is a serious problem in Pakistan. In a recently carried out nutritional survey in the country, more than 44% of children, under five years, have been observed to be stunted and underweight. Because of their palatable taste and convenience of intake, snacks are a popular food item amongst children, but such food products may lack essential nutritional and hygiene quality. In order to address child malnutrition by catering nutritious and hygienic food, an instant food product was developed using cereals (i.e. wheat, suji, corn and rice) and mango pulp, blended in various proportions, to form cereal flakes for preparing a likable snack for children consumption. The ingredients (i.e., cereal paste, mango pulp, salt and ghee) were mixed, cooked and passed through a homogenizer to obtain a uniform mix. The mixture was cooked on a drum dryer (at steam pressure of 60 lb./sq. inch) to obtain long thin sheets, which were later broken manually into small pieces. The pieces were dried at 50 °C for an hour in a dehydrator to reduce their moisture content to about 2 percent and then were packed in high density polyethylene zipper bags. The rice-mango flakes were found to be highly acceptable for sensory attributes. They were stored for 180 days at two different temperatures, i.e., 25 °C and 37 °C, in a controlled temperature cabinet and the changes in nutritional and microbiological attributes were monitored at 30-day intervals. It was observed that moisture, protein, crude fat and carotene content in the flakes decreased significantly with increase in storage period (P<0.05) while total plate count remained within the permissible range at both temperatures till 150 days of storage. However, significant changes in total plate count were observed beyond 150 days. Total coliform, yeast and mold content could not be detected till 180 days of storage time at both temperatures. Thus, the mango-based cereal flakes remained nutritionally and microbiologically acceptable up to 150 days of storage both at 25 °C and 37 °C.

Keywords: Mango cereal flakes, nutritional and microbial quality, drum dryer, storage temperature

1. INTRODUCTION

Malnutrition is a global issue and dietary surveys have revealed that the masses in developing countries like Pakistan are under fed, primarily because of poor quality and quantity of their food. In a recent nutritional survey carried out in Pakistan, it has been reported that more than 44% of the children of school going age are stunted, underweight and malnourished.

Mango is a major fruit produced in Pakistan. It is one of the few fruits which can be utilized at all stages of its maturity. This fruit is used as a dessert, as a table fruit between meals and also is processed for preparing a lot of food products. Mango is not only quite nutritious but also is a popular fruit in Pakistan due to its excellent flavor, attractive aroma and therapeutic value. It is also utilized for processing into various types of food products, but only a very small fraction of mangoes produced in the world, i.e., 0.22% of the total produce, are utilized for food processing [1].

Cereals are staple foods in most countries of the world, including Pakistan, but contain inadequate content in certain minerals and vitamins to fulfill human nutrition needs. However, mangoes are an economical source of vitamins and minerals essential for human nutrition. For instance, mango fruit contains on an average of 4800 IU of vitamin

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A and 40 mg of vitamin C per 100 g edible portion [2, 3]. Therefore, the need for preparing a nutritious food product to address malnutrition in school going children cannot be over emphasized. The blend of cereals with mango fruit can ensure highly nutritious diet, which can also have a great market potential due to its peculiar taste. Snacks like *Slanties* and *Kurkury's* are very popular among children of school going age. Cereal flakes having fruit base, like mango, can be used as nutritional alternative for preparing commercial snacks. Many studies have been reported on preparation and storage of fruit-based cereal flakes [4, 5, 6]. These flakes will possess a pleasant mango flavor and can be used with milk as a breakfast food, like corn flakes; the mango-based cereal flakes being sweet and crisp, will be highly suitable as a baby food as well. They can also be used in ice cream as a thickener and flavoring material. Hence, in consideration of the above mentioned aspects, an instant snack food recipe was developed containing 50% cereals and 20% mango pulp in the product mix. This food product could supply the consumer with a large fraction of daily requirements of vitamins, minerals and protein. The main objectives of this study were to prepare tasty and nutritious cereal flakes having natural mango flavor and to explore its shelf life at 25 °C and 37 °C.

2. MATERIALS AND METHODS

Mango pulp for these experiments was procured from the Noor Industries, Faisalabad. Cereals, fractions and other ingredients and additives were procured from the local market in Islamabad, Pakistan.

2.1 Product Recipe

At first step, calcium carbonate and sodium bicarbonate were added in the mango pulp to adjust its pH to 5.0. Cereal pastes were prepared by cooking cereal source (wheat flour/ *suji*/ com starch / rice) with water (three times weight of cereal source) at temperature of 75-80 °C. Cereal pastes obtained from four different sources were added in the mango pulp according to recipe Table 1. The pulp-cereal mixture was continuously heated at temperature of 75-80°C for half an hour. Sugar and other ingredients (salt, *ghee*) were then mixed with cooked mass. The mixture was passed through homogenizer to get a uniform mix. The mix was formed into dough. The dough was cooked on double drum drier at steam pressure of 60 Ib./sq. inch. Long thin sheets thus obtained were broken manually into small pieces using a specific mold. The pieces were dried at 50°C for about 45 min in a dehydrator in order to reduce the moisture content to about 2 percent and then packed in high density polyethylene (HDPE) zipper bags**.**

2.2 Analytical Work and Shelf Life Studies

Mango cereal flakes which were ranked highest in organoleptic evaluation were further subjected to shelf life studies. The flakes were packed in polyethylene bags, sealed and kept at two different temperatures 25 °C and 37 °C in a controlled temperature cabinet for 180 days. Two samples from each lot were examined at monthly intervals for moisture, crude fiber, protein, crude fat, β-carotene and ash according to the respective methods described in AOAC [7]. Iron was determined by atomic absorption spectroscopy (using Varian, Model 220 FS, Australia).

2.3 Sensory Evaluation

The product was periodically evaluated by a panel of ten trained judges for color, taste, flavor, texture

Table 1. Recipes of the developed cereal flakes.

Ingredient (%)	Type of Cereal Flakes			
	Mango-Wheat (*Maida*)	Mango-Corn Starch	Mango-*Suji*	Mango-Rice
Mango pulp	20	20	20	20
Pre-cooked cereal paste	50	50	50	50
Sugar	20	20	20	20
Salt	1	1	1	1
Ghee	9	9	9	9

and overall acceptability on 9- point hedonic scale according to Larmond [8].

2.4 Bacteriological Status

The product was examined microbiologically for total viable bacterial count, total coliform, yeast and mold. Total plate count was determined by using plate count agar, yeast and mold was carried out in potato dextrose agar and coliform on Lauryl Tryptose Broth [9].

2.5 Statistical Analysis

Completely randomized design was used for data analysis and means were compared by Duncan Multiple Range Test for significance as described by Steel et al. [10] using Statisca Software version 8.1. Standard deviation was used to evaluate the dispersion from the mean.

3. RESULTS AND DISCUSSION

Mango pulp and cereal sources (rice, wheat corn starch, Semolina) were analyzed for proximate composition, iron and carotene contents. The results are presented in Table 2. Mango pulp was mixed with different cereals i.e. wheat flour (*maida*), *suji*, com starch, and rice. All the four products of mango cereal flakes, i.e., mango *maida* flakes, mango *suji* flakes, mango corn starch flakes and mango rice flakes were organoleptically evaluated by the panel of ten judges and mean score of these judges for color, flavor, taste, texture and overall acceptability were recorded. The data is presented in Table 3. It shows that sample D (mango with rice) was liked by most of the judges and got total score of 40.45 with overall mean of 8.09. The samples A, B and C were equally liked by judges, however, Mango rice flakes was considered best among all the products. The flakes prepared from mango pulp and rice were packed in HDPE Zippered bag. These samples were kept at two different temperatures of 25 °C and 37 °C for 180 days to assess effect of temperatures on the quality and shelf life of mango rice flakes. Proximate analysis of mango rice flakes are presented in Table 2. Storage stability of mango rice flakes packed in HDPE zippered bag was evaluated periodically for nutritional and microbial

Table 2. Nutritional composition of mango pulp and rice (means of three replications, with standard deviation).

	Proximate Composition	Mango pulp	Rice	*Suji (Semolina)*	*Maida (Patent Flour)*	Corn Starch
1	Moisture (%)	83.50± 0.23	12.00± 0.06	11.23 ± 0.04	13.56± 0.06	10.78± 0.03
2	Ash (%)	0.50± 0.03	1.19± 0.05	0.23 ± 0.02	0.45± 0.01	0.23± 0.025
3	Protein (%)	0.50± 0.02	7.50±0.03	6.56 ± 0.04	10.78± 0.02	7.4± 0.027
4	Crude fiber (%)	0.32± 0.03	0.61±0.02	0.76± 0.03	1.24± 0.04	0.8± 0.024
4	Crude fat (%)	0.10±0.01	0.82± 0.03	0.54± 0.01	1.18± 0.07	0.56± 0.03
5	Total carbohydrates (%)	15.08± 0.05	77.88± 0.10	80.68 ± 0.09	72.79± 0.06	80.23± 0.08
	Other Parameters:					
1	β-Carotene (mg/100g)	5.50± 0.03	-	-	-	-
2	Iron (mg/100g)	4.10±0.04	3.10± 0.02	1.00± 0.035	1.30± 0.04	0.70± 0.003

Table 3. Organoleptic evaluation of freshly prepared flakes from mango cereal (Mean score by 10 judges).

Type of Cereal Flakes	Appearance (9)	Texture (9)	Color (9)	Taste (9)	Flavor (9)	Total Score (45)
A. *Maida*	4.40 d*	4.00 d	4.75 d	5.00 d	6.00 c	24.15 d
B. Corn starch	5.50 c	4.60 c	5.15 c	5.30 c	6.90 b	27.45 c
C. *Suji* (Samolina)	5.60 b	6.00 b	5.39 b	5.75 b	6.95 b	29.69 b
D. Rice	7.80 a	7.80 a	7.90 a	8.55 a	8.40a	40.45 a

*Means within a column followed by the same letter have non-significant difference (P<0.05)

Table 4. Effect of storage time on proximate analysis and microbial status of mango rice flakes (means of three replications).

S. No.	Parameter	0 day		30 days		60 days		90 days		120 days		150 days		180 days	
		25°C	37°C	25°C	37°C	25°C	37°C	25°C	37°C	25°C	37°C	25°C	37°C	25°C	37°C
1	Moisture (%)	2.21 ±0.03	2.21 ±0.02	3.77 ±0.02	3.71 ±0.03	4.39 ±0.02	4.32 ±0.03	5.40 ±0.04	5.00 ±0.036	5.61 ±0.035	5.30 ±0.038	5.69 ±0.03	5.60 ±0.04	6.41 ±0.04	6.19 ±0.03
2	Protein (%)	8.00 ±0.032	8.00 ±0.033	8.00 ±0.031	7.90 ±0.028	7.92 ±0.034	7.78 ±0.032	7.50 ±0.029	7.00 ±0.035	7.62 ±0.03	7.00 ±0.029	7.20 ±0.025	6.87 ±0.038	6.81 ±0.024	6.39 ±0.031
3	Crude fat (%)	0.92 ±0.014	0.92 ±0.01	0.92 ±0.015	0.90 ±0.012	0.90 ±0.018	0.87 ±0.010	0.88 ±0.012	0.84 ±0.013	0.86 ±0.014	0.82 ±0.012	0.82 ±0.012	0.80 ±0.011	0.81 ±0.011	0.79 ±0.012
4	Carotene (mg/l00 g)	4.00 ±0.027	4.00 ±0.028	3.70 ±0.032	3.20 ±0.027	3.10 ±0.029	2.70 ±0.026	2.70 ±0.028	1.50 ±0.026	2.10 ±0.024	1.30 ±0.025	1.89 ±0.023	0.69 ±0.023	1.55 ±0.026	0.32 ±0.02
5	Overall acceptability (out of 9.00 as total score)	8.24 ±0.02	8.24 ±0.02	8.19 ±0.02	7.97 ±0.02	8.04 ±0.02	7.85 ±0.02	7.94 ±0.02	7.70 ±0.02	7.86 ±0.02	7.53 ±0.02	7.77 ±0.02	7.38 ±0.02	7.69 ±0.02	7.23 ±0.02
6	Total plate count (CFU/g)	Nil	Nil	Nil	5	9	15	18	20	25	30	55	65	95	130
7	Coliform bacteria	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
8	Yeast and mold	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Table 5. Effect of storage temperature on proximate analysis and microbial status of mango rice flakes (means of three replications).

S. No.	Parameter	25°C							37°C						
		0	30	60	90	120	150	180	0	30	60	90	120	150	180
1	Moisture (%)	2.21 ±0.03	3.77 ±0.02	4.39 ±0.02	5.40 ±0.04	5.61 ±0.035	5.69 ±0.03	6.41 ±0.04	2.21 ±0.02	3.71 ±0.03	4.32 ±0.03	5.00 ±0.036	5.30 ±0.038	5.60 ±0.04	6.19 ±0.03
2	Protein (%)	8.00 ±0.032	8.00 ±0.031	7.92 ±0.034	7.50 ±0.029	7.62 ±0.03	7.20 ±0.025	6.81 ±0.024	8.00 ±0.033	7.90 ±0.028	7.78 ±0.032	7.00 ±0.035	7.00 ±0.029	6.87 ±0.038	6.39 ±0.031
3	Crude fat (%)	0.92 ±0.014	0.92 ±0.015	0.90 ±0.018	0.88 ±0.012	0.86 ±0.014	0.82 ±0.012	0.81 ±0.011	0.92 ±0.01	0.90 ±0.012	0.87 ±0.010	0.84 ±0.013	0.82 ±0.012	0.80 ±0.011	0.79 ±0.012
4	Carotene (mg/l00g)	4.00 ±0.027	3.70 ±0.032	3.10 ±0.029	2.70 ±0.028	2.10 ±0.024	1.89 ±0.023	1.55 ±0.026	4.00 ±0.028	3.20 ±0.027	2.70 ±0.026	1.50 ±0.026	1.30 ±0.025	0.69 ±0.023	0.32 ±0.02
5	Overall acceptability (out of 9.00 as total score)	8.24 ±0.02	8.19 ±0.02	8.04 ±0.02	7.94 ±0.02	7.86 ±0.02	7.77 ±0.02	7.69 ±0.02	8.24 ±0.02	7.97 ±0.02	7.85 ±0.02	7.70 ±0.02	7.53 ±0.02	7.38 ±0.02	7.23 ±0.02
6	Total plate count (CFU/g)	Nil	Nil	9	18	25	55	95	Nil	5	15	20	30	65	130
7	Coliform bacteria	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
8	Yeast and mold	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

attributes at two different temperatures Results are presented at Table 4 and Table 5.

3.1 Moisture

At 0 day, moisture content of mango cereal flakes was 2.21% at 25 °C and 37 °C. The moisture content of mango rice flakes increased gradually during storage in both the samples; after 180 days it increased to 6.41% and 6.19%, respectively. This increase may be attributed to the absorption of water by the product from atmosphere during storage because of slight permeable nature of polyethylene film. The increase in moisture may also be the result of browning taken place during the storage. These results were in agreement with those of Girdhari et al. [11] and Muzanila et al. [12] on mango and cassava cereal flakes, respectively.

3.2 Crude Fat

The fat contents in samples kept at 25 °C remained unchanged, whereas in samples kept at 37 °C decreased from 0.92 to 0.79% till completion of the experiment. Decrease in fat content could be attributed to the decomposition of fat to fatty acid as a result of lipolysis process which can occur at higher temperature [13]. The fat can also be oxidized by oxygen and other pro-oxidants with proportionately higher rate at increased temperatures [14].

3.3 β-Carotene

It is apparent from the results that the carotene content decreased in both samples but the effect was more pronounced in sample that was kept at 37 °C. In fact carotenes are readily oxidized by various pro-oxidants. Its breakdown rate increases rapidly with increase in storage time and temperature. Carotene content was also affected by light. Due to such factors the amount of carotene decreased in both the samples but with higher rate in the sample stored at 37 °C [5].

3.4 Protein

Protein content stored at 25°C decreased from 8.0% to 6.81%. In sample stored at 37 °C, the amount of protein decreased from 8.0% to 6.39% (Table 4). Storage temperature and time period significantly affected the changes in nitrogenous components. These changes in protein content of mango cereal flakes could be attributed to reactivation of proteases during storage [15] and also could be due to processing method and chemical interaction [16].

3.5 Organoleptic Evaluation

The freshly prepared product had highest acceptability of all mentioned characters by scoring 8.24 points as overall acceptability. The acceptability score gradually reduced to 7.69 and 7.23 till the end of the storage period at 25 °C and 37 °C, respectively. Resulting products of Millard's reaction might be responsible for adverse changes in sensory qualities during extended storage [17].

3.6 Microbiological Studies

Microbiological examination of mango rice flakes for total plate count, coliform bacteria, yeast and mold have been carried out at for 150 days applying plate count agar, *Lauryl tryptose* broth and potato dextrose agar techniques. The results are presented in Table 4 and 5.

Total bacterial count in both the samples stored at 25 °C and 37 °C was increased from nil at zero day to 95 and 130 CFU/g, respectively. Coliform bacteria, yeast and mold could not be detected in mango rice flakes stored at both the temperatures. However, a greater change in total plate count is observed at 25 °C than at 37 °C. This might be due to favorable temperature offered to the micro-organism [18]. It further proved that processing was carried out under hygienic conditions. The increase of bacterial growth may be due to the mishandling during packing or the quality of packing material. Hence it is concluded that the product i.e. mango based cereal flakes packed in HDPE zippered bags remained acceptable till storage period of 150 days at 25 °C and 37 °C.

4. CONCLUSIONS

The study concluded that nutritious mango-based rice flakes packed in HDPE-zippered bags can be stored best for 150 days at 25°C, rather than at 37°C. Under these storage conditions, the product retains its nutritional and organoleptic quality and could be a nutritious and tasty snack for school age children.

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