International Journal of Processing and Post Harvest Technology

RESEARCH PAPER

Studies on development and storage of kodo millet based pasta

■ G. SUDHA DEVI*, V. PALANIMUTHU AND P. ARUN KUMAR

AICRP on Post Harvest Technology Scheme, University of Agricultural Sciences, G.K.V.K., BENGALURU (KARANATAKA) INDIA
(Email: sugang17@gmail.com)

*Author for Correspondence

Research chronicle : Received : 31.07.2013; **Revised :** 03.05.2014; **Accepted :** 13.05.2014

SUMMARY :

Minor millets are highly nutritious products and also most neglected food material in major parts of the world. Kodo millet is one among them which is very rich in carbohydrate and crude fibre. Hence, a research study was conducted to develop pasta from processed kodo millet blended with wheat flour and water under different combinations and also to determine effect of LDPE and PP packaging materials on sensory, physico-chemical and biochemical quality of millet based pasta during storage. The kodo millet based pasta prepared under variable proportions of millet and wheat flour attained maximum overall acceptance in the sensory panel and physico-chemical and biochemical tests concludes, rate of loss of most quality attributes was low in samples stored under LDPE as compared to samples in PP. The negligible quality change recommends the use of LDPE to achieve longer storage life of pasta under ambient condition.

KEY WORDS : Kodo millet, Extrusion, Pasta, Sensory, Quality, Packaging, Storage

How to cite this paper : Devi, Sudha G., Palanimuthu, V. and Kumar, Arun P. (2014). Studies on innovative value added nectar prepared from banana and pineapple blended pulp during storage. *Internat. J. Proc. & Post Harvest Technol.,* **5** (1) : 33-40.

In India, different kinds of traditional foods made from small millet grains from staple diet for many rural and urban households. Number of technologies has been developed to enhance utility and commercial value of these grains. Pasta is a type of noodle and is a staple food of traditional Italian cuisine. Typically pasta is made from an unleavened dough of a durum wheat flour mixed with water and formed into sheets or various shapes, then cooked and served in any number of dishes. It can be made with flour from other cereals or grains and eggs may be used instead of water as it was broadly categorized into, dried (*pasta secca*) and fresh (*pasta fresca*). Though pasta is a staple food in many countries, they are still considered as snack food here in India. Several studies have been reported in the value addition for different millets (Viraktamath *et al.,* 1971; Purseglove, 1972; Vaidhi *et al.,* 1985; Begum *et al.,* 2003; Veena *et al.,* 2004) but, little attempts have been made to prepare small millets based pasta products perhaps due to many reasons including non-availability of technology. Kodo millet (*Paspalum scobiculatum*) was domesticated in India about 3000 years ago and is known to be beneficial in diabetes, duodenal ulcer and high blood pressure. It is now available in a number of varieties with high yielding potential and is recommended to be grown in Madhya Pradesh, Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra and Uttar Pradesh. It is also known to be grown in the dry areas of West Bengal *i.e.*, the upland regions of Midnapur, Purulia, Bankura, Birbhum and Burdwan districts and hilly areas of Himachal Pradesh and Nepal though it is not

well documented.

Good storage quality of processed food is an essential attribute to extend their utilization and the storage quality of processed foods was evaluated by several investigators in terms of sensory characters and chemical components. Sowbhagya and Ali (2000) prepared maize vermicelli with and without antioxidant and packed in cast polypropylene (CCP) and a laminate of metalized polyester with low density polyethylene (M-PET/PE). The packs were stored at 38^0C, 92% RH (accelerated storage) for 100-140 days. Firmness and elasticity of product remained good up to 100 days. Devraju *et al.* (2003) developed pasta with finger millet flour (50%), refined wheat flour (40%), defatted soy/whey protein concentrate (10%) and extruded using both cold (30°C) and hot water (75°C). Pasta with hot water extrusion was better in terms of cooking quality and also cooking loss found to be minimum (12%) and showed non-significant differences in the cooked pasta under sensory attributes after three months of storage. Since there was no significant research has been found under the development of the snack products from the kodo millets and also lack of studies on the packaging and storage of ready to cook pasta like product blended with kodo millet. Hence, a study was conducted with an objective to develop Kodo millet based extruded ready to cook pasta product under different formulations packed in different packaging materials for three months storage studies with biochemical (fat, protein, carbohydrate, crude fibre, ash and moisture content) and quality analysis under monthly intervals with the aim to provide a good processing packaging and storage technique for pasta like ready to cook product.

EXPERIMENTAL METHODS

Raw material and product formulation:

The raw materials used for the development of ready to cook pasta product were dehusked kodo millet rice grain and wheat flour procured from the local super market. A domestic grain pulverizer (make: Anand Associates,Gujarat) was used to mill kodo millet rice grains into desired particle size flour suitable for developing cold extruded pasta product. Through the preliminary trails it was observed that maximum 70 per cent of millet could be used to produce commercial quality pasta product, if the millet proportion exceeds 70 per cent then the remarkable loss in texture and structure of the end pasta product was observed. Hence, the maximum percentage use of kodo millet was restricted to 70 per cent and the rest was make up by the wheat flour (*atta*) which provides necessary strength for the final product. Similarly, other two combinations were prepared as detailed in Table A.

Table A: Formulation of kodo millet based *pasta* products

Formulation	Kodo millet flour (%)	Wheat flour (%)	Water (ml/kg)
K-f_1	50	50	360
K-f_2	60	40	360
K-f_3	70	30	360

Preparation of pasta:

When the dough characteristic was optimum, it was extruded using appropriate 'dies' (shanku, ribbed tube, twisted ribbons) under a cold extruder. The cutter speed was set to optimum level (3 to 12 rpm) depending upon the shape of the final product. The extruded pasta were collected in trays, steam cooked at 0.5 kg/cm^2 for 5 minutes and then dried in a convective hot air oven at 50^0 C for about 3 hours to obtain translucent pasta. The products were then packed and sealed in two different packaging materials selected for the present study namely, low density poly ethylene (LDPE-200 gauge) and polypropylene bags (PP-200 gauge) for storage studies.

Sensory evaluation of cooked kodo millet based pasta:

The pasta masala was prepared using locally available method and as per the preliminary sensory studies carried out for the commercially available pasta. The products were evaluated for sensory characteristics by a panel of 12 trained judges. Whole wheat pasta (control) was also prepared in similar way and presented for sensory evaluation along with the 3 combination samples (Based on kodo millet) Table B. The judges scored the sensory quality of cooked pasta based on its colour, texture, taste, flavor and overall acceptability on a nine point hedonic scale (Ranganna, 1997).

Table B : Mean sensory scores of different kodo millet based pasta products

Millet formulations	Colour	Texture	Flavour	Taste	Overall acceptability
K-f_1	6.88	6.82	6.96	6.92	6.90
K-f_2	6.80	6.70	7.10	6.90	7.10
K-f_3	6.72	6.66	6.66	6.60	6.66
Control	7.95	7.69	7.52	7.42	7.60
GM	7.02	7.47	7.06	6.60	7.06
F-test	*	NS	NS	NS	NS
C.D.@5%	0.69	-	-	-	-

K-f_1 - Kodo millet rice flour (50%): Wheat flour (50%), K-f_2 - Kodo millet rice flour (60%): Wheat flour (40%), K-f_3 - Kodo millet rice flour (70%): Wheat flour (30%) NS= Non- significant

Cooking quality of small millets based pasta products:

The cooking characteristics of experimental pasta samples were determined by following the established cooking procedures.

Optimum cooking time:

The small millets based pasta products (5 g) were cooked in boiling water (100 ml) over a gas stove. The optimum cooking

time of pasta was determined subjectively by pressing the product between fingers periodically at 1 min intervals. When the product was completely soft, the time was noted as optimum cooking time.

Swelling power:

Swelling power of pasta products was determined by method proposed by Schoch (1964). A known weight (5 g) of pasta was cooked in a glass beaker with 20 times its quantity of boiling water (100 ml) for 20 minutes over a water bath maintained at 100ºC. After cooking, the water was strained out and the cooked pasta was dried to remove surface moisture using filter paper and the cooked sample was weighed. From the initial and final weights of pasta, swelling power was calculated as:

$$\text{Swelling power}\left({}^{g}/_{g}\right) = \frac{W_2 - W_1}{W_1} \quad \text{.....(I)}$$

where,

W_1 = Initial sample weight before cooking, g

W_2 = Sample weight after cooking, g.

Solid loss:

Solid loss was determined by cooking pasta samples in boiling water for 20 minutes as described in Sec. 3.5.2. After cooking, the cooked material was strained out and the whole filtrate was transferred quantitatively in to a pre- weighed Petri dish. It was evaporated over a water bath followed by drying in a hot air oven maintained at 105 ± 2ºC for 1 hour. The Petri dish was again weighed with the dried solids. Then, the solid loss was calculated as:

$$\text{Solid loss (\%)} = \frac{m_2 - m_1}{m_0} \text{x} 100 \quad \text{.....(II)}$$

where,

m_0 - Initial weight of pasta taken for cooking, g

m_1 - Weight of empty Petri dish, g

m_2 - Weight of Petri dish with dried solids after evaporation, g.

Storage of pasta:

Storage stability of developed kodo millet pasta products were studied at ambient conditions by storing them in flexible packages LDPE and PP. The packaged samples were stored at ambient conditions of Bangalore (during April-June, 2012) for three months. The stored pastas' were periodically analyzed at monthly intervals for biochemical parameters and moisture in order to study their storage stability.

Colour:

The colour measurement of the pasta was made using a spectrophotometer (Make: Konica Minolta Instrument, Osaka, Japan; Model-CM 5). The pasta samples from each treatment and replication were measured for *L** (*i.e.* [-] to [+] lightness coordinate), *a** (*i.e.* green [-] to red [+] colour space coordinate) and *b** (*i.e.* blue [-] to yellow [+] colour space coordinate). The *L**, *a** and *b** readings were recorded and later statistically evaluated.

Bio-chemical analysis:

Moisture content:

Moisture content analysis of pasta samples during storage was examined for percentage difference in the weight of the samples before and after packaging during storage period as per the standard methods described by Hall (1957). The data on moisture content were presented in terms of percentage, which was calculated as:

$$\text{Moisture content}\,(\%) = \frac{W_1 - W_2}{W_1} \quad \text{.....(1)}$$

where,

W_1= Initial weight of the sample, g,

W_2= Final weight of the sample, g.

Protein:

The protein content was determined from the organic nitrogen content by Micro-Kjeldahl method. The KEL PLUS Automatic Nitrogen/Protein Estimation System by Pelican Equipments, Chennai, India, was used for this estimation. The protein content was calculated as:

$$\text{Protein (\%)} = \frac{14 \times \text{titre value} \times \text{normality of HCl}}{\text{Sample weight}} \text{x } 6.25 \quad \text{.....(2)}$$

Fat content:

Fat was estimated as crude ether extract of the dry material. The dry sample (3-5 g) was weighed accurately in a thimble and plugged with cotton. The thimble was then placed in the Automatic Soxhlet Apparatus (make: Pelican Equipments, Chennai) and extracted with anhydrous ether for about 3 h. The ether is then evaporated and the flask with the residue dried in an oven at 80-100°C, cooled in a desiccator and weighed. The fat content was then calculated as:

$$\text{Fat content (\%)} = \frac{\text{weight of ether extract}}{\text{Weight of sample}} \text{x} 100 \quad \text{.....(3)}$$

Crude fibre:

Crude fibre content of pasta samples during storage was examined for amount of water, fat and ash content present in the samples during quality analysis of storage period as per the standard method described by AOAC (1980). The data on moisture content were presented in terms of percentage, which was calculated as:

$$\text{Crude fibre (\%)} = \frac{\left[100 - \{\text{moisture} + \text{fat}\}\right] \times \text{We} - \text{Wa}}{\text{Wt. of sample taken}} \quad \text{.....(4)}$$

where,

W_e = Pre-weighed ash, g.

W_a = Weight of the dish after washing, g.

Ash content:

The total ash content was determined by weighing accurately in a previously heated and cooled silica / porcelain dish with about 3-5 g of the samples (AOAC, 1980). The samples were charred carefully on a heater or flame, then heated in a muffle furnace maintained at 525°- 550°C for 3 hours or until white ash is obtained. Then the ash content was calculated as mentioned above:

$$\text{Ash (\%)} = \frac{W_1}{W_2} x100 \quad .....(5)$$

where,

W_1 = Weight of the sample, g.

W_2 = Weight of the residue after ashing, g.

Carbohydrate:

The available carbohydrate content in food sample was determined by the method of difference *i.e.*, by subtracting from 100, the sum of values (per 100 g) of moisture, protein, fat, ash and crude fibre.

Statistical analysis:

The data obtained in the present study was analyzed (ANOVA) by using the AGRESS software (CRBD) for the significance level of the dependent and independent variables.

EXPERIMENTAL FINDINGS AND ANALYSIS

The experimental findings obtained from the present study have been discussed in following heads:

Cooking characterstics of kodo millet pasta:

Cooking characteristics namely, cooking time, swelling power and solid loss for the best all the three combinations of the kodo millet based pasta were determined and

Table 1 : Cooking characteristics of kodo millet based pasta products

	Cooking quality of kodo millet pasta		
Millet formulations	Cooking time (min)	Swelling power (g/g)	Solid loss (%)
K-f_1	7.59	3.85	2.98
K-f_2	7.48	3.25	3.52
K-f_3	7.43	2.95	4.56
Control	8.12	3.53	9.84

Table 2: Effect of storage on tristimulus colour values of kodo millet based pasta stored in various packaging films

Packaging materials	Storage duration (month)	Mean tri-stimulus colour values		
		L*	a*	b*
PP	0	24.6427	-0.3533	-1.7467
	1	26.7600	3.4067	12.9933
	2	25.8100	5.1200	16.4967
	3	24.7800	5.2000	17.1833
LDPE	0	24.6400	-0.3533	-1.7467
	1	23.5300	3.7300	13.7433
	2	22.9000	4.8367	14.8600
	3	21.6033	4.5633	15.8600
Packaging (P)	F-Test	*	NS	NS
	S.E.±	0.283	0.048	0.163
	C.D. @5%	0.85077	-	-
	C.D. @1%	-	-	-
Storage duration (D)	F-Test	NS	**	**
	S.E.±	0.4	0.06	0.23
	C.D. @5%	-	0.1872	0.69206
	C.D. @1%	-	0.255	0.95353
P X D	F-Test	NS	*	NS
	S.E.±	0.567	0.085	0.32
	C.D. @5%	-	0.25744	-
	C.D. @1%	-	-	-

LDPE - Low density poly ethylene, PP - Poly propylene, * and ** indicate significance of values at P=0.05 and 0.01, respectively, NS=Non-significant

observations are detailed in Table 1.

Cooking time, swelling power solid loss:

The cooking time, swelling power, solid loss required for kodo millets based pasta along with wheat based pasta products varied from 7.43 (min) to 8.12 (min), 2.95(g/g) to 3.85(g/g) and 2.98(%) to 9.84(%) (Table 1). Similar results were obtained by Roopa (2008) with barnyard millet based vermicelli products.

Colour:

The influence of different packages on tri-stimulus colour values (L*, a*, b*) of kodo millet pasta during ambient storage is presented in Table 2. It was observed that, the lightness (whiteness) factor L* of kodo millet pasta significantly decreased from initial value of 24.64 to 21.60 in LDPE packages during three months of ambient storage. The reduction in L* value of pasta was more pronounced in LDPE package than in PP package. The change in the appearance (pale) of the packaged products were observed throughout the storage period. The type of package, storage duration and the interaction effect on L* value of pasta products were non significant. Similarly, both a* and b* values of kodo millet pasta products increased with storage in all the packages indicating the change in colour of the products.

Biochemical changes in kodo millets based pasta during storage:

Moisture content:

Table 3 illustrates the change in the moisture content of all the treatments during storage. For samples blended under different ratios of millet and wheat flour (K-f_1, K-f_2, K-f_3 and control), moisture content remained with lower rate of increase under storage studies without remarkable changes in K-f_1. However, samples packaged in different packaging materials showed increased trend throughout the storage period but the rate of percentage of increase was less in LDPE (5.11 to 8.98 %) as compared to samples in PP. Hence, for a given storage period, the moisture migration was higher to the pasta stored in the polypropylene package when compared to LDPE. The changes in moisture content noticed in the present study were in similarity with the findings observed by many researchers as given by Srirajrajeshwari and Mamatha (1999).

Protein:

The changes in protein content of pasta samples prepared under different treatments during storage packaged in different

Table 3: Effect of packaging films on moisture content of different kodo millet based pasta products during storage

Millet formulations	Moisture content (%)						
	LDPE (200 gauge)				PP (200 gauge)		
	Storage period (months)				Storage period (months)		
	0	1	2	3	1	2	3
K-f_1	5.45	5.85	6.35	6.95	4.85	5.76	8.63
K-f_2	5.11	5.40	5.66	6.05	5.40	8.94	10.12
K-f_3	5.30	6.85	7.70	8.98	5.37	8.92	11.55
Control	5.43	5.51	6.77	7.14	5.51	10.0	13.24

Table 4 : Effect of packaging films on protein content of different kodo millet based pasta products during storage

Millet formulations	Protein content (%)						
	LDPE (200 gauge)				PP (200 gauge)		
	Storage period (months)				Storage period (months)		
	0	1	2	3	1	2	3
K-f_1	12.31	12.11	11.21	11.10	12.28	11.07	10.86
K-f_2	11.47	11.38	10.13	8.88	11.35	10.46	10.37
K-f_3	11.28	11.19	9.08	8.68	11.01	8.96	8.54
Control	14.90	14.70	13.61	12.81	13.98	13.5	12.04

Table 5: Effect of packaging films on fat content of different kodo millet based pasta products during storage

Millet formulations	Fat content (%)						
	LDPE (200 gauge)				PP (200 gauge)		
	Storage period (months)				Storage period (months)		
	0	1	2	3	1	2	3
K-f_1	0.66	0.59	0.48	0.31	0.51	0.42	0.28
K-f_2	0.59	0.52	0.45	0.35	0.53	0.48	0.43
K-f_3	0.52	0.48	0.34	0.28	0.51	0.39	0.31
Control	0.25	0.12	0.10	0.07	0.12	0.10	0.08

packaging materials are given in Table 4. Irrespective of the different combinations, a marginal change in protein content during storage was observed throughout the storage period as compared to control samples attained drastic change in protein content after storage. Ramananthan *et al*. (1975) has observed similar trend in their research study. But, the rate of change in the sample protein was less in treatment Kf_1 and Kf_2 as compared to other treatments. The samples packaged in both the packaging materials showed interesting protein change behaviour during storage, *i.e.* the reduction in protein content of samples stored in LDPE (8.68 to 14.90 %) but the samples stored under PP (8.54 to 14.90%) has showed minimum change throughout the storage period.

Fat:

A gradual decrease in fat content of all pasta samples irrespective of the combinations followed in the production of pasta was observed (Table 5). Even though the rate of decrease was highly not significant in all the samples, there was a observable change noticed in the treatments as compared to control samples. The change in the fat content observed in the present study was in correlation with the findings by Ramananthan *et al*. (1975).

Table 6: Effect of packaging films on carbohydrates of different kodo millet based pasta products during storage

Millet formulation	Carbohydrate content (%)						
	LDPE (200 gauge)				PP (200 gauge)		
	Storage period (months)				Storage period (months)		
	0	1	2	3	1	2	3
K-f_1	78.55	78.42	78.95	78.63	79.33	79.74	77.22
K-f_2	79.74	79.47	78.88	81.5	78.95	76.07	74.07
K-f_3	79.50	78.55	79.95	79.14	80.18	78.80	76.68
Control	75.40	75.45	76.03	76.30	77.40	73.13	70.85

Table 7: Effect of packaging films on ash content of different kodo millet based pasta products during storage

Millet formulations	Ash content (%)						
	LDPE (200 gauge)				PP (200 gauge)		
	Storage period (months)				Storage period (months)		
	0	1	2	3	1	2	3
K-f_1	1.30	1.30	1.28	1.28	1.30	1.28	1.28
K-f_2	1.31	1.31	1.31	1.31	1.20	1.13	1.18
K-f_3	1.30	1.28	1.28	1.27	1.28	1.28	1.27
Control	1.46	1.45	1.44	1.44	1.46	1.46	1.45

Table 8 : Effect of packaging films on fibre content of different kodo millet based pasta products during storage

Millet formulations	Fibre content (%)						
	LDPE (200 gauge)				PP (200 gauge)		
	Storage period (months)				Storage period (months)		
	0	1	2	3	1	2	3
K-f_1	1.73	1.73	1.73	1.73	1.73	1.73	1.73
K-f_2	1.85	1.85	1.59	1.33	1.85	1.32	1.28
K-f_3	1.65	1.65	1.65	1.65	1.65	1.65	1.65
Control	2.56	2.56	1.44	1.52	2.16	1.97	1.72

Table 9: Sensory scores of kodo millet based pasta products before and after storage under different packages

Type of pasta product	Colour			Texture			Flavour			Taste			Overall acceptability		
	Before storage	After storage		Before storage	After storage		Before storage	After storage		Before storage	After storage		Before storage	After storage	
		LDPE	PP		LDPE	PP		LDPE	PP		LDPE	PP		LDPE	PP
K-f_1	7.20	7.00	6.90	7.48	7.30	7.29	7.02	6.95	6.80	7.30	6.99	6.80	7.52	6.84	6.70
K-f_2	6.80	6.80	6.50	6.70	6.00	6.00	7.10	6.10	6.00	6.60	6.20	6.20	6.66	6.50	6.40
K-f_3	6.30	6.10	6.09	6.78	6.50	6.49	6.78	6.00	5.90	6.86	6.60	6.50	6.78	6.50	6.40
Control	7.95	7.00	7.00	7.69	7.20	7.20	7.52	7.10	7.10	7.42	7.05	7.05	7.62	7.40	7.40

Carbohydrates:

Immediately after production, samples under treatment ($K\text{-}f_1$, $K\text{-}f_2$ and $K\text{-}f_3$) did not show any noticeable changes in carbohydrate content, but remarkable change was observed between the control and treatment samples (Table 6). This trend was continued throughout the storage period with very negligible change in carbohydrate value upto three months of storage as compared to control samples. Similar observations were recorded by Gopalan *et al*. (2002) and Kulkarni *et al*. (1992).

Ash content and crude fibre:

The decimal change in the ash content and crude fibre content of the samples under different treatments are detailed and tabulated in Table 7 and 8, respectively. Since, ash content in any product is purely depends on the mineral composition, there was no much variation in ash content of pasta samples prepared under different combinations and packaged in different packaging materials were observed because of lack of change in the mineral proportions during storage period. Also, similar trend was observed in percentage change of crude fibre content in pasta samples throughout the storage. The observations are in correlation with the research findings of several earlier workers (Gopalan *et al*., 2002; Malleshi and Desikachar, 1985; Kulkarni *et al*., 1992).

Changes in sensory quality of kodo millet based pasta during storage:

Organoleptic evaluation for colour, texture, flavor, taste and overall acceptability of small millets based pasta products was carried out after 3 months of storage. The sensory scores obtained for overall acceptability of different kodo millet based pasta stored in two packages are given in Table 9. The overall acceptability in case of $K\text{-}f_2$ declined from 6.40 to 6.66. Similarly the reduction in overall acceptability under $K\text{-}f_1$, $K\text{-}f_3$ was 6.70 to 7.52 and 6.40 to 6.78, respectively. However, the reduction in sensory scores was slightly more pronounced in the products stored in poly propylene packages as compared to LDPE after three months of storage.

Conclusion:

Though the study has followed different combinations for the development of kodo millet based ready to cook pasta, finaly the best sensory score was attained by Kf_2 followed $Kf_1$and Kf_3. The results and observation during the storage studies has literally proved through a remarkable reduction in moisture, protein, fat and carbohydrates at different rates in all the samples packaged in different packaging materials, that PP an LDPE materials used for packaging ready to cook pasta has failed to retain the original quality of the product during storage. Accordingly, a very low change in ash and crude fibre during storage was also observed irrespective of the packaging materials used for the study. The gradual change in the product quality packaged in the PP might be due to in appropriate moisture and gas barrier offered by the packaging material during storage which lead to quality loss in the product. In the view to select a most preferable packaging material for the storage of ready to cook pasta among PP and LDPE, the study clearly recommends LDPE for the package of ready to cook pasta product for better storage and shelf life and also concludes that LDPE packed kodo millet based pasta (kodo millet + wheat flour @60 and 40% each) could be stored at room temperature for 3 months without appreciable quality deterioration.

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