Optimization of initial dough moisture content for shepu enriched proso millet based multi grain pasta

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SUMMARY :
Minor millets are rich in dietary fibre and other nutritional components. But their inclusion in daily urban diet is restricted due to lack of processing technology and value added products. Under this context, a study was undertaken to develop ready-to-cook pasta products using different small millets with proso millet as base by cold extrusion technique and La Montferrina Pasta Machine was employed. Among 16 proso millet based multi grain pasta formulations tested, four formulations namely, Proso:Wheat:Barnyard (30%:60%:10%); Proso:Wheat:Foxtail (30%:60%:10%); Proso:Wheat:Kodo (50%:40%:10%); and Proso:Wheat:Little (50%:40%:10%) were selected as best based on sensory evaluation of extruded pasta products. Enrichment study of above four pasta formulations with iron rich shepu powder (14.74 mg Fe/100 g) was carried out and depending upon the millets combination, an incorporation level of 1.0-1.5 per cent shepu powder was found to be optimum. The cooking characteristics namely, cooking time, swelling power and solid loss of shepu enriched multi grain pasta varied from to 7.15 to 7.45 min, 1.89 to 2.20 (g/g) and 4.80 to 8.65 per cent, respectively. For the production of proso millet based multi-grain pasta, optimum initial moisture content of dough was found to be 30 per cent. The developed pasta could be stored for over 3 months at ambient conditions without much quality deterioration (in terms of biochemical parameters, tristimulus colour, texture and microbial counts) and among the packages tested, LDPE film (200 gauge) was better compared to polypropylene film for pasta products. The Cost:Benefit Ratios (>1:1.74) worked out for proso millet based multi grain pasta products were highly favourable and, therefore, can be recommended for commercial exploitation.

KEY WORDS : Minor millets, Pasta, Moisture content, Proso millet, Foxtail millet, Barnyard millet, Kodo millet, Shepu, Wheat, Little millet, Sensory score, Cold extrusion

Minor millets are underutilized plant species, locally important but rarely traded internationally with unexploited economic potential. They are nutritionally superior to rice and wheat; provide protein, minerals and vitamins (Rao, 1986, AACC, 2000) and contain higher proportion of dietary fibre (Malleshi and Hadimani, 1993). Furthermore, they remain underutilized cereals even in agro-ecological systems where they grow due to their minimal

inclusion in the commercial food systems and lack of research and novel product development processes.

Shepu, (Genus: Anethum; Family: Apiaceae) also known by names sabbasige soppu (Kannada), sada kuppi (Tamil) and satha kuppa (Malayalam) is grown as an annual herb which is rich in iron content.

Pasta is a traditional cereal-based food product that is becoming increasingly popular worldwide because of its convenience, nutritional quality and palatability. Fortification of millet pasta with green leafy vegetable mixes aids in supplementing them with minerals to some extent. Subir *et al.* (2009) pointed out that since millets are rich in fibres and legumes are rich in proteins and other vitamins, the products obtained by blending millets with legumes has greater nutritional value.

EXPERIMENTAL METHODS

Raw materials :
Minor millets required for the work were procured from local farmers and shepu from nearby markets.

Millet dehulling :
The millet grains were first fed to a grain destoner-cum-grader to achieve grading. The grains were preheated for three hours in a tray dryer maintained at 55^0 C to achieve effective dehulling.

Flour milling :
A domestic Grain Pulverizer was used to mill different millet rice grains into suitable flours and grits. The pulverized flour and grits were further sieved manually using BS 100 mesh sieve in the case of flour and BS 25 mesh, 52 mesh and 60 mesh sieves in the case of grits; in order to obtain flour and grits of uniform particle size. Both flour and grits were used in the development of cold extruded products. The dehulled millets were also milled in the pulverizer to a size range of less than 151µm pertaining to that of flour. A portion of dehulled millets were also kept at grit sizes of 151-251 µm, 251-351 µm and 592 µm by proper sieving.

Shepu leaves were dried in a hot air oven at 60ºC for 24 hours prior to milling in an Ultra centrifugal Mill.

Development of small millets based cold extruded pasta products :
The best proportion of proso millet incorporation in pasta was found to be 60 per cent with 40 per cent of wheat flour (Sudha *et al.*, 2013). Thus, the base proportion of proso millet was kept at 60 per cent. Out of the remaining 40 per cent, binder as well as multi millet incorporation was done.

Description of pasta machine (Cold extruder) :
The laboratory model Pasta Machine was a small, compact

cold extruder. The unit was basically a single screw extruder with a short stainless steel screw of uniform pitch powered by a 3 hp electrical motor through a speed reduction system. The flours and other ingredients were put in the feeding trough and the kneader (paddle type) switch was first selected to blend the ingredients thoroughly. Later, required quantity of water was added and the flours were worked for a while to get optimum dough characteristics suitable for cold extrusion. Once the dough of required consistency was ready, extrusion switch was selected to continuously produce pasta of desired shape. A pasta cutter blade, optionally attached at the outlet of the die could cut the extruded pasta to the desired size.

Formulation of small millet flour blends for pasta production:
Initially, the proso millet based multi grain pasta was made out of the following formulations with flour of particle size, less than 151 µm.

Pasta product manufacture :
The millet based pasta products were prepared by following the systematic procedure advocated by the pasta machine manufacturer (especially for hard semolina of durum wheat). The sieved (BS 100 mesh size) flours of millet rice and wheat were first blended (in the machine itself) for 5 min and then kneaded for about 20 min after adding optimum quantity of water. The quantity of water was decided based on manufacturer recommendations (for millet and wheat flour). When the dough characteristic was optimum, it was extruded using dies in three available shapes – shanku, ribbed tube, twisted ribbons. 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 tray dryer at 50^0 C for about 3 hours to obtain translucent pasta. The products were then packed in LDPE bags (200 gauge), thermally sealed and stored at ambient conditions.

Sensory evaluation of cooked pasta products :
The small millet based pasta products were optimally cooked just like the regular commercially available pasta and were evaluated for sensory characteristics by a panel of 12 trained judges. For comparison, control was also prepared (which contained the maximum accepted levels of proso millet flour (60%) and wheat flour (40% in pasta) in similar way and presented for sensory evaluation along with the experimental samples. The judges scored the cooked pasta for colour, texture, taste, flavour and overall acceptability based on a 9 point hedonic scale.

Nutritional enrichment study of millet pasta using green leafy vegetable :
The selected best formulations in section 3.2.5 were used

for the preparation of nutrient enriched pasta by addition of green leafy vegetable powder (shepu). Shepu ('sabasige' in Kannada) greens, being rich in iron (14.74 mg/100g) was incorporated in the above selected millet pasta formulations (Table 3). The moisture content of the shepu powder was 91.35 per cent. To avoid the problem of bitterness in taste of final product shepu level was kept between 0.5 and 2 per cent in the trials. To arrive at an accepted level of incorporation, the shepu powder was varied at four levels, *i.e.* 0.5, 1.0, 1.5 and 2.0 per cent and the nutrient enriched millet pasta samples were prepared.

Pasta from the nutrient enriched 16 pasta formulations were prepared and were subjected to sensory evaluation to arrive at the most acceptable product with level of shepu incorporation. The following were the best selected nutrient enriched pasta formulations (Table 4).

Optimum initial moisture level for extrusion of shepu enriched proso millet based multi grain pasta :

From the trials conducted to extrude the shepu enriched multi grain pasta formulations at different initial moisture contents, it was observed that the pasta products prepared from 30 per cent initial dough moisture had desirable cooking characteristics of lower cooking time, higher swelling power and lower solid loss. Hence, the initial dough moisture content of 30 per cent (before extrusion) was taken as the optimum for manufacture of shepu enriched proso millet based multi grain pasta.

EXPERIMENTAL FINDINGS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized in the Table from 1 to 11.

Selection of best multi grain pasta formulation with barnyard millet as an ingredient :

From the sensory evaluation of various multi grain pasta products that contained barnyard millet as one of the ingredients at 10 per cent level, it was clear that the pasta from the formulation BF_1 had obtained consistently higher organoleptic scores for colour (7.88), texture (8.03), flavour (8.12), taste (8.08) and overall acceptability (7.94); when compared to other formulations and control pasta. Hence, this formulation BF_1 was selected as the best for production of multi grain pasta having barnyard millet as the add-on millet ingredient.

Selection of best multi grain pasta formulation with foxtail millet as an ingredient :

From the sensory evaluation of various multi grain pasta products that contained foxtail millet as one of the ingredients at 10 per cent level, it was clear that the pasta from the formulation FF_1 had obtained consistently higher organoleptic scores for colour (8.07), texture (8.02), flavour (7.98), taste (7.98) and overall acceptability (7.99) when compared to other formulations and control pasta. Hence, this formulation FF_1

Table 1 : Formulations of proso millet based multi grain pasta products				
Formulation code	Proso millet flour (%)	Other millet flour (%)	Wheat flour (%)	Water (ml/kg)
Barnyard millet combinations				
BF_1	30	10	60	254
BF_2	40	10	50	250
BF_3	50	10	40	246
BF_4	60	10	30	242
Foxtail millet combinations				
FF_1	30	10	60	255
FF_2	40	10	50	252
FF_3	50	10	40	248
FF_4	60	10	30	244
Kodo millet combinations				
KF_1	30	10	60	255
KF_2	40	10	50	252
KF_3	50	10	40	248
KF_4	60	10	30	244
Little millet combinations				
LF_1	30	10	60	254
LF_2	40	10	50	250
LF_3	50	10	40	246
LF_4	60	10	30	242

was selected as the best for the production of multi grain pasta having foxtail millet as the add-on millet ingredient.

Selection of best multi grain pasta formulation with kodo millet as an ingredient :

From the sensory evaluation of various multi grain pasta products that contained kodo millet as one of the ingredients at 10 per cent level, it was clear that the pasta from the formulation KF_3 had obtained consistently higher organoleptic scores for colour (7.85), texture (7.20), flavour (7.70), taste (7.70) and overall acceptability (7.80) when compared to other formulations and control pasta. Hence, this formulation KF_3 was selected as the best for production of multi grain pasta having kodo millet as the add-on millet ingredient.

Selection of best multi grain pasta formulation with little millet as an ingredient :

From the sensory evaluation of various multi grain pasta

products that contained little millet as one of the ingredients at 10 per cent level, it was clear that the pasta from the formulation LF_3 had obtained consistently higher organoleptic scores for colour (7.95), texture (7.93), flavour (8.06), taste (7.91) and overall acceptability (8.01) when compared to other formulations and control pasta. Hence, this formulation LF_3 was selected as the best for production of multi grain pasta having little millet as the add-on millet ingredient.

Nutritional enrichment of multi grain pasta with green leafy vegetable shepu :

Nutritional enrichment of best selected proso millet based multi grain pasta formulations by incorporating shepu (green leafy vegetable) at different levels (0.5, 1.0, 1.5 and 2.0%) was attempted and the resultant nutrient enriched pasta products along with control were subjected to organoleptic evaluation. The results are presented in subsequent sections below separately for individual formulation (based on optional add-

Table 2 : Best selected formulations for multi-millet pasta

Optional/add-on millet	Formulation code	Formulation
Barnyard	BF_1	Barnyard (10%) : Proso (30%) : Wheat(60%)
Foxtail	FF_1	Foxtail (10%) : Proso (30%) : Wheat(60%)
Kodo	KF_3	Kodo (10%) : Proso (50%) : Wheat(40%)
Little	LF_3	Little (10%) : Proso (50%) : Wheat(40%)

Table 3 : Formulations of proso millet based multi grain pasta products with shepu greens incorporation

Formulation	Proso millet flour	Wheat flour	Millet flour	Shepu powder
Barnyard				
$F_1S_1b_1$	30	60	9.5	0.5
$F_1S_2b_2$	30	60	9.0	1.0
$F_1S_3b_3$	30	60	8.5	1.5
$F_1S_4b_4$	30	60	8.0	2.0
Foxtail				
$F_1S_1f_1$	30	60	9.5	0.5
$F_1S_2f_2$	30	60	9.0	1.0
$F_1S_3f_3$	30	60	8.5	1.5
$F_1S_4f_4$	30	60	8.0	2.0
Kodo				
$F_3S_1k_1$	50	40	9.5	0.5
$F_3S_2k_2$	50	40	9.0	1.0
$F_3S_3k_3$	50	40	8.5	1.5
$F_3S_4k_4$	50	40	8.0	2.0
Little				
$F_3S_1l_1$	50	40	9.5	0.5
$F_3S_2l_2$	50	40	9.0	1.0
$F_3S_3l_3$	50	40	8.5	1.5
$F_3S_4l_4$	50	40	8.0	2.0

b_1: Barnyard millet flour (9.5%) S_1: *Shepu* leaf powder (0.5%)
b_2: Barnyard millet flour (9.5%) S_2: *Shepu* leaf powder (1.0%)
b_3: Barnyard millet flour (8.5%) S_3: *Shepu* leaf powder (1.5%)
b_4: Barnyard millet flour (8.0%) S_4: *Shepu* leaf powder (2.0%)

on millet).

Optimization of initial dough moisture content for shepu enriched proso millet based multi grain pasta :

The effect of initial moisture level of (finally selected) four formulations of shepu enriched proso millet based multi grain pasta on the cooking quality of products in terms of cooking time, swelling power and solid loss were studied and the results are presented in Table 11.

Cooking quality of shepu enriched proso millet based multi grain pasta products extruded with 30 per cent initial dough moisture content :

Cooking time :

The cooking time (Table 11) of pasta samples extruded from different formulations varied from 7.15 to 7.45 minutes. The lowest cooking time was recorded for both $F_3S_3l_3$ and control and the pasta of $F_3S_2k_2$ recorded maximum cooking time of 7.45 minutes.

Swelling power :

The swelling power of shepu enriched multi grain pasta samples ranged from 1.89 to 2.20 g/g (Table 11). The treatment $F_1S_3f_3$ recorded a highest swelling power while the treatment $F_3S_3l_3$ recorded the minimum swelling power.

Solid loss :

The solid loss of pasta products prepared from different formulations showed considerable variation (range: 4.80 to 8.65%) with maximum value for control sample and minimum value for $F_1S_3b_3$.

Cooking quality of enriched multi grain pasta products extruded from dough of 33 per cent initial moisture :

Cooking time :

The cooking time required for different small millets based pasta products varied from 7.15 to 8.80 min (Table 11). The cooking time was minimum (7.15 min) for control pasta followed by treatment $F_3S_2k_2$ (8.10 min).

Swelling power :

The swelling power of various enriched multi grain of pasta products during cooking varied from 1.79 g/g to 2.10 g/g (Table 11). The highest swelling power was observed in treatment $F_1S_3b_3$ and the least value was observed in $F_3S_3l_3$.

Solid loss :

The solid loss of various proso millet based multi grain *pasta* products enriched with shepu during cooking is presented in Table 11. It could be observed that the solid loss varied from 5.00 to 8.65 per cent. The lowest solid loss was

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Table 4 : Best selected formulations for multi-millet pasta incorporated with shepu greens

Optional/add-on millet	Formulation code	Formulation
Barnyard	$F_1S_3b_3$	Proso(30%) : Wheat(60%) : *Shepu*(1.50%) : Barnyard(8.50%)
Foxtail	$F_1S_3f_3$	Proso(30%) : Wheat(60%) : *Shepu*(1.50%) : Foxtail(8.50%)
Kodo	$F_3S_2k_2$	Proso(50%) : Wheat(40%) : *Shepu*(1.00%) : Kodo(9.00%)
Little	$F_3S_3l_3$	Proso(50%) : Wheat(40%) : *Shepu*(1.50%) : Little(8.50%)

Table 5 : Proximate analysis of different small millet rice grains and shepu (per 100 g edible portion on dry basis)

Type of millet rice	Moisture content (%)	Carbo-hydrates (%)	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	Energy (kcal)	Iron (µg/g)	Cu (µg/g)	Na (µg/g)	Zn (µg/g)	Mg (µg/g)	Mn (µg/g)	Starch (%)
Barnyard	10.12	69.31	11.96	3.72	2.01	2.88	357.84	44.70	6.73	125.50	19.40	780.00	11.32	34.60
Foxtail	9.09	68.89	12.95	3.89	2.02	3.06	357.77	27.50	9.40	31.40	27.20	35.90	17.70	32.50
Kodo	9.08	70.12	12.37	3.62	2.05	2.76	359.74	97.53	13.20	76.80	59.40	590.40	31.50	37.30
Little	11.54	64.11	14.66	3.93	1.97	3.79	353.45	24.35	7.60	31.30	29.70	41.80	17.60	44.40
Proso	11.53	64.37	14.12	3.86	2.02	4.10	351.80	11.53	8.35	76.90	22.30	670.80	19.80	41.60
Wheat	14.28	68.57	12.89	1.20	1.96	1.10	330.64	5.20	14.50	4.30	112.50	4.10	28.60	48.70
Shepu	91.35	5.51	1.74	0.20	–	1.20	30.80	147.20	88.90	54.50	7.90	67.80	56.50	–

Table 6 : Selected formulations for proso millet based pasta products with multi-millet incorporation

Millet	Best accepted multi-millet formulation
Barnyard	BF_1 (Barnyard (10%) : Proso (30%) : Wheat (60%))
Foxtail	FF_1 (Foxtail (10%) : Proso (30%) : Wheat (60%))
Kodo	KF_3 (Kodo (10%) : Proso (50%) : Wheat (40%))
Little	LF_3 (Little (10%) : Proso (50%) : Wheat (40%))

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observed with treatment $F_1S_3b_3$ and the highest solid loss of 8.65 per cent was observed in control sample.

Cooking quality of shepu enriched proso millet based multi grain pasta products extruded with 35 per cent initial dough moisture :

Cooking time :

The Table 11 shows a maximum cooking time for the treatment $F_1S_3b_3$ (8.00 min.) and the minimum cooking time for the control (7.15 min.).

Swelling power :

Table 11 shows that the swelling power of proso millet based multigrain pasta extruded from 35 per cent dough moisture content. The swelling power was found to be in range of 1.77 to 2.06 g/g with minimum value for the treatment $F_3S_3l_3$ and maximum value for the control.

Solid loss :

The solid loss of shepu enriched pasta samples extruded at 33 per cent dough moisture is presented in Table 11. The minimum value for solid loss was observed in $F_1S_3b_3$ (5.15%) and maximum value was observed in control (8.65%).

Optimum initial moisture level for extrusion of shepu enriched proso millet based multi grain pasta :

From the trials conducted to extrude the shepu enriched multi grain pasta formulations at different initial moisture contents, it was observed that the pasta products prepared from 30 per cent initial dough moisture had desirable cooking characteristics of lower cooking time, higher swelling power and lower solid loss. Hence, the initial dough moisture content of 30 per cent (before extrusion) was taken as the optimum for manufacture of shepu enriched proso millet based multi grain pasta.

Table 7: Sensory scores of shepu enriched proso millet based multi grain pasta products having barnyard millet

Millet formulation	Colour	Texture	Flavour	Taste	Overall acceptability
$F_1S_1b_1$	7.45	7.63	7.59	7.37	6.90
$F_1S_2b_2$	7.95	7.65	7.91	7.70	7.65
$F_1S_3b_3$	7.86	7.98	7.98	7.75	7.81
$F_1S_4b_4$	7.50	7.63	7.60	7.57	7.66
Control	7.55	7.39	7.39	7.47	7.63
GM	7.68	7.59	7.63	7.64	7.46
F-test	NS	**	**	*	**
C.D. (P=0.05)	-	0.45	0.29	0.32	0.38
SEm±	0.16	0.15	0.10	0.11	0.13

$F_1S_1b_1$– Proso (30%): Wheat (60%): Shepu (0.50%): Barnyard (9.50%)
$F_1S_2b_2$– Proso (30%): Wheat (60%): Shepu (1.00%): Barnyard (9.00%)
$F_1S_3b_3$– Proso (30%): Wheat (60%): Shepu (1.50%): Barnyard (8.50%)
$F_1S_4b_4$– Proso (30%): Wheat (60%): Shepu (2.00%): Barnyard (8.00%)
Control– Proso (30%): Wheat (60%)
NS=Non-significant; *= Significant; **= Highly significant

Table 8 : Mean sensory scores of shepu enriched proso millet based multi grain pasta products having foxtail millet

Millet formulation	Colour	Texture	Flavour	Taste	Overall acceptability
$F_1S_1f_1$	7.80	7.10	7.67	7.60	7.60
$F_1S_2f_2$	7.70	7.10	7.65	7.43	6.95
$F_1S_3f_3$	7.76	8.02	8.03	8.10	8.12
$F_1S_4f_4$	7.20	7.20	6.78	6.75	7.30
Control	7.55	7.39	7.39	7.47	7.63
GM	7.53	7.36	7.30	7.41	7.40
F-test	**	**	**	**	**
C.D. (P=0.05)	0.39	0.42	0.41	0.37	0.32
SEm±	0.14	0.15	0.14	0.13	0.11

$F_1S_1f_1$– Proso(30): Wheat(60): Shepu(0.50): Foxtail(9.50)
$F_1S_2f_2$– Proso(30): Wheat(60): Shepu(1.00): Foxtail (9.00)
$F_1S_3f_3$– Proso(30): Wheat(60): Shepu(1.50): Foxtail (8.50)
$F_1S_4f_4$– Proso(30): Wheat(60): Shepu(2.00): Foxtail (8.00)
Control– Proso(30): Wheat(60); **– Highly significant

Organoleptic quality of various proso millet based, enriched multi grain pasta products after storage :

Before and after 3 months of storage, organoleptic evaluation of proso millet based multi grain pasta products for colour, texture, flavour, taste and overall acceptability was carried out. A declining trend of sensory scores with storage was observed in the pasta products for all the sensory parameters namely, colour, texture, flavour, taste and overall acceptability. However, the reduction in sensory scores was slightly more pronounced in the products stored in poly

Table 9 : Mean sensory scores of shepu enriched proso millet based multi grain pasta products having kodo millet

Millet formulation	Colour	Texture	Flavour	Taste	Overall acceptability
$F_3S_1k_1$	7.64	7.68	7.73	7.66	7.60
$F_3S_2k_2$	8.09	7.92	7.96	7.87	8.01
$F_3S_3k_3$	7.83	7.68	7.61	7.53	7.64
$F_3S_4k_4$	7.47	7.70	7.39	6.83	7.15
Control	7.55	7.39	7.39	7.47	7.63
GM	7.71	7.71	7.64	7.51	7.59
F-test	**	NS	**	**	**
C.D. (P=0.05)	0.26	–	0.25	0.26	0.28
SEm±	0.09	–	0.09	0.09	0.10

$F_3S_1k_1$: Proso (50%): Wheat (40%): Shepu (0.50%): Kodo (9.50%)
$F_3S_2k_2$: Proso (50%): Wheat (40%): Shepu (1.00%): Kodo (9.00%)
$F_3S_3k_3$: Proso (50%): Wheat (40%): Shepu (1.50%): Kodo (8.50%)
$F_3S_4k_4$: Proso (50%): Wheat (40%): Shepu (2.00%): Kodo (8.00%)
Control: Proso (60%): Wheat (40%)

Table 10 : Mean sensory scores of shepu enriched proso millet based multi grain pasta products having little millet

Millet formulation	Colour	Texture	Flavour	Taste	Overall acceptability
$F_3S_1l_1$	7.67	7.42	7.38	7.48	7.54
$F_3S_2l_2$	7.58	7.40	7.60	7.60	7.50
$F_3S_3l_3$	8.05	8.01	8.05	8.02	8.12
$F_3S_4l_4$	7.45	7.20	7.31	7.34	7.41
Control	7.55	7.39	7.39	7.47	7.63
GM	7.58	7.52	7.58	7.57	7.62
F-test	**	**	**	**	**
C.D. (P=0.05)	0.25	0.20	0.33	0.32	0.21
SEm±	0.09	0.07	0.12	0.11	0.07

$F_3S_1l_1$: Proso (50%): Wheat (40%): Shepu (0.50%): Little (9.50%)
$F_3S_2l_2$: Proso (50%): Wheat (40%): Shepu (1.00%): Little (9.00%)
$F_3S_3l_3$: Proso (50%): Wheat (40%): Shepu (1.50%): Little (8.50%)
$F_3S_4l_4$: Proso (50%): Wheat (40%): Shepu (2.00%): Little (8.00%)

Table 11 : Effect of initial dough moisture content on cooking quality of shepu enriched proso millet based multi grain pasta

Millet formulations	Moisture content (%)								
	30%			33%			35%		
	Cooking time (min)	Swelling power (g/g)	Solid loss (%)	Cooking time (min)	Swelling power (g/g)	Solid loss (%)	Cooking time (min)	Swelling power (g/g)	Solid loss (%)
$F_1S_3b_3$	7.24	2.15	4.80	8.40	2.07	5.00	8.00	2.03	5.15
$F_1S_3f_3$	7.33	2.20	6.25	8.80	2.10	6.45	7.85	2.04	6.45
$F_3S_2k_2$	7.45	1.93	8.20	8.10	1.87	8.25	7.80	1.85	8.10
$F_3S_3l_3$	7.15	1.89	7.80	8.70	1.79	8.00	7.95	1.77	7.75
Control	7.15	2.06	8.65	7.15	2.06	8.65	7.15	2.06	8.65

$F_1S_3b_3$- Proso (30%): Wheat (60%): Shepu (1.50%): Barnyard (8.50%)
$F_1S_3f_3$- Proso(30): Wheat(60): Shepu(1.50): Foxtail (8.50)
$F_3S_2k_2$- Proso (50%): Wheat (40%): Shepu (1.00%): Kodo (9.00%)
$F_3S_3l_3$- Proso (50%): Wheat (40%): Shepu (1.50%): Little (8.50%)
Control- Proso (60%): Wheat (40%)

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propylene packages when compared to LDPE package and, therefore, the later was preferable than the former. Decrease in sensory scores of food products is common during storage since the stored products normally undergo subtle quality changes and loose their appeal.

Influence of storage on tri-stimulus colour parameters of proso millet based multi grain pasta products :

The influence of different packaging material and storage duration on the tri-stimulus color values (L*, a*, b*) of the proso millet based shepu enriched multi grain pasta products were analyzed. It was observed that the lightness (whiteness) factor L* of proso millet pasta decreased both in PP and LDPE packages during three months of ambient storage. The reduction in L* value of pasta was less pronounced in LDPE package than in PP package and the products stored in PP became slightly duller than in LDPE package. However, the type of package, storage duration and the interaction effect on L* and b* values of pasta remained non significant. The a* value of the proso millet based pasta slightly increased in the PP package that indicated a slight deviation from reddish to greenish tint. The type of package, storage duration and interaction effect on a* value of pasta were highly significant.

Barnyard millet incorporated proso millet pasta was found to be satisfactory in course of storage with respect to colour because the deviation of all the colour parameters remained non significant.

In the proso millet based pasta products developed with the addition of foxtail millet in the formulation, the results of colour change remained satisfactory only with respect to the lightness value 'L'.

The effect of storage duration and packaging material on color parameters of kodo millet formulated proso millet pasta was found to be non significant.

The selected proso millet based pasta with little millet incorporation was found to be highly significant with respect to the colour parameter a* in course of its storage.

In the studies of Petitot *et al.* (2010), while faba bean flour was incorporated into semolina pasta, an increase in a* colour value was observed. An increase in redness or a* value also attributes to the Maillard reaction or non- enzymatic browning that happens during drying of pasta.

Effect of storage on microbial counts in proso millet based multi grain pasta products :

From the microbial studies conducted on the selected pasta products at one month intervals, the yeast and mould counts in pasta were observed to be negligible even at the end of storage. The dryness of the products and thus comparatively lesser water activity of the pasta can be attributed to have prevented microbial growth. Similar trend was reported by Sudhadevi *et al.* (2013) for pasta products.

Effect of storage on textural properties of proso millet based multi grain pasta products :

The textural characteristics of proso millet based multi grain pasta products before and after storage for three months in LDPE and PP packages indicated that the hardness of the pasta products in the LDPE package considerably increased while the change was not predictable in PP packaged pasta. Variation in textural properties during storage of extruded products was also reported by Anton and Luciano (2007) for
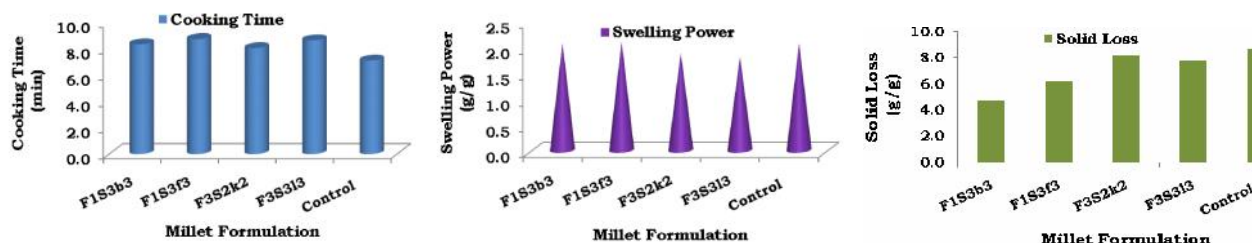

Fig. 1 : Cooking characteristics of proso millet based multi grain pasta extruded with dough at 33% moisture content
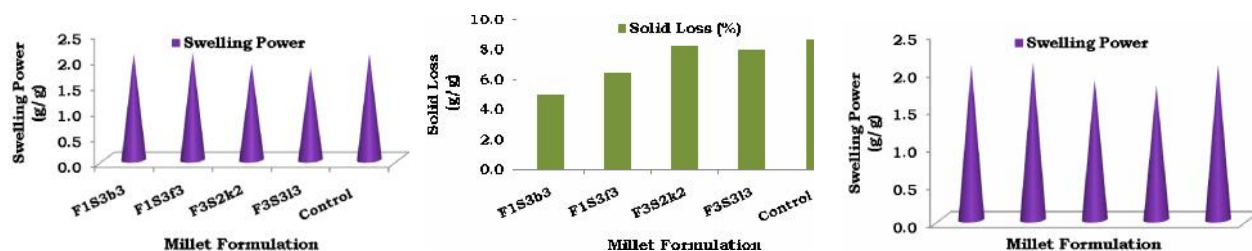

Fig. 2 : Cooking characteristics of proso millet based multi grain pasta extruded with dough at 33% moisture content

the snack products and Balasubramanium *et al.* (2011) for composite flour product with whole pearl millet, finger millet and decorticated soy bean.

Cost rconomics of production of small millet based pasta products :

The cost economics was worked out taking into account all aspects of fixed and variable costs involved in the production of proso millet based multi grain pasta products. The cost: benefit ratio for different pasta products packaged in

LDPE film (best) was: proso-foxtail pasta - 1:1.92, proso-little pasta -1:1.74, proso – kodo pasta - 1:1.76, proso - barnyard pasta -1:1.90. Since all the cost: benefit ratios were favourable, it can be recommended to manufacture proso millet based multi grain pasta products. Similar work related to the present work was also done by Carini *et al.* (2013a and b); Lakshmi *et al.* (2013); Nisha *et al.* (2012); Rao and Deosthale (1993); Rathod and Udipi (1991); Vijayakumar and Mohankumar (2009) and Zardetto and Rosa (2009).

LITERATURE CITED

AACC (2000). Approved Methods of the American Association of Cereal Chemists (10th Edn.) - Moisture determination 44(15A). Minnasota, St. Paul.

Balasubramanium, S., Singh, K.K. and Patil, R.T. (2011). Quality evaluation of millet-soy blended extrudates formulated through linear programming. *J. Food. Sci. Tech.,* **49** (4) : 450-458.

Carini, E., Curti, E., Cassotta, F., Najm, N.E. and Vittadini, E. (2013a). Physico-chemical properties of ready to eat, shelf-stable pasta during storage. *J. Food Chem.,* **144** : 74-79.

Carini, E., Curti, E., Cassotta, F. and Vittadini, E. (2013b). Water dynamics of ready to eat shelf stable pasta meals during storage. *J. Innovative Food Sci. & Emerging Technol.,* **17** : 163-168.

Lakshmi, D.N., Aparna, K. and Kalpana, K. (2013). Utilization of fish mince in formulation and development of pasta products. *Internat. Food Res. J.,* **20**(1) : 219-224.

Malleshi, N.G. and Hadimani, N.A. (1993). Studies on milling, physico-chemical properties, nutrient composition and dietary fibre content of millets. *J. Food Sci. Technol.*, **30**(1) : 17-20.

Nisha, A., Mike, J. and Christopher, M.F. (2012). Effect of inulin soluble dietary? bre addition on technological, sensory, and structural properties of durum wheat spaghetti. *J. Food Chem.,* **132** : 993-1002.

Rao, D.S. and Deosthale, Y.G. (1983). Mineral composition, ionizable iron and soluble zinc in malted grains of pearl millet and ragi. *J. Food Chem.,* **11**(1) : 217-223.

Rao, M.A. (1986). Rheological properties of fluid foods. In: engineering properties of foods, M.A. Rao & S.S.H. Rizvi (Eds.), pp. 1-48.

Rathod, P. and Udipi, S.A. (1991). The nutritional quality and acceptability of weaning foods incorporating amaranth. *Food and Nutri. Bull.* (13), The United Nations University, USA.

Subir Kumar Chakraborty, Daya S. Singh, Kumbhar, B.K. and Singh, Dheer (2009). Process parameter optimization for textural properties of ready-to-eat extruded snack food from millet and legume pieces blends. *J.Text. Stu.,* **40** (6): 710 - 726.

Sudha Devi, G., Palanimuthu, V. and Arun Kumar, P. (2013). Development of proso millet based cold extruded product. *J. Environ. & Ecol.,* **31**(1A) : 212-215.

Vijayakumar, P.T. and Mohankumar, B.J. (2009). Formulation and characterization of millet flour blend incorporated composite flour. *Internat. J. Agri. Sci.*, **1**(2) : 46-54.

Zardetto, S. and Rosa, M.A. (2009). Effect of extrusion process on properties of cooked, fresh egg. *J. Food Engg.*, **92** (1) : 70–77.

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