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Development of Ready to cook Kodo millet pasta

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Abstract
Kodo millet is a tropical small millet crop, indigenous to India and grown for grain fodder purpose. The
grain is composed of 66.6 g of carbohydrates, 8.3 g of protein, 3.6 g of fat, 2.6 g of minerals, 9 g of fibre
and 353 k. cal of energy per 100 g which is comparable to other millets. Realizing the awareness of the
consumers towards the nutritional and health constituents present in processed products, it is important to
develop the product which could satisfy the nutritional need as well as the health promoting properties in
the processed products.
In this study ready to cook Kodo millet pasta was standardized with varying proportions of Kodo millet
flour, wheat flour and fine semolina. The ready to cook Kodo millet pasta can be consumed up to four
and half months without any deterioration in the product. The results illustrate that 100 g sample of ready
to cook Kodo millet pasta contains 0.94% ash, 8.31% moisture, 10.50% protein, 1.29% fat, 1.25% crude
fiber, 78.96% carbohydrates, 1.55 mg of iron, 2.35 mg of zinc and 28.65 mg of calcium.

Keywords: Kodo millet, ready to cook pasta, extrusion, storage study

Introduction

Kodo millet [*Paspalum scrobiculatum* (L.)] is a tropical small millet crop, indigenous to India
and grown for grain and fodder purpose. It is commonly known as rice grass, cow grass and
ditch millet. It belongs to Paniceae tribe of Poaceae family and is a wild annual self-pollinating
crop of paspalum genus. Kodo millet is widely distributed in damp habitats across the tropical
and subtropical countries such as Phillipines, Indonesia, Vietnam, Thailand and West Africa.
In India Madhya Pradesh, Tamil Nadu, Rajasthan, Uttar Pradesh, Andhra Pradesh and West
Bengal have rich genetic diversity of millets. Kodo millet is a monocot and an annual tufted
grass that grows to heights of approximately four feet. The grain is enclosed in hard, corneous,
persistent husks that are difficult to remove. The grain may vary in colour from light red to
dark grey. Kodo millet is highly nutritious and a good substitute to rice or wheat. The grain is
composed of 66.6 g of carbohydrates, 8.3 g of protein, 3.6 g of fat, 2.6 g of minerals, 9 g of
fibre and 353 k.cal of energy per 100 g which is comparable to other millets
(https://millets.res.in/millets_info.php). Kodo millet is very easy to digest; it contains a high
amount of lecithin and is excellent for strengthening the nervous system.
Kodo millets are rich in B vitamins, especially niacin, B6 and folic acid, as well as the
minerals such as calcium, iron, potassium, magnesium and zinc. Regular consumption of kodo
millet is very beneficial for post menopausal women suffering from signs of cardiovascular
disease, like high blood pressure and high cholesterol levels. Realizing the awareness of the
consumers towards the nutritional and health constituents present in processed products, it is
important to develop the product which could satisfy the nutritional need as well as the health
promoting properties in the processed products.
The worldwide acceptance of pasta is attributed to its low cost, ease of preparation, versatility,
good sensory quality and long shelf life. Pasta being a wheat based product, is a good source
of carbohydrates (74–77%, dry basis) (Monge *et al.*, 1990) [9] and proteins (11–15%, db) but
deficient in lysine and threonine (Abdel-Aal and Hucl 2002) [1]. This provides an opportunity
for the use of non-traditional raw materials to increase the nutritional quality of pasta (Del
Nobile *et al.* 2005). Nowadays health conscious consumers also demand food products, which
contain health promoting food materials or ingredients. The aim of this work is to develop the
ready to cook kodo millet pasta.

Materials and Methods
Description of pasta machine
The laboratory model of *italic* pasta machine was a small, compact, cold extruder. The unit has

single screw extruder with a short screw of uniform pitch powered by 1hp electrical motor.

Procurement of the raw materials
Kodo millet and other ingredients were procured from local market of Dharwad city for the development of ready to cook Kodo millet pasta. The details of the procedure are given in the flow chart Fig 1. With the variation of the kodo millet flour and other ingredients product was standardized.
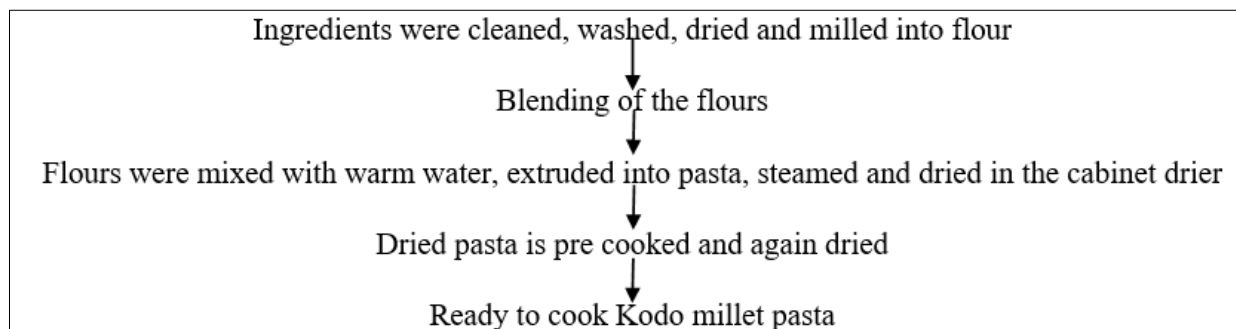
Ingredients were cleaned, washed, dried and milled into flour

↓

Blending of the flours

↓

Flours were mixed with warm water, extruded into pasta, steamed and dried in the cabinet drier

↓

Dried pasta is pre cooked and again dried

↓

Ready to cook Kodo millet pasta

Fig 1: Procedure for preparation of ready to cook Kodo millet pasta

Development of the ready to cook Kodo millet pasta
Wheat flour having particle size distribution 420 microns (40.457%) and Kodo millet flour having particle size distribution 420 microns (47.592%) were sieved and mixed in various proportions, warm water was added to moisten the flour and the mix was extruded in extruder machine with the cutting knife speed 7 in pasta maker. The process of extrusion with various ingredients is standardized. Extruded pasta was steamed for 5 minutes and then dried in cabinet drier for 4 hours at $75°±5 °$C.

To prepare instant kodo millet pasta pre cooking is required. Hence pre cooking for 5 minutes in boiling water was carried out after steam drying of samples. Characteristics of semolina and the Maillard reactions that occur in food processing affect technological and sensory properties of pasta (R. Acquistucci, 1996) [11].

Cooking quality of ready to cook Kodo millet pasta
Cooking quality is considered as the most important quality characteristics of pasta. Cooking time, cooking loss, water absorption index, swelling index and texture are the parameters that determine the cooking quality.

Swelling power: Swelling power of pasta products was determined by method proposed by Schoch (1964) [12]. A known weight (10 g) of pasta was cooked in a glass beaker with 10 times its quantity of boiling water (100 ml) for 5 minutes over a water bath maintained at 100° C. 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:

$$\text{Swelling power}\left(\frac{g}{g}\right) = \frac{W_2 - W_1}{W_1} \qquad \ldots..(1)$$

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 swelling power section. 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 $105 ± 2 °$C for 1 hour. The Petri dish was again weighed with the dry solids. Then the solid loss was calculated as:

$$\text{Solid loss(\%)} = \frac{m_2 - m_1}{m_0} \times 100 \qquad \ldots..(2)$$

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 stability of ready to cook Kodo millet pasta
Storage stability of developed ready to cook Kodo millet pasta product was studied at ambient conditions by storing them in Aluminium foil pouches (150 g per pack). The packed samples were stored at ambient conditions of Dharwad (during September – February) for six months. The stored pasta was periodically analyzed at 15 days intervals and evaluated for changes in moisture content, free fatty acid content and sensory qualities.

Moisture content: A known quantity of sample was weighed into previously weighed moisture cups and dried in a hot air oven at 98 to 100° C to a constant weight (AOAC 2005). Moisture content was calculated using the formula

$$\text{Moisture content (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Weight of the sample}} \times 100 \qquad \ldots..(3)$$

Free fatty acid content (% acid value): The amount of free fatty acid content present in the ready to cook kodo millet pasta indicates the quality of fat in foods. Standard procedure was used to estimate the free fatty acid content of ready to cook Kodo millet pasta.
Reagents used are 1% phenolphthalein in 95% ethanol, 0.1 N potassium hydroxide and Neutral solvent: Mix 25 ml diethyl ether, 25 ml 95% alcohol and 1 ml of 1% phenolphthalein solution and neutralize with N/10 alkali.

Procedure: 50g of sample was added in 1:1 chloroform and methanol mix (150ml: 150ml). The mixture kept overnight and extract was filtered. In a conical flask 25 ml of filtrate was added with 50 ml of hot neutral alcohol and 3-4 drops of

phenolphthalein indicator. Titrate the contents against 0.1 N potassium hydroxide. Shake constantly until a pink colour which persists for fifteen seconds is obtained.

$$\text{Acid value (mg KOH/g)} = \frac{\text{Titre value} \times \text{Normality of KOH} \times 56.1}{\text{Weight of the sample (g)}} \quad …..(4)$$

Sensory evaluation of the developed products
300 ml of water was poured in a vessel and boiled. Then a pinch of salt, oil and ready to cook kodo millet pasta was added to the boiling water. The pasta was cooked on a medium flame for 3 minutes. Once done the pasta was drained to a colander. For seasoning oil was heated in a pan, added ginger garlic paste, onion and fried until they turn golden brown. Then added chilly powder, chilly sauce, soya sauce, vinegar, tomato sauce and properly mixed. Then sauce mixture cooked pasta was added and tossed gently till sauce gets coated well.

Semi - trained panelists (10) evaluated cooked pasta samples for sensory parameters using 9 point hedonic scale, where 1- dislike extremely, 2- dislike very much, 3- dislike moderately, 4- dislike slightly, 5- neither like nor dislike, 6- like slightly, 7- like moderately, 8- like very much and 9- like extremely by a semi trained panel of ten judges for the appearance, texture, flavor, taste and overall acceptability. Pasta products with an overall acceptability mean score above 5 were considered as acceptable (Bustos and others 2011). Acceptability index was calculated by summing up of all the sensory scores of appearance, texture, flavor, taste and overall acceptability and it was divided by maximum score (54) and multiplied by 100.

$$\text{Acceptability Index(AI)} = \frac{\text{Total scores} \times 100}{\text{Maximum score}} \quad …..(5)$$

Nutrient Composition of the ready to cook Kodo millet pasta
Nutrient composition of the ready to cook Kodo millet pasta was analyzed in the NABL accredited lab at PJTSAU, Hyderabad for nutrition labeling.

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

Results and Discussion
Trial 1
Trial 1 was carried out with increase in proportion of kodo millet flour along with other ingredients. From the Table 1 it is observed that there is decrease in the weight of the extruded

pasta as the increase in incorporation of kodo millet flour. But after drying the weight of the pasta increased from incorporation of kodo millet flour. The final yield of the pasta after drying ranged from 236 to 247 g. In a study conducted by Alfiya *et al.,* initial dough moisture content of 30 per cent (before extrusion) was taken as optimum for manufacturing of shepu enriched proso millet grain pasta which are on par with the current study when 33.33% of water was added.

Table 1: Production parameters of Kodo millet pasta with varying proportions of Kodo millet flour

Kodo millet flour (%)	Weight of pasta before steaming (g)	Weight of pasta after steaming (g)	Weight of pasta after drying (g)	Machine waste (g)
50	349.00	352.00	236.00	62.00
60	348.00	350.00	245.00	55.00
70	344.00	349.00	247.00	63.00

Table 2 reveals swelling power ranged from 2.1 to 2.4 g/g. As the percentage of Kodo millet flour increased the solid loss also increased from 3.33% to 5.38%.

Table 2: Cooking quality of Kodo millet pasta with varying proportions of Kodo millet flour

Kodo millet flour (%)	Swelling power (g/g)	Solid loss (%)
50	2.4	3.33
60	2.1	4.68
70	2.3	5.38

Organoleptic evaluation (Table 3) revealed that Kodo millet pasta prepared from 50 per cent incorporation of Kodo millet flour had the highest acceptability index (84.07) followed by 60 per cent (71.85) and 70 per cent (66.85). Statistical significant difference was observed for appearance, taste, texture and overall acceptability among 50 to 70 per cent variation of Kodo millet flour. The most acceptable Kodo millet pasta with 50 per cent variation had the highest scores for appearance (8.00), colour (7.40), texture (7.00), taste (7.50), flavour (7.70) and overall acceptability (7.80).

Hence 50 per cent variation was selected for further trials. By noting the observation of cooked pasta, it is found that the perfect shape of pasta was not retained. To improve the texture and retain shape during cooking, it was decided to add fine semolina at varying levels to the 50 per cent variation of kodo millet pasta and assess best proportion. Gurkirat Kaur *et al.* 2012 [7] found that by enrichment with variable fiber sources improved the brightness of pasta, as colour of pasta enhanced significantly.

Table 3: Mean organoleptic scores of kodo millet pasta with varying proportions of kodo millet flour

Kodo millet flour (%)	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability	Acceptability index (%)
50	8.00 ±0.47	7.40 ±0.70	7.00±1.15	7.50 ±1.08	7.70±0.48	7.80±0.79	84.07
60	6.60 ±1.07	6.80 ±0.79	6.30±0.82	6.10±1.10	6.40±1.17	6.60 ±0.97	71.85
70	5.80±1.14	6.50±1.08	6.20 ±0.63	5.60±1.26	5.90±1.10	6.10±1.70	66.85
F	13.95	2.77	2.36	7.32	9.18	8.28	
S.Em	0.30	0.28	0.28	0.36	0.31	0.30	
CD	0.87**	NS	NS	1.06**	0.89**	0.88**	

*Significant at 5% level (*p*< 0.05), **Significant at 1% level (*p*< 0.01), NS: Non-significant, No. of replications: 10

Trial 2
To prepare instant kodo millet pasta pre cooking is required. Hence pre cooking for 5 minutes in boiling water was carried out after steam drying of samples. From the Table 4 it is

observed that as the percentage of fine semolina increased the weight of extruded pasta also increased. The similar trend was followed after steaming and after drying of pasta. The final yield after drying ranged from 214 to 250 g.

Table 4: Production parameters of kodo millet pasta with varying proportions of fine semolina

Variation (Fine semolina)	Weight of pasta before steaming (g)	Weight of pasta after steaming (g)	Weight of pasta after drying (g)	Machine waste (g)
R1	294.00	293.00	214.00	90.00
R2	324.00	322.00	243.00	49.00
R3	339.00	337.00	250.00	75.00

Incorporation of the fine semolina: R1 - 10%, R2 – 20%, R3 – 30%

Table 5 reveals that swelling power decreased as the increase in incorporation of fine semolina. Sosulski and Wu (1988) [13] reported that the incorporation of fiber ingredients into wheat flour increased water hydration values in proportional to the level of replacement. Composite flours containing 20 per cent of fiber sources had water hydration capacities that were 8 per cent greater than that of the control flour.

Solid loss of the ready to cook kodo millet pasta ranged from 6 to 12 per cent. Gurkirat Kaur (2012) [7] in a study found that there was an increase in the leaching of solids in cooked water by addition of cereal brans, mainly in case of 25 per cent durum wheat bran enriched pasta. Kunerth and Youngs (1984) [8] reported that greater cooking losses from spaghetti made with ground whole wheat than with semolina is due to disruptions in the gluten matrix by bran particles, along with the presence of water-soluble components within the bran and aleurone layers. The disruption in gluten matrix, along with space between bran particle and matrix in dried spaghetti could promote water absorption and expose starch granules to swelling and rupture.

Table 5: Cooking quality of ready to cook kodo millet pasta with varying proportions of fine semolina

| Variation	Swelling power (g/g)	Solid loss (%)
R1	1.6	6
R2	1.5	6
R3	1.3	12

According to Table 6 organoleptic evaluation revealed that acceptability index ranged from 78.43 to 86.02% where R2 had the highest acceptability index (86.02). Statistical analysis showed that there was significant difference in scores for flavour, taste and overall acceptability among R1, R2, R3 and R4. The most acceptable instant kodo millet pasta (R2) had the highest scores for appearance (7.80), colour (7.40), flavour (7.70), taste (7.90), texture (7.70), and overall acceptability (7.95).

The acceptability index (86.02) and scores for all parameters i.e, appearance, colour, flavour, taste, texture and overall acceptability are highest in R2 compared to other variations. Hence R2 was selected for further storage study. The results of study conducted by Alfiya are on par where in higher organoleptic scores (8.01) were achieved with 50 per cent proso millet, 9.00 per cent kodo millet incorporated shepu pasta.

Table 6: Mean organoleptic scores of kodo millet pasta with varying proportions of fine semolina

Variation	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability	Acceptability index (%)
R1	7.20 ±0.42	7.10 ±0.57	7.10 ±0.32	7.05 ±0.69	7.40 ±0.70	7.10 ±0.57	79.54
R2	7.80 ±0.63	7.40 ±0.84	7.70 ±0.67	7.90 ±0.74	7.70 ±0.67	7.95 ±0.50	86.02
R3	7.40 ±0.70	7.00 ±0.82	7.20 ±0.42	7.10 ±0.57	7.35 ±0.94	7.45 ±0.83	80.56
R4	7.05 ±0.76	7.10 ±0.74	7.00 ±0.67	7.20 ±0.63	6.90 ±0.88	7.10 ±0.99	78.43
F	2.57	0.54	3.28	3.62	1.67	2.87	
S.Em	0.20	0.24	0.17	0.21	0.26	0.24	
CD	NS	NS	0.49*	0.60*	NS	0.68*	

*Significant at 5% level ($p < 0.05$), **Significant at 1% level ($p < 0.01$), NS: Non-significant, No. of replications: 10

Dried sample   **Cooked sample**
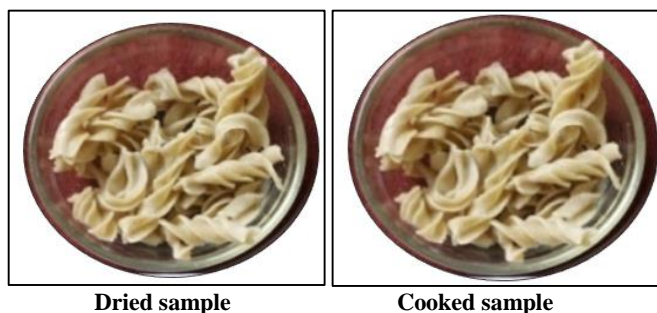
Fig 2: Developed ready to cook kodo millet pasta

Effect of storage on moisture content and free fatty acid content of ready to cook kodo millet pasta
The changes in the moisture content of the ready to cook kodo millet pasta during storage are shown in Table 7. The initial moisture content was 9.38%. After 150th day of storage (11.65%) there was significant increase in moisture content during the storage. Significant changes were found from 60th day. The increased moisture content was significant with five per cent level ($p < 0.05$). The highest moisture content was 11.65% and was seen at 150th day of storage. According to Gurkirat Kaur (2012) [7] significant increase in the moisture content may be due to the change in temperature conditions of the surroundings.

Storage period tangibly affected free fatty acid content of pasta. Free fatty acids for kodo millet enriched pasta increased with storage period, but the values remained in the acceptable range because of which, the taste, flavour and acceptability of pasta was not much affected. Free fatty acid content was 0.06 mg KOH/g on initial day and it increased to 0.07 mg KOH/g on 30th day, further it increased to 0.08 mg KOH/ g on 135th day and on 150th day it increased drastically to 0.39 mg KOH/g. Significant changes were found from 150th day.

Effect of storage on organoleptic quality of ready to cook kodo millet pasta

The storage quality and acceptability of the product depend on the changes that take place during storage and method of handling which have a high impact on the shelf life of the food thus affect the acceptability. The sensory acceptability of the ready to cook kodo millet pasta were assessed on each withdrawal during storage period and recorded in terms of appearance, colour, flavor, texture, taste and overall acceptability and are presented in the Table 8. There were significant changes in the appearance, colour, flavour, taste, texture and overall acceptability. The highest overall acceptability were observed at 0, 1, 2 and 3 months of storage. On 150th day rancidity was observed and the shape was not retained after cooking hence the study was discontinued. Payumo et al. (1969) [10] studied the organoleptic test for the coco noodles prepared from wheat, coco and mung bean flour in ratio of 50:30:10. The noodles were acceptable over a storage period of 6 months.

Table 7: Effect of storage on moisture and free fatty acid content of ready to cook kodo millet pasta

Storage Days	Parameters	
	Moisture (%)	Acid Value (mg KOH/g)
Initial day	9.38±0.19	0.06
15	9.65±0.32	0.06
30	9.83±0.02	0.07
45	9.98±0.03	0.07
60	10.23±0.11	0.07
75	10.88±0.21	0.07
90	11.02±1.23	0.07
105	11.06±0.19	0.07
120	11.45±0.02	0.07
135	11.47±1.25	0.08
150	11.65±0.12	0.39
F	6.49	4754.6
S.Em±	0.17	0.01
CD	0.51**	0.03**

*significant at 5% level, ** significant at 1% level, NS- Non significant, No. of replications: 3

Table 8: Effect of storage on sensory parameters of ready to cook kodo millet pasta during storage

Storage days	Appearance	Colour	Flavor	Taste	Texture	Overall acceptability
Initial day	7.90±0.88	7.70±0.95	7.40±0.52	7.60±0.97	7.20±0.92	7.40±0.70
15	8.10±0.74	7.70±0.48	7.80±0.42	7.70±0.48	7.70±0.48	7.70±0.48
30	7.80±0.63	7.90±0.57	7.90±0.57	8.00±0.47	7.80±0.42	7.70±0.48
45	8.10±0.74	7.70±0.95	7.70±0.95	7.70±0.82	7.50±0.85	7.70±0.67
60	7.90±0.58	7.90±0.74	7.70±0.67	7.60±0.70	7.40±0.52	7.50±0.53
75	7.80±0.42	7.80±0.42	7.80±0.63	7.50±0.70	7.40±0.70	7.70±0.67
90	7.90±0.58	7.90±0.57	7.85±0.67	7.45±0.89	7.10±0.99	7.50±0.85
105	7.00±0.067	6.50±0.53	6.60±0.52	6.50±0.70	6.35±0.47	6.70±0.67
120	6.70±0.48	6.60±0.52	6.60±0.84	6.50±0.70	6.50±0.53	6.70±0.48
135	6.90±0.88	6.60±0.70	6.40±0.70	6.40±0.84	6.50±0.53	6.20±0.63
F	6.17	8.17	8.08	6.27	6.08	7.42
S.Em±	0.21	0.21	0.21	0.24	0.21	0.20
CD	0.60**	0.59**	0.59**	0.66**	0.60**	0.56**

*significant at 5% level, ** significant at 1% level, NS- Non significant, No. of panellists: 10

Nutrient Composition of the ready to cook kodo millet pasta

Nutrient composition of the ready to cook kodo millet pasta (Table 9) was analyzed from the PJTSAU accredited laboratory for nutrition labeling, it was found that in 100 g sample there is 0.94% ash, 8.31% moisture, 10.50% protein, 1.29% fat, 1.25% crude fiber, 78.96% carbohydrates, 1.55 mg of iron, 2.35 mg of zinc and 28.65 mg of calcium. In a study conducted by Abdallah B and *et al.* the rice pasta produced had 7.92% protein, 2.3% fat, 1.37% ash and 1.31% crude fibre. Compared to rice pasta kodo millet pasta has the less fat and high protein content.

Table 9: Nutrient Composition of the ready to cook kodo millet pasta

Nutrients	Values/100g
Moisture (%)	8.31
Protein (g)	10.50
Fat (g)	1.29
Crude fiber(g)	1.25
Ash (g)	0.94
Carbohydrate (g)	78.96
Energy (kcal)	369
Iron (mg)	1.55
Zinc (mg)	2.35
Calcium (mg)	28.65

Conclusion

In the present study "Ready to cook kodo millet pasta" was

standardized with varying proportions of kodo millet flour and other ingredients. The standardized formula was kept for the storage study and it can be consumed up to four and half months without any deterioration in the product. The results illustrate that Ready to cook kodo millet pasta had highest calcium (28.65 mg / 100 g) content.

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