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Development of value added *Khakara* from barny ard millet: Consumer acceptability, nutritional and shelf- life evaluation

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■ **ABSTRACT :** Barnyard millet is one of the important underutilized nutritious minor millets. It is also called as Japanese Barnyard millet, *Ooda, Oodalu, Sawan and Sanwank*. In developing countries like India with increasing urbanization, the demand for ready-to-eat food is increasing popularly. *Khakara* is one of the famous traditional Gujrathi snacks commonly prepared from wheat flour and most preferred food item among all age groups. Hence, an attempt was made to develop value added barnyard millet *Khakara*. Three types of *Khakara* namely, plain, pulse and vegetable *Khakara* were developed. Trials were conducted by incorporating wheat flour, soybean flour and green gram *dal* flour and dehydrated carrot powder to barnyard millet flour at different levels for developing plain, pulse and vegetable *Khakara*, respectively. Consumer acceptability studies were also conducted for the best accepted *Khakara.* The nutrient composition and shelf- life evaluation of the developed *Khakara* were estimated by following standard procedures. The findings indicated that plain *Khakara* repared with 40 per cent incorporation of wheat flour to barnyard millet, pulse *Khakara* with 10 per cent incorporation of soybean flour and green gram *dal* flour and vegetable *Khakara* with 10 per cent incorporation of dehydrated carrot powder were best accepted. Forty per cent of the consumers liked extremely plain *Khakara*. There was significant increase in the macro and micronutrient composition of *Khakara* in pulse and vegetable *Khakara* when compared to plain *Khakara*. The developed *Khakara* had a shelf life 45-60 days. The moisture and free fatty acid content of the stored *Khakara* were within the BIS specification

■ **KEY WORDS:** Barnyard millet, *Khakara*, Nutrient composition, Consumer acceptability

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Millet is a collective term referring to a number of small-seeded annual grasses. Millets belong to various genera in the subfamily 'Ponicoideae', that are a part of the grass family 'Poaceae'. They possess remarkable ability to survive under severe drought conditions. Millets have been food commodities since ancient times. Because of their important nutritional qualities, there is a need to revive their usage in daily diet. Millets can substitute major cereals for better health benefits. Among minor millets, barnyard millet (*Echinochloa frumentacea* Link) is an important minor millet having fair amounts of protein (12%) that is highly digestible (81.13%) coupled with low carbohydrate content (58.56%) of slow digestibility *i.e.,* 25.88 per cent (Veena, 2003). The dietary fibre is an important phytochemical component of barnyard millet (13% total dietary fibre with 4.66 and 8.18% of soluble and insoluble fractions, respectively) that could be considered in the management of disorders like diabetes mellitus, obesity, hyperlipidemia, etc.

Supplementation of cereal based products with millets has become increasingly popular due to nutritional and economic advantages. With proper preparation, 30 per cent of minor millets can be gainfully substituted for value added foods such as bakery products, extruded foods, ready-to-eat and allied mixes for the convenient preparation by rural and town folk at low cost. Thus, the characteristic nature of

minor millet with high yielding capacity, disease resistant, tolerant to adverse conditions and with better nutritive value in terms of complex carbohydrate and high dietary fibre render their suitability for the development of convenience, therapeutic and ready-to-eat (RTE) products. Further, in the present existing situation of the society, it is the need of the day to exploit the positive nutritional benefits of millets and popularize them among all sectors of the society for achieving nutritional and therapeutic food security.

Thus, for the health conscious in the present world, minor millet especially Barnyard millet is perhaps one more addition to the existing list of healthy foods, owing to its nutritional superiority. Apart from this, the grain has high utilization potential owing to its excellent capacity to blend with other food grains without imparting any off flavour or aftertaste. Thus, the millet can be incorporated in traditional foods and valuarized to novel food uses (Veena, 2003). Hence, the present investigation was undertaken to develop value added *Khakara* from barnyard millet and to evaluate for consumer acceptability and nutritional efficiency.

■ RESEARCH METHODS

Processing of raw ingredients:

Barnyard millet constituted the main ingredient and other ingredients such as wheat flour, soybean, green gram *dal* and carrot were added either as a source of lysine, antioxidants, minerals and dietary fibre. Millet grains, wheat and green gram *dal* were made into fine flour (sieve mesh No. 65 mics). The soy flour was made by roasting the whole soybean, made into *dal* by passing through household grinder. The ground *dal* was cleaned and separated from husk and then made into fine flour (sieve mesh No. 65 mics) with the help of domestic electric mixture, which was then used for preparation of value added *Khakhara*. Fresh carrots were washed, peeled, grated and then dried in cabinet drier (Temp. 50-55°C for 3 hrs). After drying, the carrot gratings were powdered using electric grinder and stored in air tight container for further use.

Product development:

Three types of *Khakara's* namely plain, pulse and vegetable *Khakara* were prepared with barnyard millet. Wheat flour was added to barnyard millet at 20, 30 and 40 per cent level to prepare plain *Khakara.* Three variations of pulse *Khakara* were developed. Each variation comprised of barnyard millet flour: wheat flour: soybean flour: and green gram dal flour in the ratio of 40:40:10:10 (variation I), 30:40:15:15 (variation II) and 20:40:20:20 (variation III). For development of vegetable *Khakara,* dehydrated carrot powder was incorporated in barnyard millet flour. Different variations comprised of barnyard millet flour: wheat flour: dehydrated carrot powder in the ratio as (55:40:5; variation I), (50:40:10; variation II) and (45:40:15; variation III).

Organoleptic evaluation:

The value added barnyard millet *Khakara* was evaluated for organoleptic quality attributes by ranking the responses using a 5 point ranking scale (Amerine *et al.*, 1965) by a panel of fifteen-twenty semi-trained judges.

Consumer acceptance:

An evaluation proforma was developed to note the consumer acceptance and the response of consumers towards the developed *Khakara* was recorded. Consumers were requested to give their individual opinion/acceptance about the developed *Khakara*. The individuals were given separate proforma to record their observation.

Nutritional quality:

The proximate principles namely, protein, fat, carbohydrate, total ash, crude fibre, vitamins such as vitamin C, total and β-carotene and minerals such as iron, calcium, magnesium and phosphorus content of all the three types of *Khakara* has been assessed following the standard AOAC methods (Anonymous,1983).

Each selected developed value added *Khakara* was analyzed in triplicate for moisture, protein, fat, total mineral, iron, calcium, magnesium, phosphorus, vitamin C, total and β-carotene and total and reducing sugars. Moisture, fat and total minerals were estimated by AOAC (2005) method. The crude fibre in developed *Khakara* was analysed by the procedure given by AOAC (1990).While protein and carbohydrate contents were found out by (NIN, 1983). The energy content of value added *Khakara* was computed by summing up the values obtained by multiplying the values with Atwater constants for carbohydrates, crude fat and protein with 4, 9 and 4, respectively. The products were analysed for total sugars using Anthrone method (Thayumanavan and Sadasivam, 1984). Reducing sugars were determined by Nelson-Somogyi method (Somogyi, 1952). Vitamin C by titration method (A.O.A.C.,1984) and total and β-carotene was estimated by procedures given by Zakaria *et al.* (1979). Iron, calcium and magnesium were analyzed by Atomic Absorption Spectrophotometer (AAS) (Model:AAS Analyst 700). Phosphorus was calculated by using food composition tables (Gopalan *et al.*, 2004).

Statistical analysis:

The analysis of variance (ANOVA) was used to find out significant differences between the variations for different sensory characters, and nutrient content (Panse and Sukhatme, 1985).

■ RESEARCH FINDINGS AND DISCUSSION

Trials for standardization of *Khakara* carried out for inclusion of different ingredients revealed that plain *Khakara* developed by incorporating 40 per cent wheat flour

was highly acceptable. The mean acceptability scores for *Khakara* prepared with incorporation of wheat flour are presented in Table 1. The overall acceptability scores ranged from 1.00 (variation I) to 4.60 (variation IV) with highest score for *Khakara* prepared with 40 per cent incorporation of wheat flour. The mean scores for acceptability ranged from 2.85 to 3.22 with lowest score for flavour and highest score for colour, respectively. Variation IV had significantly higher ($p<0.05$) score for colour, taste and texture over other three variations. However, variation II and variation III were at par for all the sensory characters except for overall acceptability. Variation I had significantly lower ($p<0.05$) scores over all other variation for all sensory parameters. The overall acceptability scores increased as the level of incorporation of wheat flour increased.

Table 1: Acceptability scores of plain *Khakara*

Variations	Mean value of sensory score				
	Colour	Taste	Texture	Flavour	Overall acceptability
I	1.70	1.20	1.20	1.00	1.00
II	3.20	3.00	3.00	2.70	3.10
III	3.50	3.00	3.10	3.10	3.90
IV	4.50*	4.40*	4.60*	4.60*	4.60*
Mean	3.22	2.90	2.97	2.85	3.15
S.E.+	0.20	0.18	0.15	0.19	0.16
C.D.	0.55	0.50	0.43	0.53	0.46

* indicate significance of value at P=0.05

The mean acceptability scores for *Khakara* prepared with incorporation of pulses to barnyard millet are presented in Table 2. There was a significant difference among all the variations for different sensory characters. The mean scores for acceptability ranged from 3.30 to 3.83 with lowest score for taste and highest score for colour, respectively. Variation I scored significantly higher ($p<0.05$) values for all the sensory parameters when compared to variation II and variation III. The scores of variation II and variation III were at par for all the sensory characters. The overall acceptability scores decreased as the level of incorporation of pulses increased. The overall acceptability score ranged from 2.80 (III variation) to 4.80 (I variation) with highest score for *Khakara* prepared with 10 per cent incorporation of pulses.

Table 2: Acceptability scores of pulse *Khakara*

Variation	Mean value of sensory score				
	Colour	Taste	Texture	Flavour	Overall acceptability
I	4.50*	4.60*	4.70*	4.70*	4.80*
II	3.60	2.80	2.80	2.80	3.00
III	3.40	2.50	2.50	2.50	2.80
Mean	3.83	3.30	3.33	3.33	3.53
S.E.+	0.16	0.17	0.15	0.21	0.23
C.D.	0.47	0.51	0.43	0.61	0.68

* indicate significance of value at P=0.05

The mean acceptability scores for *Khakara* prepared with incorporation of carrot powder to barnyard millet are presented in Table 3. The mean scores for acceptability ranged from 3.53 to 4.06. Except for texture, variation II had significantly higher ($p<0.05$) values over variation I and variation III for colour, taste, flavour and overall acceptability. However, variation I and variation III were at par for all the sensory characters. The overall acceptability scores ranged from 3.00 (variation I and III) to 4.30 (variation II) with highest score for *Khakara* prepared with 10 per cent incorporation of carrot powder.

Table 3: Acceptability scores of vegetable *Khakhra*

Variations	Mean value of sensory score				
	Colour	Taste	Texture	Flavour	Overall acceptability
I	3.20	3.10	3.90	3.10	3.00
II	4.50*	4.50**	4.30	4.30*	4.30*
III	3.40	3.00	4.00	3.00	3.00
Mean	3.70	3.53	4.06	3.46	3.43
S.E.+	0.21	0.23	0.18	0.23	0.22
C.D.	0.62	0.69	NS	0.68	0.66

NS=Non- significant * and** indicate significance of value at P=0.05 and 0.01, respectively

Table 4 shows the consumer acceptance of developed *Khakara*. It is evident from the Table 4 that maximum per cent of consumers 'like extremely' the plain *Khakara* (40.00%) followed by pulse *Khakara* (36.67%) and vegetable *Khakara* (33.33%). Both plain and pulse *Khakara* were 'liked slightly' by sixty per cent of the consumers. While, 61.67 per cent of the consumers 'liked slightly' vegetable *Khakara*. Only few per cent of consumers said that pulse *Khakara* (3.33%) and vegetable *Khakara* (5.00%) were 'neither liked nor disliked'

Table 4: Consumer acceptance of developed *khakara* (n=60)

Khakara	Like extremely		Like slightly		Neither like nor dislike		Dislike slightly		Dislike extremely	
	No.	%	No.	%	No.	%	No.	%	No.	%
Plain	24	40.00	36	60.00	-	-	-	-	-	-
Pulse	22	36.67	36	60.00	2	3.33	-	-	-	-
Vegetable	20	33.33	37	61.67	3	5.00	-	-	-	-

by them. However, none of the respondents was in 'dislike' category for developed *Khakara*.

Table 5 shows the macronutrient composition of value added *Khakara*. From the table it can be revealed that the moisture content of value added *Khakara* ranged from 6.18 per cent to 7.16 per cent. The highest moisture content was recorded for plain *Khakara* and it was statistically (<0.05) significant over the other two *Khakara*s. Pulse and vegetable *Khakara* recorded 6.18 per cent and 6.53 per cent of moisture and both differed significantly ($p<0.05$) from each other. Pulse *Khakara* recorded 12.15 per cent of protein and it was significantly ($p<0.05$) high from the plain and vegetable *Khakara*. Vegetable *Khakara* recorded 8.19 per cent of protein and plain *Khakara* recorded 8.16 per cent of protein. The protein content of plain *Khakara* and vegetable *Khakara* were not statistically significant ($p<0.05$). Fat content of *Khakara* ranged from 1.6 per cent to 2.6 per cent and highest fat content was recorded for vegetable *Khakara* while lowest fat content was recorded for plain *Khakara*. The values of fat content did not differ significantly for all the three types of *Khakara*s. Total ash content of plain *Khakara* was 3.33 per cent, while for pulse *Khakara* it was 3.60 per cent and for vegetable *Khakara* 3.53 per cent. The values of all the three *Khakara*s differed significantly ($p<0.05$) from each other. The crude fibre content of all the three *Khakara*s ranged from 0.91 to 1.84 per cent. The highest crude fibre was recorded by pulse *Khakara* (1.84%) and lowest value was recorded for plain *Khakara* (0.91%) which exhibited non-significant difference among them. The carbohydrate content of all the three types of *Khakara* ranged from 74.48 per cent to 78.96 per cent. The plain *Khakara* had 78.96 per cent, pulse *Khakara* had 74.48 per cent and vegetable *Khakara* had 77.33 per cent of carbohydrate. The carbohydrate content of both plain and vegetable *Khakara* exhibited significantly ($p<0.05$) higher carbohydrate content over pulse *Khakara*. Plain *Khakara* supplied 362 Kcal of energy and pulse *Khakara* supplied 363 Kcal of energy, whereas vegetable *Khakara* supplied highest (365 Kcal) energy content which exhibited non-significant difference among them. The highest total and reducing sugars was noted in pulse *Khakara i.e.*, 14.32 per cent and 2.55 per cent, respectively. Pulse *Khakara* recorded statistically higher ($p<0.05$) values for total sugars over plain *Khakara* and vegetable *Khakara*. The reducing sugar content of pulse *Khakara* was higher which exhibited significant difference ($p<0.05$) over the other two *Khakara*.

The micronutrient content of value added *Khakara* is presented in Table 6. The vitamin C content of all the three types of *Khakara* ranged from 5.81 mg/100g to 9.30 mg/100g and lowest vitamin C content was recorded by plain *Khakara* and highest vitamin C content was recorded by vegetable *Khakara*. Vegetable *Khakara* exhibited significantly ($p<0.05$) higher values for vitamin C content over other two types of *Khakara*. Plain and pulse *Khakara* also differed significantly ($p<0.05$) over each other with respect to vitamin C. The β-carotene and total carotene content of developed *Khakara* ranged from 105.65 µg/100g and 126.30 µg/100g and 1231.17 µg/100g to 1940.00µg/100g, respectively. The highest values for both β-carotene and total

Table 5: Macronutrient composition of value added *Khakara*

Macronutrient Composition	Moisture (g/100g)	Protein (g/100g)	Fat (g/100g)	Total ash (g/100g)	Crude fibre (g/100g)	Carbohydrate (g/100g)	Energy (Kcal/100g)	Total sugars (g/100g)	Reducing sugars (g/100g)
Plain *Khakara*	7.16*	8.16	1.6	3.33	0.91	78.96*	362	10.25	1.75
Pulse *Khakara*	6.18	12.15*	1.8	3.60*	1.84	74.48	363	14.32*	2.55*
Vegetable *Khakara*	6.53	8.19	2.6	3.53	1.82	77.33	365	8.78	2.21
Mean	6.62	9.50	2.00	3.48	1.52	76.92	363	11.11	2.17
S.E.±	0.04	0.21	0.05	0.03	0.02	0.64	1.29	0.26	0.03
C.D.	0.14	0.64	NS	0.10	NS	1.94	NS	0.79	0.09

NS=Non-significant * indicate significance of value at P=0.05

Table 6: Micronutrient composition of value added *Khakara*

Micronutrient composition	Vitamin C (mg/100g)	β-carotene (µg/100g)	Total carotene (µg/100g)	Iron (mg/100g)	Calcium (mg/100g)	Phosphorus (mg/100g)	Magnesium (mg/100g)
Plain *Khakara*	5.81	105.65	1231.17	6.10	29.70	310.00	46.70
Pulse *Khakara*	8.13	122.40	1680.00	5.18	39.59	363.50*	60.60*
Vegetable *Khakara*	9.30*	126.30*	1940.00*	6.340*	45.25*	335.00	47.57
Mean	7.75	118.12	1617.10	5.87	38.18	336.17	51.62
S.E.±	0.10	1.13	34.25	0.06	0.67	3.16	0.77
C.D.	0.30	3.41	103.07	0.19	2.03	9.51	2.32

NS=Non-significant * indicate significance of value at P=0.05

carotene content were recorded by vegetable *Khakara* and it differed significantly ($p<0.05$) from plain and pulse *Khakara*. The highest iron content was recorded by vegetable *Khakara* (6.34 mg/100g) and it exhibited significantly higher ($p<0.05$) values than pulse *Khakara* while it was at par with plain *Khakara*. Among the two *Khakara*s the iron content of plain *Khakara* recorded 6.10 mg/100g and pulse *Khakara* recorded 5.18 mg/100g and both the values did not differ significantly ($p<0.05$) from each other with respect to iron content.

Highest calcium content was recorded by vegetable *Khakara* (45.25 mg/100g) and plain and pulse *Khakara* recorded 29.70 and 39.59 mg/100g, respectively. The calcium content of all the three types of *Khakara* differed significantly ($p<0.01$). The phosphorus content of developed *Khakara* ranged from 310.00 to 363.50 mg/100g. The highest value was recorded by pulse *Khakara* and lowest by plain *Khakara*. However, all the three types of *Khakara* differed significantly ($p<0.05$) over each other. Pulse *Khakara* recorded statistically ($p<0.05$) higher magnesium content (60.60 mg/100g) when compared to plain *Khakara* and vegetable *Khakara* which recorded 46.70 mg/100g and 47.57 mg/100g, respectively. The values of plain and vegetable *Khakara* were at par with each other.

In case of plain *Khakara* the 100 per cent barnyard *Khakara* was least accepted, this could be due to presence of more fibre in barnyard millet flour (Gopalan *et al*., 2004) and lack of gluten (*http://www.gramene.org/ species/setaria/ foxtail millet_intro.html*). *Khakara* is a famous Gujarati snack item usually prepared from wheat flour. The whole process of preparation of *Khakara* almost resembles chapatti except for roasting process. During roasting pressure is applied with cloth bundle or wooden bundle to avoid puffing so that crispy texture will be obtained. For preparation of *Khakara* gluten content in wheat flour plays an important role for flexible and smooth rolling and to obtain required shape and texture. However, barnyard millet flour doesn't contain any gluten (*http://www.gramene.org/species/setaria/foxtailmillet_ intro.html*) which is causing poor acceptability of 100 per cent barnyard millet flour *Khakara* due to its poor texture. It is for the same reason the acceptability score increased as wheat flour increased in *Khakara*. On the other hand in case of pulse *Khakara* as the pulse content increased the acceptability decreased. Though the pulses are rich in protein they do not contribute to increased gluten. Instead the carbohydrates present in pulses increased starch content in the mixture which interferes with the different sensory characters and functional properties of other flour. Hence, the variation with least incorporation of pulse resulted in high acceptability. So also in case of vegetable *Khakara*, the product was acceptable at 10 per cent incorporation of dehydrated carrot powder (Variation II). The acceptability scores decreased with increase in carrot powder (variation III). The reason for low acceptability with increased incorporation of vegetable powder might be due to the stickiness of the carrot powder due to its sugar content while roasting. Singh and Kulshrestha (2008) also reported acceptability of food products only upto 15 per cent incorporation of carrot powder.

For consumer acceptance the texture of product is more important to obtain better acceptability. As explained in previous result regarding product development, the plain *Khakara* which contained 100 per cent barnyard millet was unacceptable due to its poor texture. Later the texture was improved by incorporation of wheat flour which was taken as the control before incorporating pulses and vegetables. Singh *et al.* (2005) while discussing about physico-chemical characteristics of wheat flour and millet flour blends reported improved texture by blending wheat flour and barnyard millet flour together. However, the incorporation of pulses and vegetables diluted or decreased the per cent of barnyard millet in *Khakara*. Thus, altering the highly acceptable proportion of ingredient in *Khakara* could have caused less acceptability to *Khakara* that were incorporated with pulse and vegetables Further, the increased oil and fibre content in pulse and vegetable *Khakara* respectively interfered with the texture of the *Khakara* causing comparatively less likeliness for the product over plain *Khakara*. Not only that, while preparing vegetable *Khakara* it was noted that the sugar present in carrot resulted in stickiness of the product and the product was getting struck with pan and getting slightly burnt while making *Khakara*.

The macronutrient composition of *Khakara* reported significantly ($p<0.05$) high carbohydrate content in plain *Khakara* (Table 5). Barnyard millet contains comparatively less carbohydrate than wheat flour (Gopalan *et al*., 2004). However, for the preparation of *Khakara* 40 per cent wheat flour was incorporated which contributed towards high carbohydrate content that was statistically significant ($p<0.05$). Pulse *Khakara* recorded significantly ($p<0.05$) highest total ash content in place of plain *Khakara*. This could be once again attributed to 40 per cent wheat flour in plain *Khakara*. Barnyard millet flour is containing more minerals which resulted in significantly ($p<0.05$) high content of total ash. Whereas the plain *Khakara* contained only 60 per cent of barnyard millet flour which reduced the total ash content (Table 5). Thus, pulse *Khakara* scored significantly ($p<0.05$) high total ash content over the other two products.

Micronutrient composition of *Khakara* revealed that vegetable *Khakara* scored high values for the entire nutrients except for phosphorus and magnesium (Table 6). The significantly ($p<0.05$) high content of phosphorus and magnesium in pulse *Khakara* is due to incorporation of soybean flour (Singh *et al*., 2006). The significantly high content of β-carotene and other nutrients is due to incorporation of dehydrated carrot gratings was because

carrots are rich in carotene (Desobry *et al*.,1998).

Conclusion:

Thus, from the present investigation it is clear that barnyard millet could be successfully value added. Hence, it can be concluded that the barnyard millet is a potential grain among the millets with superior nutrient content, could be a worthy addition to one's daily diet. However, further scientific investigations with regard to other novel foods can be carried out. Long term intervention feeding should be carried out to see the clinical efficacy of barnyard millet based food products. Barnyard millet noodles possessing good storage quality can be of good commercial value.

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