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RESEARCH PAPER

Nutritional and Anti-nutritional Composition of Fermented Food Products Developed by Using Dehydrated Curry Leaves (*Murraya koenigii*)

Manohar Lal* and Navjot Kaur

Department of Food and Nutrition, Punjab Agricultural University, Ludhiana-141004, Punjab, India

*Corresponding author: manu2lal@gmail.com

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Abstract

Value added fermented food products (*naan, kulcha,* bread, *bhatura, vada* and *wadiyan*) were developed by using dehydrated curry leaves at different levels i.e. 2.5 and 5 per cent. Highly acceptable samples supplemented at 2.5 and 5 per cent level were analysed. All the developed products using dehydrated curry leaves were found to have significantly higher content of protein ranging from 5.54-15.40%, fibre 0.36-1.73% and total ash 1.61-3.63% as compared to unsupplemented (control) samples. However, there was also a significant increase in antinutritional components of test samples of fermented food products as compared to the control samples. The oxalate content of test samples ranged from 22.40 to 100.81 mg/100g. The phytate phosphorus content was found to be the highest in *wadiyan* (136.13 mg/100g) and lowest in *kulcha* (26.60 mg/100g). Trypsin inhibitor (TI) content of test samples ranged from 51.24 to 183.03 TIU/g of protein and were found to be highest the in *wadiyan* and lowest in bread. Efforts to reduce the content of anti nutritional factors in these foods are required to be made.

Keywords: Anti-nutritional factors, dehydrated curry leaves, unsupplemented samples, phytate phosphorus, trypsin inhibitor, fermented Products

Fermentation is the ancient form of food preservation which has been practiced for thousands of years by the man. It not only preserves the food but is also known to improve flavour, digestibility and nutritional quality of foods. Locally available raw materials have been used by every civilization for the development of fermented foods, which are indigenous to them (Joshi *et al.* 2015). Fermentation has been used by food producers and households for the domestic preparation and preservation of foods (Motarjemi 2002). It is reported to enhance the nutritional quality of any product by enhancing the digestibility of proteins and carbohydrates, solubility of vitamins and proteins as well as bioavailability of minerals. Fermentation synthesize B vitamins such as folic acid, riboflavin, niacin, thiamin, biotin. It also reduces the anti-nutritional factors and improves the protein quality.

Nutritional quality of cereals and pulses can however be improved by several methods such as genetics improvement, amino acid fortification and mutual supplementation of cereals and pulses. Fermentation technology makes an important contribution to human nutrition, particularly in developing countries where economic problems pose a major barrier for ensuring food safety leading to malnutrition (Holzapfel, 2002).

A variety of fermented foods are prepared and consumed in various parts of India. Some of the commonly consumed fermented foods of India are *Bhatura, Dosa, Dhokla, Dahi, Idli, Jalebi, Kanji, Khaman, Nan, Srikhand, Vada, Kulcha* and *Wadian.* Mostly these foods are cereals and pulses based which are lack in micronutrients, so there is a need to supplement these food products with such a material with which the nutritional quality can be enhanced. The quality of fermented foods can be enhanced further by supplementation with some underutilized plants such as basil leaves, drumstick leaves, curry leaves and pumpkin leaves (Riat P 2007) Curry leaf is one of the fantastic aromatic herb used in many dishes in Indian cuisine. Curry leaves known as *Murraya koenigii* is a tropical to sub-tropical tree in the rutaceae family which is a native to India. Curry leaves are called by different names in India like *kariveppilai* (in Tamil), *kariveppaku* (in Telugu) and *karipatta* (in Hindi). The leaves of *Murraya koenigii* are also used as herb in ayurvedic medicines. Their properties include much value as an anti-diabetic, antioxidant, antimicrobial, anti-inflammatory, hepatoprotective and anti hypercholesterolemic (Grover *et al.* 2002). Curry leaves contains good amount of calcium and other minerals. β-carotene content of curry leaves is also high (Khoo *et al.* 2011). The incorporation of curry leaves in the fermented foods can therefore, enhance the nutritive value and will provide enormous health benefits.

Fermented foods that can be prepared from cereals and legumes supplemented with curry leaves powder are *Bhatura, Bread, Wadian, Nan, Kulcha* and *Vada.* Value addition of fermented food products with curry leaves can be advocated as a feasible food based approach to combat malnutrition. Information on nutritional and anti-nutritional composition of curry leaves and availability of various nutrients from the fermented products prepared from cereals-legume combination supplemented with curry leaves has not been widely much studied. Thus, keeping in mind all the perspectives the present study was conducted for developing and nutritional evaluation of value added fermented food products using dehydrated curry leaves.

MATERIALS AND METHODS

Raw Materials

Curry leaves were procured from Department of Agronomy, Punjab Agricultural University Ludhiana. Fresh leaves were blanched for 2 minutes at 80°C, cooled and the excess water was drained off. Leaves were dried in hot air oven at 60± 5°C for 8 hours and cooled at room temperature. The other raw materials were procured from local market i.e. refined wheat flour, black gram *dhal,* oil, salt and spices.

Preparation of Products

Different fermented food products were prepared by using dehydrated curry leaves at different levels i.e. 2.5 per cent, 5 per cent and 7.5 per cent. The products were prepared as per the standard practice (Riat, P 2007).The highly acceptable products were analyzed for their nutritional and anti-nutritional composition.

Composition Analysis

Proximate composition viz. moisture, crude protein, crude fat, crude fibre, ash was analyzed by standard methods (AOAC, 2000). The moisture content of samples was determined by air-oven drying at 105 °C for 8 hrs. Protein content was calculated by determining total nitrogen employing Microkjeldhal method (Kel plus Classic, Pelican Equipments Inc., India). Crude fat was extracted with petroleum ether, using Socs Plus and for fibre, acid and alkali washing was given in Fibra Plus Apparatus (Pelican Equipments Inc., India). Available carbohydrate was calculated by subtracting the sum of per centage value of crude protein, crude fat, ash and crude fibre from 100 on dry matter basis. Gross energy was computed with the help of formula mentioned below

Gross Energy = (Crude Protein × 4) + (Crude Fat × 9) + (Carbohydrate × 4)

Anti-nutritional factors

The oxalate, phytate phosphorus and trypsin inhibitor content of highly acceptable test samples along with their respective control samples were analyzed.

Oxalates content was analyzed through methods given by Abeza *et al.* (1968). Phytate phosphorus content was analyzed spectrophotometrically through method given by Haug and Lantzsch, (1983). Trypsin inhibitor content of developed products were analyzed by method given by Roy and Rao, 1971.

Statistical Analysis

The data were analyzed statistically by using various statistical tools such as mean and standard error. To test the significance difference between the control and highly acceptable samples of developed products, ANOVA and two tail t-test was applied using SPSS 16 software.

RESULTS AND DISCUSSION

Sensory evaluation

Six fermented food products were prepared using basic ingredients i.e. refined wheat flour, black gram *dhal* for control samples and for test samples dehydrated curry leaves powder was supplemented at different levels. The developed products were organoleptically evaluated by semi-trained panel of 10 judges from the Department of Food and Nutrition by using 8 point hedonic rating scale to judge the acceptability of the developed products. Appearance, colour, flavour, texture, taste and overall acceptability of different attributes were considered for evaluation. Test products made from refined wheat flour and black gram *dhal* supplemented with dehydrated curry leaves such as *naan*, bread and *wadiyan* were found to be highly acceptable.

The best score for appearance and colour was obtained by test bread (7.70) and (7.60) respectively. The best score for texture and flavour were obtained by test *naan* i.e. 7.80 and 7.90. The test samples of *naan*, bread and *bhatura* were found to be highly acceptable with the overall acceptability of 7.70, 7.66 and 7.51. The acceptable test samples along with their control samples were nutritionally analysed for proximate, mineral content, vitamin content, amino acid content, *in-vitro* protein & starch digestibility and anti- nutritional factors.

Proximate composition of developed fermented products

As is evident from Table 1, test sample (T2) of *naan* supplemented with 5 per cent dehydrated curry leaves was found to be highly acceptable amongst the test samples. The moisture content of *naan* was found to be 5.42 per cent for the control and 5.58 per cent for T2 with a significant difference ($p<0.01$). The protein content of control *naan* was 6.13 per cent which increased significantly upto 6.83 per cent with incorporation of dehydrated curry leaves. The fat and fibre content was 4.18 per cent and 0.70 per cent which was significantly higher than control. There was a significant increase in ash content of T2 (1.86%) than that of control (1.36%). The carbohydrate content of control was found to be 84.32g and that of T2 was 82.70g per 100g. The energy content was found to be 396.91 Kcal for control and 395.21 Kcal for T2. Rani and Punia (2014) supplemented fine powder of four beans i.e. cluster beans, cowpea beans, french beans and sem beans in *dhokla* at 5 and 10 per cent level. The protein content of control *dhokla* was 15.60 per cent which increased significantly upto 17.21 per cent with incorporation of beans powder whereas crude fibre and ash content of supplemented *dhokla* was found to be 18.75 per cent and 19.64 per cent respectively as compared to control i.e. 17.60 per cent.

It was observed that test sample (T1) of *kulcha* supplemented with 2.5 per cent dehydrated curry leaves was found to be the best amongst the test samples. (DATA NOT SHOWN). The proximate composition of control and test sample (T1) of *kulcha* presented in Table 1 revealed that the moisture content of *kulcha* was found to be 2.53 per cent for control and 2.60 per cent for T1. The protein content of control *kulcha* was 5.31 per cent which increased significantly up to 5.54 per cent with incorporation of dehydrated curry leaves. Incorporation of 2.5 per cent of dehydrated curry leaves also enhanced the fat and fibre content of test sample to 3.13 per cent and 0.36 per cent leaves as compared to control. There was also a significant increase in ash content of T1 (1.61%) than that of control (1.36%). The carbohydrate content of T1 was found to be 86.70g whereas in control it

Table 1: Proximate composition of the developed products using dehydrated curry leaves (g/100g on dry weight basis)

Treatment	Moisture (%)	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	CHO (g)	Energy (Kcal)
			Naan				
Control	5.42±0.005	6.13±0.005	3.92±0.005	0.20±0.05	1.36±0.005	84.32±0.005	396.91±0.09
Accepted (5% DCL)	5.58±0.005	6.83±0.005	4.18±0.005	0.70±0.05	1.86±0.005	82.70±0.05	395.21±0.30
t-value	19.59**	85.73**	31.48**	6.12**	61.23**	27.92**	4.17 **
			Kulcha				
Control	2.53±0.005	5.31±0.005	3.05±0.005	0.13±0.005	1.36±0.005	87.60±0.05	399.08±0.005
Accepted (2.5% DCL)	2.60±0.05	5.54±0.005	3.13±0.005	0.36±0.005	1.61±0.005	86.70±0.05	397.12±0.005
t-value	1.20^{NS}	28.16**	9.79**	28.16**	30.61**	11.02**	240.05**
			Bread				
Control	25.90±0.05	5.50±0.05	3.80±0.05	0.17±0.005	1.19±0.005	63.40±0.06	309.80±0.05
Accepted (5% DCL)	25.80±0.05	6.02±0.005	4.03±0.005	0.62±0.005	1.72±0.005	61.69±0.06	307.11±0.005
t-value	1.25^{NS}	8.96**	3.96*	55.11**	64.91**	29.47**	46.36**
			Bhatura				
Control	1.88±0.005	6.21±0.005	30.67±0.005	0.17±0.005	1.39±0.005	59.66±0.005	539.51±0.005
Accepted (2.5% DCL)	1.96±0.005	6.40±0.10	30.70±0.05	0.43±0.005	1.64±0.005	58.70±0.05	536.71±0.45
t-value	9.78**	1.89^{NS}	0.57^{NS}	31.84**	30.61**	16.54**	6.11**
			Vada				
Control	1.31±0.005	12.45±0.005	31.57±0.005	2.18±0.005	2.72±0.005	49.75±0.005	532.93±0.05
Accepted (2.5% DCL)	1.38±0.005	12.70±0.05	31.25±0.005	2.46±0.005	3.04±0.005	48.80±0.05	527.25±0.51
t-value	8.57**	4.30^{NS}	39.12**	34.29**	39.12**	16.37**	11.05**
			Wadiyan				
Control	3.80±0.05	14.82±0.005	1.92±0.005	1.32±0.005	2.93±0.005	75.19±0.005	377.32±0.005
Accepted (5% DCL)	3.89±0.005	15.40±0.05	2.09±0.005	1.73±0.005	3.63±0.005	73.19±0.005	373.17±0.005
t-value	1.55^{NS}	9.99**	20.82**	50.21**	85.73**	244.94**	508.26**

Values are expressed as Mean ± SE; * Significance at 5% level of significance; ** Significance at 1% level of significance; NS - Non significant; DCL- Dehydrated Curry Leaves.

was found to be 87.60g per 100g. The energy content was found to be 399.08 Kcal for control and 397.12 Kcal for T1.

Test sample (T2) of bread supplemented with 5 per cent dehydrated curry leaves was the best amongst the test samples. Non-significant difference was observed in the moisture content of test and control samples. Incorporation of dehydrated curry leaves resulted in significant increase in protein content i.e. 6.02 per cent as compared to control i.e. 5.50 per cent. The fat and fibre content of test samples were found to be significantly higher i.e. 4.03 and 0.62 per cent as compared to control samples i.e. 3.80 and 0.17 per cent. There was a significant increase in ash content

of treatment T2 (1.72%) than that of control (1.19%). The carbohydrate content of control was found to be 63.40g while that of T2 was 61.69g per 100g. The energy content was found to be 309.80 Kcal for control and 307.11 Kcal for T2. Abraham *et al* (2013) studied the proximate composition of bread supplemented with *Moringa oleifera* leaf powder and found that moisture content of control sample to be 35.20 per cent while the moisture content of test sample of bread supplemented with 5 per cent leaves to be 27.68 per cent. The crude protein, crude fat, total ash and crude fibre content of control sample was found to be 9.07 per cent. 1.51 per cent, 1.10 per cent and 2.10 per cent respectively whereas for test sample the values were found to be 13.97 per cent, 2.65 per cent, 1.65 per cent and 3.28 per cent respectively.

Test sample (T1) of *bhatura* supplemented with 2.5 per cent dehydrated curry leaves was found to be highly acceptable amongst the test samples. The proximate composition of control and test sample (T1) of *bhatura* presented in Table 1 revealed that the moisture content of *bhatura* was found to be 1.88 per cent for control and 1.96 per cent for T1. Non-significant difference was observed in protein and fat content of in test samples i.e. 6.40 per cent and 30.70 per cent as compared to control i.e. 6.21 per cent and 30.67 per cent. However significant increase in fibre and ash content was observed in test samples i.e. 0.43 per cent and 1.64 per cent as compared to control samples i.e. 0.17 per cent and 1.39 per cent.. The carbohydrate content of T1was found to be 58.70g whereas in control it was found to be 59.66g per 100g. Their respective energy content were found to be 539.51 Kcal control and 536.71 Kcal.

The moisture content of *vada* supplemented with 2.5 per cent dehydrated curry leaves was found to be 1.38 per cent which was significantly higher than that of control i.e. 1.31 per cent (Table 1). Non-significant difference was observed in protein content of test sample (T1) i.e. 12.70 per cent as compared to control i.e. 12.45 per cent. Significant decrease in fat content was seen in test sample i.e. 31.25 per cent as compared to control i.e. 31.57 per cent. Incorporation of dehydrated curry leaves resulted in significant increase in fibre and ash content of test samples i.e. 2.46 and 3.04 as compared to control. The carbohydrate content of T1was found to be 48.80g whereas in control it was found to be 49.75g per 100g. The energy content was found to be 532.93 Kcal for control and 527.25 Kcal for T1. Bansal and Kochhar (2014) reported the protein, fat, crude fibre and total ash content of control sample of *vada* to be 22.30 per cent, 11.40 per cent, 0.75 per cent and 2.86 per cent whereas that of test sample was 25.34 per cent. 11.62 per cent, 1.75 per cent and 3.00 per cent respectively.

It was found that test sample (T2) of *wadiyan* supplemented with 5 per cent level of dehydrated curry leaves was found to be highly acceptable amongst test samples (Table 1). The moisture content of *wadiyan* was found to be 3.80 per cent for control and 3.89 per cent for T2. The protein content of control *wadiyan* was 14.82 per cent which increased significantly up to 15.40 per cent with incorporation of dehydrated curry leaves. The fat and fibre content of test sample was 2.09 per cent and 1.73 per cent which was significantly higher than control i.e. 1.92 and 1.32 per cent respectively. There was a significant increase in ash content of T2 (3.63%) than that of control (2.93%). The carbohydrate content of control was found to be 75.19g and that of T2 was 73.19g per 100g. The energy content was found to be 377.32 Kcal for control and 373.17 Kcal for T2. Maushumi (1997) reported the crude protein content of different fermented foods varied from 4.4_per cent (*jalebi*) to 20.8_per cent (*wadiyan*) on dry matter basis. The minimum ash content (1.4%) was observed in wheat fermented products whereas the maximum ash content (3.9%) was observed in pulse products.

Anti-nutritional factors of developed products

Highly acceptable developed food products were analyzed for their anti-nutritional composition which is presented in Table 2. The anti-nutritional components studied were oxalates, phytate phosphorus and trypsin inhibitor. The test sample of *naan* (T2) supplemented with 5 per cent level of dehydrated curry leaves was found to be contain 22.40 mg oxalates whereas in control samples it was

Table 2: Anti-nutritional factors of the developed products using dehydrated curry leaves

Treatment	Oxalates (mg/100g)	Phytate Phosphorus (mg/100g)	Trypsin Inhibitor (TIU/g of protein)
	Naan		
Control	18.08±0.005	24.42±0.005	55.46±0.005
Accepted (5%DCL)	22.40±0.05	34.48±0.005	67.32±0.005
t-value	74.45**	12.32**	14.53**
	Kulcha		
Control	21.07±0.005	25.50±0.05	72.97±0.005
Accepted (2.5%DCL)	23.50±0.05	26.60±0.05	77.40±0.05
t-value	41.8**	13.47**	76.34**
	Bread		
Control	30.67±0.005	28.48±0.005	43.82±0.005
Accepted (5%DCL)	34.81±0.005	31.50±0.05	51.24±0.005
t-value	507.04**	52.04**	908.76**
	Bhatura		
Control	36.28±0.005	27.41±0.005	50.44±0.005
Accepted (2.5%DCL)	38.46±0.005	29.62±0.005	55.50±0.05
t-value	266.99**	270.66**	87.20**
	Vada		
Control	67.61±0.005	91.47±0.005	86.48±0.005
Accepted (2.5%DCL)	69.24±0.005	92.90±0.05	90.46±0.005
t-value	199.63**	24.64**	487.44**
	Wadiyan		
Control	97.73±0.005	131.21±0.005	167.44±0.005
Accepted (5%DCL)	100.81±0.005	136.13±0.005	183.03±0.005
t-value	377.22**	602.57**	19.09**

Values are expressed as Mean ± SE; ** Significance at 1% level of significance; DCL– Dehydrated curry leave.

18.08 mg/100 g. The phytate phosphorus content of T2 was observed to be 34.48 mg/100 g which was significantly higher than that of control sample i.e. 24.42 mg/100 g. The trypsin inhibitor content of T2 was also significantly higher than that of control sample i.e. 67.32 TIU/ g of protein for T2 and 55.46 TIU/ g of protein for control. Riat (2007) reported that *naan* contain 30mg phytate phosphorus and trypsin inhibitor content was found to be 56 TIU/g of protein. The oxalates, phytate phosphorus and trypsin inhibitor contents of test sample of *kulcha* (T1) were found to be significantly higher than that of control i.e. 23.50 mg, 26.60 mg and 77.40 TIU/ g of protien for T1 and for control it was 21.07 mg, 25.50 mg and 72.97 TIU/ g of protein respectively whereas Riat (2007) reported the phytate phosphorus content of *kulcha* to be 26mg/100g while trypsin inhibitor content was 73TIU/g of protein. The test sample of bread (T2) supplemented with 5 per cent level of dehydrated curry leaves was found to be contain 34.81 mg oxalates while the control samples it was 30.67 mg/100 g. The phytate phosphorus content of test sample (T2) was observed as 31.50 mg/100g which was significantly higher than that of control sample i.e. 28.48 mg/100 g. The trypsin inhibitor content of T2 was also significantly higher than that of

control sample i.e. 51.24 TIU/ g of protein for T2 and 43.82 TIU/100g of protein for control. In bread, the values for phytate phosphorus and trypsin inhibitor were observed as 29mg/100g and 44 TIU/g of protein respectively (Riat, 2007).

CONCLUSION

Incorporation of dehydrated curry leaves at 2.5 and 5 per cent level resulted in enhancement of nutrient content different of value added fermented food products. There was significant increase in protein, fibre and ash content of supplemented food products as compared to unsupplemented samples. At the same time, the anti-nutritional factors of developed products were also found to be increased which is of serious concern. The dehydrated curry leaves can be utilized for development of highly nutritious fermented food products that call for more research in this direction.

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