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Manohar Lal
Assistant Professor, Department Nutrition and Dietetics, Chandigarh School of Business, Chandigarh Group of Colleges, Mohali, Punjab, India

Pragati Godara
Assistant Professor, Department Nutrition and Dietetics, Chandigarh School of Business, Chandigarh Group of Colleges, Mohali, Punjab, India

Somyarki Upadhya
Assistant Professor, Department Nutrition and Dietetics, Chandigarh School of Business, Chandigarh Group of Colleges, Mohali, Punjab, India

Jaspreet Kaur
Assistant Professor, Department Nutrition and Dietetics, Chandigarh School of Business, Chandigarh Group of Colleges, Mohali, Punjab, India

Corresponding Author:
Manohar Lal
Assistant Professor, Department Nutrition and Dietetics, Chandigarh School of Business, Chandigarh Group of Colleges, Mohali, Punjab, India

Effect of curry leaves supplementation on the sensorial and nutritional attributes of fermented food products

Manohar Lal, Pragati Godara, Somyarki Upadhya and Jaspreet Kaur

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Abstract
The sensorial and nutritional evaluation of six value added fermented food products developed by using dehydrated (2.5 to 7.5%) curry leaves (*Murraya koenigii)* was conducted. All the products were sensorily evaluated by using 8 point hedonic rating scale. *Naan*, bread and *wadiyan* developed by using 5 percent level of dehydrated curry leaves and *kulcha*, *bhatura* and *vada* supplemented with 2.5 percent level of dehydrated curry leaves were found to be highly acceptable. The nutritional evaluation of acceptable developed products revealed that addition of dehydrated curry leaves powder significantly improved iron (4.02-9.39 mg/100 g) and calcium (103.34-219.30 mg/100 g) levels. Lysine content of developed products ranged from (170-573 mg/100 g protein), methionine (24-126 mg/100 g protein), cysteine (83-208 mg/100 g protein) and tryptophan (119-267 mg/100 g protein). The β-carotene and vitamin C content of developed fermented food products using dehydrated curry leaves ranged from 124.17 to 210.58 µg/100 g and 0.40 to 0.81 mg/100 g. *In-vitro* protein and starch digestibility was also enhanced in supplemented products. Incorporation of dehydrated curry leaves in fermented food products are therefore recommended to enhance vitamin and mineral content for combating micronutrient deficiencies.

Keywords: Curry leaves, nutritional evaluation, sensory attributes, fermented food products

Introduction
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). Curry leaves are a popular leaf-spice which is used in very small quantities for their distinct aroma due to the presence of volatile oil and their ability to improve digestion. Hippocrates- "Let food be your medicine and let medicine be your food." These leaves are used or added in almost all dishes to give a nice aroma to the dish. The major constituent responsible for the aroma and flavour has been reported as pinene, sabinene, caryophyllene, cadinol and cadinene. Apart from incorporating sensorial effect they also contribute to the nutritional attributes of the foods. Their properties include much value as an anti-diabetic, antioxidant, antimicrobial, anti-inflammatory, hepatoprotective and anti hypercholesterolemic. These leaves can also be considered as medicinal or nutraceutical foods. Curry leaves contains good amount of calcium and other minerals.
Nutritional quality of cereals and pulses can be improved by several methods such as genetics improvement, amino acid fortification and mutual supplementation of cereals and pulses. Of equal importance is the application of different processing technologies in order to increase the bio-availability of indigenous nutrients in grain such as protein, starch and minerals. One such household technology that is widely practiced in many developing countries is the fermentation technique. The method of fermentation has been practised for thousands of years not only for the preservation of the food but also for improving flavour, digestibility and nutritional quality of foods. The fermentation can be carried by the natural micro-flora or a culture containing defined micro-flora can be added to the substrate. The fermentation process may take few hours to several days for product development depending on the type of substrate and microorganism used. Fermentation has been 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 enhances the B vitamins, such as folic acid, riboflavin, niacin, thiamine and biotin. It also aids in the production of organic acids, nutritional enrichment, reduction of endogenous toxins and reduction in the duration of cooking. It also reduces the anti-nutritional factors i.e. phytic acid in cereal grains which can block absorption of several important minerals like zinc, calcium, iron, magnesium and other minerals and lead to mineral deficiencies. Nitrites, prussic acid, oxalic acid, nitrosamines, and glucosides are some other potentially toxic chemicals found in foods that can be reduced or eliminated by fermentation.

The protein quality as well as amino acid content of foods is also enhanced by fermentation to a great extent. There is a substantial increase in available lysine, leucine, tryptophan and methionine contents in fermented food products. The chemical changes occurring during fermentation include an increase in free sugars indicating a partial breakdown of carbohydrates. The total soluble sugars, total reducing and non-reducing sugars are also increased by fermentation. The ascorbic acid level is also increased after fermentation of rice and black gram mixture. Fermentation increases the vitamin C content which further enhances iron absorption.

A variety of fermented foods are 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* and *Wadian.* Among these *Bhatura, Bhalla, Nan, Kulcha, Vada* and *Wadian* have been found to be commonly consumed in Punjab. Mostly these foods are cereals and pulses based and these are very good sources of calcium, phosphorus and iron etc. The microbial fermentation of cereal-legume mixture is said to improve their nutritive value, availability of proteins, certain amino acids, carbohydrates, certain B vitamins and minerals and reduces the anti-nutrients like phytates, trypsin-inhibitors, flatus factors and lectins (Chavan and Kadam, 1989) [9].

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**.** The fermented foods are primarily restricted to households and are losing their sheen in the fast food culture. So, there is a need to conserve our traditional food recipes based on the fermented foods as the plant material used for these is completely organic thus nutritious, healthy, safe to eat and may helpful to overcome various health disorders among masses. Fermented foods that can be prepared from cereals and legumes supplemented with curry leaves powder are *Bhatura, Bread, Wadian, Naan, Kulcha* and *Vada.* Value addition of fermented food products with curry leaves can be advocated as a feasible food based approach to combat malnutrition. The incorporation of curry leaves in the fermented foods will definitely enhance the nutritive value and will provide enormous health benefits. Accordingly,the present study was carried out with a objective of developing value added food products supplemented with curry leaves and evaluate the same from sensory and nutritional point of view.

Materials and Methods

Preparation of Curry leaves Products

All the raw ingredients i.e. refined wheat flour, black gram *dhal* along with other ingredients like oil, spices, sugar and salt were procured in bulk from the local market of Ludhiana. The curry leaves were procured from the Department of Agronomy, Punjab Agricultural University Ludhiana, Punjab, India. Sorting, washing, blanching, drying and grinding of dried curry leaves was carried out. Dried powder was then stored in low density polythene bags in an air tight container. Six cereal and pulse based fermented products namely *naan, bhatura, kulcha, vada, vadiyan* and bread were developed using dehydrated curry leaves in the Food Laboratory of Department of Food and Nutrition, College of Home Science, Punjab Agricultural University, Ludhiana. Experimental products were prepared by using dehydrated curry leaves at different levels ranging from 2.5 percent to 7.5 percent, whereas control samples were prepared by using 100% of cereals and pulses.

Sensory evaluation of developed products

The developed products were sensorily evaluated by a semi-trained panel of 10 judges using 8 point hedonic scale from Department of Food and Nutrition, College of Home Science, Punjab Agricultural University Ludhiana. The judges were served each preparation with one control and three test samples. Control samples were prepared from ingredients used in usual recipes and test (*naan, kulcha,* bread, *bhatura, vada* and *wadiyan*) samples were prepared by using dehydrated curry leaves at three different levels of 2.5 percent (T_1), 5 percent (T_2) and 7.5 percent (T_3). Different sample codes i.e. T_1, T_2 and T_3 were given to different levels used in fermented food products to prevent any biasedness. The sensory evaluation was performed in well in food laboratory under controlled environmental conditions with minimum distractions to reduce the effect of physical conditions on panelist judgment. Sensory evaluation of the developed products was carried out to determine the most suitable level of curry leaves incorporated in fermented food for each product. The panel was provided 8 point hedonic scale for attributes like appearance, colour, texture, aroma, taste and overall acceptability. Depending upon the acceptability of the products, scores were given by the panel on eight-point hedonic rating scale which ranged from 1(Disliked extremely) to 8 (Liked extremely). The mean scores for the varieties for each product were then calculated. The most acceptable products were subjected to further chemical analysis.

Chemical Analysis

The control samples as well as the most acceptable ones were thoroughly mixed in blender and dried in an oven at 60°C in petri dishes. The dried samples were ground to fine powder and stored in air tight polythene bags for further chemical analysis. Mineral content- calcium and iron was measured by using AOAC (2000) [3] standard methods. Amino acid – methionine, lysine, cystine and trytophan estimation was carried out by using Horn *et al.* (1946) [12], Carpenter (1960) [7] modified by Booth (1971) [6], Liddel and Saville (1959) [14] and Concon (1975) [11]. Vitamin C was estimated by using AOVC (1996) [4] and β Carotene was carried out by using Rangana (2002) [16]. *In vitro* starch digestibility was determined by using method of Singh *et al.* (1982) [19].

Statistical analysis: The data was analysed with the help of various statistical tools such as mean and standard error. To test the significance difference between samples of control and test samples of developed products, ANOVA and two tail t-test was applied using SPSS 16 software.

Results and Discussion

The results of study of various products *viz., Naan, kulcha,* bread, *bhatura, vada* and *wadiyan* by supplementing dehydrated curry leaves at different levels are presented here.

Organoleptic evaluation of developed products using dehydrated curry leaves

The sensory evaluation scores for the products are given in Table 1. *Naan* was found to be highly acceptable at 5% supplementation level with acceptability score of 7.7. The scores of T_2 treatment were found to be higher in the range of 7.50-7.90 than T_1 (2.5%) i.e. 7.15-7.40 for all sensory parameters followed by T_3 but lower than control which was found in the range of 7.55-7.80. The mean scores for the appearance and colour of T_2 were lower i.e.7.70 and 7.50 than that of control i.e. 7.80 and 7.80 respectively, whereas the mean score for texture and flavour of T_2 was higher i.e. 7.80 and 7.90 than that of control i.e. 7.75 and 7.55. The overall acceptability was found to be higher in control as compared to T_1 and T_3 whereas it was same with T_2. Khatoon *et al.* (2011) [13] evaluated the performance of curry leaves in *idli* by using 3 percent (T_1), 4 percent (T_2) and 5 percent (T_3) levels respectively. The average sensory score of different parameters in control sample of *idli* incorporated with dehydrated curry leaves indicated that T_2 had the highest score for colour and appearance (8.6), texture (8.52), taste and flavour (8.52) and overall acceptability (8.59).

kulcha was found to be highly acceptable at 2.5% supplementation level with overall acceptability of 6.8 on 8 point hedonic rating scale. The results revealed that the highest scores for all the sensory parameters amongst the test samples were obtained by T_1 treatment (2.5%). The scores of T_1 treatment were found to be higher in the range of 6.60-7.00 than T_2 (5%) i.e. 6.00-6.80 for all sensory parameters followed by T_3 i.e.5.30-6.00 but lower than control which was found in the range of 7.50-7.70. The mean scores for the appearance, colour, texture, flavour and taste of T_1 were lower i.e.6.70, 6.80, 6.60, 7.00 and 7.00 than that of control i.e. 7.50, 7.70, 7.50, 7.50 and 7.60 respectively. The overall acceptability was found to be higher in control as compared to T_1, T_2 and T_3. Makinde and Akinoso (2014) [15] studied the effect of sesame flour supplementation on physical, nutritional and sensory quality of bread. Sesame flour was supplemented at different levels i.e. 5, 10, 15 and 20 percent and breads at 5 percent level of supplementation were found to be overall acceptable.

Bread was found to be acceptable at 5% supplementation level with overall acceptability score of 7.6. The scores of T_2 treatment were found to be higher in the range of 7.60-7.80 than T_1 (2.5%) i.e. 6.10-6.80 for all sensory parameters followed by T_3 i.e. 6.00-6.60 but lower than control which was found in the range of 7.50-7.60. The mean scores for the appearance, colour, flavour and taste of T_2 were higher i.e.7.70, 7.60, 7.80 and 7.60 than that of control i.e. 7.50, 7.50, 7.50 and 7.50 respectively, while in case of texture the mean scores obtained by control and T_2 were same. The overall acceptability was found to be higher in T_2 as compared to control, T_1 and T_3. Chandel and Jood (2015) [8] also evaluated the organoleptic and nutritional quality of bread by supplementing at different levels i.e. 10, 20, 30 and 40 percent with linseed flour. The linseed flour added up to 30 percent level produces acceptable breads in terms of baking and sensory characteristics. The results revealed that the highest scores for all the sensory parameters amongst the test samples of *Bhatura* were obtained by T_1 treatment (2.5%).

Table 1: Ingredients used in the developed products

Code	Naan	Kulcha	Bhatura	Vada	Vadiyan	Bread
C	Maida (100 g) + curd (5 g)	Maida (100 g) + yeast (3 g) + sugar (6 g) + salt (2 g) + Luke warm water (54 ml) + refined oil (10 ml) + bread improver (0.5 g) + gluten powder (1 g)	Maida (100 g) + curd (5 g)	Black gram *dhal* (100 g) + cumin seeds (5 g) + black pepper powder (5 g) + salt (2 g) + green chillies (5 g) + refined oil (250 ml)	Black gram *dhal* (100 g) + *Heeng* (10 g) + black pepper powder (1 g) + cardamom (10 g) + cloves (0.5 g) + fenugreek (1 g) + red pepper (1 g) + *Petha* (65 g)	Maida (100 g) + yeast (3g) + powdered sugar (6 g) + salt (2 g) + luke warm water (54 ml) + refined oil (10 ml) + bread improver (0.5 g) + gluten powder (1 g)
T_1	Maida (97.5 g) + curd (5 g) + dehydrated curry leaves (2.5 g)	Maida (97.5 g) + yeast (3g) + sugar (6 g) + salt (2 g) + Luke warm water (54 ml) + refined oil (10 ml) + bread improver (0.5 g) + gluten powder (1 g) + dehydrated curry leaves (2.5 g)	Maida (100 g) + curd (5 g) + dehydrated curry leaves (2.5 g)	Black gram *dhal* (97.5 g) + cumin seeds (5 g) + black pepper powder (5 g) + salt (2 g) + green chillies (5 g) + refined oil (250ml) + dehydrated curry leaves (2.5 g)	Black gram *dhal* (97.5 g) + *Heeng* (10 g) + black pepper powder (1 g) + cardamom (10 g) + cloves (0.5 g) + fenugreek (1 g) + red pepper (1 g) + *Petha* (65 g) + dehydrated curry leaves (2.5 g)	Maida (97.5 g) + yeast (3g) + powdered sugar (6 g) + salt (2 g) + luke warm water (54 ml) + refined oil (10 ml) + bread improver (0.5 g) + gluten powder (1 g) + powdered curry leaves (2.5 g)
T_2	Maida (95 g) + curd (5 g) + dehydrated curry leaves (5 g)	Maida (97.5 g) + yeast (3g) + sugar (6 g) + salt (2 g) + Luke warm water (54 ml) + refined oil (10 ml) + bread improver (0.5 g) + gluten powder (1 g) + dehydrated curry leaves (5 g)	Maida (95 g) + curd (5 g) + dehydrated curry leaves (5 g)	Black gram *dhal* (95 g) + cumin seeds (5 g) + black pepper powder (5 g) + salt (2 g) + green chillies (5 g) + refined oil (250ml) + dehydrated curry leaves (5 g)	Black gram *dhal* (95 g) + *Heeng* (10 g) + black pepper powder (1 g) + cardamom (10 g) + cloves (0.5 g) + fenugreek (1 g) + red pepper (1 g) + *Petha* (65 g) + dehydrated curry leaves (5 g)	Maida (95 g) + yeast (3g) + powdered sugar (6 g) + salt (2 g) + luke warm water (54 ml) + refined oil (10 ml) + bread improver (0.5 g) + gluten powder (1 g) + powdered curry leaves (5 g)
T_3	Maida (92.5 g) + curd (5 g) + dehydrated curry leaves (7.5 g)	Maida (97.5 g) + yeast (3g) + sugar (6 g) + salt (2 g) + Luke warm water (54 ml) + refined oil (10 ml) + bread improver (0.5 g) + gluten powder (1 g) + dehydrated curry leaves (7.5 g)	Maida (92.5 g) + curd (5 g) + dehydrated curry leaves (7.5 g)	Black gram *dhal* (92.5 g) + cumin seeds (5 g) + black pepper powder (5 g) + salt (2 g) + green chillies (5 g) + refined oil (250ml) + dehydrated curry leaves (7.5 g)	Black gram *dhal* (92.5 g) + *Heeng* (10 g) + black pepper powder (1 g) + cardamom (10 g) + cloves (0.5 g) + fenugreek (1 g) + red pepper (1 g) + *Petha* (65 g) + dehydrated curry leaves (7.5 g)	Maida (92.5 g) + yeast (3g) + powdered sugar (6 g) + salt (2 g) + luke warm water (54 ml) + refined oil (10 ml) + bread improver (0.5 g) + gluten powder (1 g) + powdered curry leaves (7.5 g)

Table 2: Organoleptic Scores for the developed products

Levels	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
Naan						
C	7.80^{a}±0.13	7.80^{a}±0.13	7.75^{a}±0.13	7.55^{a}±0.15	7.60^{a}±0.16	7.70^{a}±0.10
T_1	7.15^{ab}±0.18	7.15^{a}±0.18	7.15^{a}±0.18	7.25^{a}±0.20	7.40^{a}±0.16	7.22^{a}±0.16
T_2	7.70^{a}±0.15	7.50^{a}±0.16	7.80^{a}±0.13	7.90^{a}±0.31	7.60^{a}±0.16	7.70^{a}±0.11
T_3	6.50^{b}±0.12	6.20^{b}±0.32	6.15^{b}±0.39	6.10^{b}±0.40	6.45^{b}±0.32	6.28^{b}±0.33
Kulcha						
C	7.50^{a}±0.16	7.70^{a}±0.15	7.50^{a}±0.16	7.50^{a}±0.16	7.60^{a}±0.16	7.56^{a}±0.09
T_1	6.70^{b}±0.15	6.80^{b}±0.13	6.60^{b}±0.16	7.00^{a}±0.14	7.00^{b}±0.00	6.82^{b}±0.06
T_2	6.00^{c}±0.00	6.35^{b}±0.18	6.15^{bc}±0.10	6.25^{b}±0.13	6.80^{b}±0.13	6.31^{c}±0.06
T_3	5.30^{d}±0.15	5.50^{c}±0.22	5.60^{c}±0.16	5.50^{c}±0.22	6.00^{c}±0.21	5.58^{d}±0.15
Bread						
C	7.50^{a}±0.16	7.50^{a}±0.16	7.60^{a}±0.16	7.50^{a}±0.16	7.50^{a}±0.16	7.52^{a}±0.14
T_1	6.10^{b}±0.17	6.50^{b}±0.22	6.65^{b}±0.23	6.60^{b}±0.22	6.80^{b}±0.13	6.53^{b}±0.14
T_2	7.70^{a}±0.15	7.60^{a}±0.16	7.60^{a}±0.16	7.80^{a}±0.13	7.60^{a}±0.16	7.66^{a}±0.13
T_3	6.00^{b}±0.00	6.30^{b}±015	6.00^{b}±0.25	6.20^{b}±0.24	6.60^{b}±0.16	6.22^{b}±0.12
Bhatura						
C	7.50^{a}±0.16	7.40^{a}±0.22	7.40^{ab}±0.22	7.30^{ab}±0.15	7.50^{a}±0.16	7.42^{a}±0.15
T_1	7.45^{a}±0.30	7.45^{a}±0.21	7.55^{a}±0.15	7.60^{a}±0.30	7.50^{a}±0.22	7.51^{a}±0.21
T_2	6.20^{b}±0.20	6.40^{b}±0.22	6.75^{bc}±0.22	6.70^{bc}±0.21	6.70^{b}±0.16	6.55^{b}±0.13
T_3	6.10^{b}±0.17	6.00^{b}±0.25	6.20^{c}±0.13	6.20^{c}±0.20	6.30^{b}±0.15	6.16^{b}±0.14
Vada						
C	7.70^{a}±0.15	7.50^{a}±0.16	7.30^{a}±0.21	7.50^{a}±0.16	7.60^{a}±0.16	7.52^{a}±0.07
T_1	7.10^{a}±0.17	6.90^{ab}±0.23	6.70^{ab}±0.26	7.00^{a}±0.29	7.10^{a}±0.18	6.96^{a}±0.20
T_2	6.30^{b}±0.15	6.40^{b}±0.16	5.80^{bc}±0.24	5.90^{b}±0.23	6.40^{b}±0.16	6.16^{b}±0.18
T_3	5.60^{c}±0.22	5.60^{c}±0.22	5.60^{c}±0.26	5.20^{b}±0.13	5.70^{c}±0.21	5.54^{b}±0.18
Wadiyan						
C	7.40^{a}±0.22	7.50^{a}±0.22	7.60^{a}±0.22	7.30^{a}±0.15	7.40^{a}±0.16	7.44^{a}±0.18
T_1	6.70^{ab}±0.21	6.70^{ab}±0.21	6.20^{b}±0.35	6.40^{a}±0.33	6.70^{ab}±0.21	6.54^{b}±0.24
T_2	7.10^{a}±0.11	6.90^{ab}±0.13	6.40^{b}±0.37	6.70^{a}±0.36	6.80^{ab}±0.20	6.78^{ab}±0.24
T_3	6.20^{b}±0.17	6.10^{b}±0.27	6.10^{b}±0.10	6.45^{a}±0.15	6.60^{b}±0.16	6.29^{b}±0.11

Means with different notations (a, b, c and d) indicates significant difference at 5% level of significance.
C- 100% Refined wheat flour, T_1- 97.5% Refined wheat flour +2.5% dehydrated curry leaves, T_2- 95% Refined wheat flour +5% dehydrated curry leaves, T_3- 92.5% Refined wheat flour +7.5% dehydrated curry leaves

The scores of T_1 treatment were found to be higher in the range of 7.45-7.60 than T_2 (5%) i.e. 6.20-6.75 for all sensory parameters followed by T_3 i.e. 6.00-6.30 but lower than control which was found in the range of 7.30-7.50. The mean scores for the colour, texture and flavour of T_1 were higher i.e.7.45, 7.55 and 7.60 than that of control i.e. 7.40, 7.40 and 7.30 respectively, however the mean score for appearance was found to be higher for control i.e. 7.50 as compare to T_1 i.e. 7.45. The overall acceptability was found to be higher in T_1 as compared to control, T_2 and T_3. Verma (2015) [21] supplemented chapati using dehydrated garden cress leaves powder at 2.5, 5, 7.5 and 10 percent levels. The organoleptic scores were found to be higher at 10 percent level of supplementation. *Vada* was found to be acceptable at 2.5% supplementation level with overall acceptability of 6.9. The scores of T_1 treatment were found to be higher in the range of 6.70-7.10 than T_2 (5%) i.e. 5.80-6.40 for all sensory parameters followed by T_3 i.e. 5.20-5.70 but lower than control which was found in the range of 7.30-7.70. The mean scores for the appearance, colour, texture, flavour and taste of T_1 were lower i.e.7.10, 6.90, 6.70, 7.00 and 7.10 than that of control i.e. 7.70, 7.50, 7.30, 7.50 and 7.60 respectively. The overall acceptability was found to be higher in control as compared to T_1, T_2 and T_3. Bansal and Kochhar (2014) [5] conducted a study on sensory and nutritional evaluation of value added products i.e. *halwa, idli, vada, dhokla* and *panjeeri* using peanut flour. The organoleptic evaluation of *vada* with 10 percent of peanut flour revealed the highest scores with an overall acceptability score of 8.0 and was liked very much followed by control with overall acceptability 7.96 which was liked moderately.

Wadiyan was found to be acceptable at 5% level of supplementation with non-significant difference ($p<0.05$) from control sample with overall acceptability of 6.7. The results revealed that the highest scores for all the sensory parameters amongst the test samples were obtained by T_2 treatment (5%). The scores of T_2 treatment were found to be higher in the range of 6.40-7.10 than T_1 (2.5%) i.e. 6.20-6.70 for all sensory parameters followed by T_3 i.e. 6.10-6.60 but lower than control which was found in the range of 7.30-7.60. The mean scores for the appearance, colour, texture, flavour and taste of T_2 were lower i.e.7.10, 6.90, 6.40, 6.70 and 6.80 than that of control i.e. 7.40, 7.50, 7.60, 7.30 and 7.40 respectively. The overall acceptability was found to be higher in control as compared to T_1, T_2 and T_3. Chauhan and Intelli (2014) also evaluated the value added products using dried cauliflower leaves. Organoleptic evaluation of *dhokla* revealed that the control sample was adjudged as liked extremely (8.00) on 9-point hedonic scale for appearance, odour, taste and flavour than supplemented samples. Odour acceptability of *dhokla* supplemented with dried cauliflower leaves decreased with increase in levels of cauliflower leaves i.e. 8.00, 4.80, 2.60 for these samples respectively. In case of taste and flavour, samples supplemented with 2 gm and 5 gm dried cauliflower leaves powder were rated as neither liked nor disliked and disliked moderately with these values i.e. (4.80, 2.40) and (4.40, 2.40) respectively. The data also revealed that 2 gm incorporation of dried cauliflower leaves was considered. The acceptable test samples along with their control samples were nutritionally analysed for mineral content, vitamin content, amino acid content, *in-vitro* protein and starch digestibility.

Mineral content of developed products using dehydrated curry leaves

The mineral content of test samples (T_1) supplemented with 2.5 percent and (T_2) supplemented with 5 percent dehydrated curry leaves and control samples has been given in Table 3.

The calcium content of *naan* supplemented with 5 percent dehydrated curry leaves was observed to be 165.56 mg/100 g which was significantly higher than that of control i.e. 64.79 mg/100 g. The iron content of T_2 was also significantly higher than that of control i.e. 8.99 mg/100 g in T_2 and 8.38 mg/100 g in control.

The iron content of control sample of *kulcha* was observed to be 8.32 mg/100 g while in T_1 was found to be 8.44 mg/100 g which was significantly higher than that of control. The calcium content was also significantly higher in T_1 as compared to control i.e. 108 mg/100 g in T_1 and 58.25 mg/100 g in control. The test sample T_2 (supplemented with 5% dehydrated curry leaves) and control samples of bread were analysed for its calcium and iron contents. The test sample (T_2) contain significantly higher amount of calcium than that of control i.e. 166.22 mg in T_2 and 67.80 mg/100 g in control. The iron content of bread also found to be significantly higher in T_2 (9.39 mg/100 g) as compared to control (8.93 mg/100 g). Abraham *et al*. (2013) [2] conducted a study on supplementation of *Moringa oleifra* leaf powder in wheat bread. The control sample of wheat bread had 5.74 mg/100 g iron and the highest iron content was found in test sample supplemented with 5 percent level of *Moringa oleifra* leaves i.e. 6.87mg/100 g. The calcium content was highest in test sample supplemented with 2 percent level of *Moringa oleifra* leaves i.e. 52.21 mg/100 g whereas in control sample it was found to be 55.67 percent.

The iron content of control of *bhatura* was found to be higher than that of T_1 (supplemented with 2.5% dehydrated curry leaves) i.e. 8.47 mg/100 g in control and 8.27 mg/100 g in T_1. The calcium content of T_1 found to be significantly higher than that of control i.e. 103.34 mg/100 g in T_1 and 55.86 mg/100 g in control. The test sample (T_1) of *vada* supplemented with 2.5% of dehydrated curry leaves was found to be contain significantly higher amount of iron as compared to control i.e. 4.02 mg/100 g iron in T_1 and 3.82 mg/100 g in control sample. There was a significant increase in calcium content of *vada* supplemented with 2.5% of dehydrated curry leaves as compared to control i.e. 132.80 mg/100 g in T_1 and 85.06 mg/100 g in control. Bansal and Kochhar (2014) [5] reported 3.50 mg/100 g iron and 150.50 mg/100 g calcium in control recipe of *vada.*

Shah (2005) [18] reported that protein and iron content of *shev*, *chakli*, *mungdal* and *udad dal wada* to be 16.66 g and 7.8 mg, 11.66 g and 21.58 mg, 21.58 g and 9.50 mg, 16.91 g and 9.10 mg/100 g respectively. Singh and Kawatra (2006) [20] reported ionizable iron content of products ranged from 1.3 in *kurmura* to 2.9 mg/100 g in biscuit prepared from dried amaranthus leaves. Ionizable iron expressed as per cent of total iron was highest in biscuit (57.4%) followed by cake (27.5%) and *namakpara* prepared with dried and fresh amaranthus leaves (25 and 23.7%, respectively), *pakora* with fresh leaves (19.3%), *kurmura* with dried leaves (16.1%), *vada* (16.2%) and *kurmura* with fresh leaves (22.4%).

The test sample of *wadiyan* supplemented with 5 percent level of curry leaves was found to be highly acceptable amongst the test samples. The iron content of T_2 was found to be 4.43 mg/100 g which is significantly higher than that of control i.e. 3.97 mg. The calcium content was also found to be higher in T_2 (219.3 mg/100 g) as compare to control (124.66 mg/100 g).

Table 3: Mineral content of the developed products (on dry weight basis)

Treatment	Iron (mg/100 g)	Calcium (mg/100 g)
Naan		
Control	8.38±0.005	64.79±0.005
Accepted (5% DCL)	8.99±0.005	165.56±0.005
t-value	74.70**	12.34**
Kulcha		
Control	8.32±0.005	58.25±0.005
Accepted (2.5% DCL)	8.44±0.005	108.00±0.57
t-value	14.69**	86.16**
Bread		
Control	8.93±0.005	67.80±0.05
Accepted (5% DCL)	9.39±0.005	166.22±0.005
t-value	56.33**	16.96**
Bhatura		
Control	8.47±0.005	55.86±0.005
Accepted (2.5% DCL)	8.27±0.005	103.34±0.005
t-value	24.49**	58.15**
Vada		
Control	3.82±0.005	85.06±0.005
Accepted (2.5% DCL)	4.02±0.005	132.80±0.05
t-value	24.49**	82.22**
Wadiyan		
Control	3.97±0.005	124.66±0.005
Accepted (5% DCL)	4.43±0.005	219.30±0.05
t-value	56.33**	16.31**

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

Amino acid composition of developed products using dehydrated curry leaves: Highly acceptable test samples of developed fermented food products analysed for their amino acid composition i.e. methionine, lysine, cysteine and tryptophan has been presented in table 4. It was found that the methionine content in test sample (T_2) of *naan* supplemented

with 5 percent level of dehydrated curry leaves was found to be 114mg and in control sample it was found to be 110 mg. The test sample of *naan* (T_2) was found to be contain 239 mg of lysine which was significantly higher than that of control sample i.e. 213mg. The cysteine and tryptophan contents of test sample were also found to be contained significantly higher amount i.e. 119 mg and 267 mg respectively than that of control (112mg and 25mg respectively). Riat (2007) [17] found the lysine content of *naan* 215 mg/100 g of protein, cysteine content was found to be 113 mg/100 g of protein and methionine content of *naan* was found to be 110 mg/100 g of protein.

The test sample of *kulcha* (T_1) supplemented with 2.5 percent level of dehydrated curry leaves was found to contain 104 mg methionine content which was significantly higher than that of control i.e. 97 mg/100 g of protein. The cysteine content of control sample of *kulcha* was found to be 136 mg/100 g of protein and for test sample (T_1) it was 134 mg/100 g of protein. The lysine content of test sample *kulcha* (T_1) was found to be 231 mg/100 of protein and for control it was 220 mg/100 g of protein. The tryptophan content of test sample of *kulcha* was significantly higher i.e. 130 mg than that of control sample i.e. 96 mg/100 g of protein. Riat (2007) [17] reported lysine, cysteine and methionine content of *kulcha* to be 222, 132 and 106 mg/100 g of protein respectively. The test samples of bread (T_2) supplemented with 5 percent level of dehydrated curry leaves was found to contain significantly higher amount of methionine, lysine, cysteine and tryptophan i.e. 112 mg, 249 mg, 208 mg and 213 mg/100 g of protein respectively than that of control samples of bread i.e. 105 mg, 215 mg, 199 mg and 183 mg/100 g of protein respectively. Abdel and Hucl (2002) [1] reported that lysine content of wheat bread was 230 mg/100 g of protein, the tryptophan content of bread was found to be 110 mg/100 g of protein and cysteine content was found to be 210 mg/100 g of protein. Riat (2007) [17] reported lysine, cysteine and methionine content of bread 224 mg. 203 mg and 111 mg/100 g of protein respectively.

The test sample of *bhatura* (T_1) supplemented with 2.5 percent level of dehydrated curry leaves was found to be 24 mg methionine content and for control it was 20 mg/100 g of protein. The cysteine content of control sample of *bhatura* was found to be 172 mg and for test sample (T_1) it was 174 mg/100 g of protein. The lysine content of test sample *bhatura* (T_1) was found to be 170 mg/100 g of protein and for control it was 152 mg/100 g of protein. The tryptophan content of test sample of *bhatura* was significantly higher i.e. 133 mg/100 g of protein than that of control sample i.e. 101 mg/100 g of protein. Riat (2007) [17] reported the lysine, cysteine and methionine content of *bhatrua* 157 mg, 173 mg and 23 mg/100 g of protein.

The methionine content in test samples (T_1) of *vada* supplemented with 2.5 percent level of dehydrated curry leaves was found to be 126 mg and in control sample it was found to be 121 mg/100 g of protein. The test sample of *vada* (T_1) was found to have 205 mg of lysine and for control it was190 mg/100 g of protein. The cysteine content of control and test sample of *vada* was found to be same i.e. 132 mg/100 g of protein. The tryptophan contents of test sample of *vada* was found to be contain significantly higher amount i.e. 119 mg than that of control i.e. 111 mg/100 g of protein. The test samples of *wadiyan* supplemented with 5 percent level of dehydrated curry leaves was found to contain significantly higher amount of methionine, lysine, cysteine and tryptophan i.e. 109 mg, 573 mg, 83 mg and 266 mg/100 g of protein respectively than that of control samples of *wadiyan* i.e. 102 mg, 526 mg, 72 mg and 208 mg/100 g of protein respectively. Riat (2007) [17] reported that *wadiyan* contain 550 mg lysine, 76 mg cysteine and 105 mg methionine per100 g of protein.

Table 4: Amino acid composition of developed products (mg/100 g protein)

Treatment	Methionine (mg)	Available Lysine (mg)	Cysteine (mg)	Tryptophan (mg)
Naan				
Control	110±0.05	213±0.005	112.00±0.005	25±0.005
Accepted (5%DCL)	114±0.005	239±0.005	119±0.005	267±0.005
t-value	0.68^{NS}	31.84**	8.57**	296.38**
Kulcha				
Control	97±0.005	220±0.05	136±0.005	96±0.005
Accepted (2.5%DCL)	104±0.005	231±0.005	134±0.005	130±0.005
t-value	8.57**	1.89^{NS}	2.44^{NS}	41.64**
Bread				
Control	105±0.005	215±0.005	199±0.005	183±0.005
Accepted (5%DCL)	112±0.005	249±0.005	208±0.005	213±0.005
t-value	8.57**	41.61**	11.02**	36.74**
Bhatura				
Control	20±0.05	152±0.005	172±0.005	101±0.005
Accepted (2.5%DCL)	24±0.005	170±0.05	174±0.005	133±0.005
t-value	0.68^{NS}	3.10^{NS}	2.44^{NS}	39.12**
Vada				
Control	121±0.005	190±0.05	132±0.005	111±0.005
Accepted (2.5%DCL)	126±0.005	205±0.005	132±0.003	119±0.005
t-value	6.12*	2.58^{NS}	0.50^{NS}	9.79**
Wadiyan				
Control	102±0.005	526±0.005	72±0.005	208±0.005
Accepted (5%DCL)	109±0.005	573±0.005	83±0.005	266±0.005
t-value	8.57**	57.56**	13.47**	71.03**

Values are expressed as Mean ± SE
** Significance at 1% level of significance
DCL– Dehydrated curry leaves
NS- Non Significant

Vitamin C and β-Carotene content of developed products using dehydrated curry leaves

Vitamin content of value added fermented food products as compared to their control is given in Fig. 1 and 2. It was found that test sample (T_2) of *naan* supplemented with 5 percent level of dehydrated curry leaves contain 210.58 µg/100 g β-carotene which wsa significantly higher than that of control i.e. 19.43 µg/100 g. The vitamin C content of *naan* supplemented with 5 percent level of dehydrated curry leaves was also significantly higher (0.67 mg/100 g) as compared to control sample (0.62 mg/100 g). Verma (2015) [21] reported 1550 µg β-carotene content in *chapatti* supplemented at 10 percent level of dehydrated garden cress leaves.

The vitamin C content of *kulcha* supplemented with 2.5 percent level of dehydrated curry leaves was found to be 0.51mg and for control it was found to be 0.44 mg/100 g. The β-carotene content of *kulcha* supplemented with 2.5 percent level of dehydrated curry leaves was found to be 176.97 µg/100 g which is significantly higher than that of control i.e. 21.98 µg/100 g. The β-carotene content of bread supplemented with 5 percent level of dehydrated curry leaves was found to be 203.46 µg/100 g and for control it was found to be 25.18 µg/100 g. The vitamin C content of test sample (T_2) of bread was found to be 0.48 mg/100 g which is significantly higher than that of control i.e.0.38 mg/100 g. The vitamin C content of test sample (T_1) of *bhatura* was found to be 0.75 mg/100 g and for control it was found to be 0.72 mg/100 g. The β-carotene content of *bhatura* supplemented with 2.5 percent level of dehydrated curry leaves was found to be 132.20 µg/100 g which is significantly higher than that of control i.e. 13.44 µg/10 g. It was found that test sample of *vada* supplemented with 2.5 percent level of dehydrated curry leaves contain 124.17 µg/100 g β-carotene which was significantly higher than that of control i.e. 11.81 µg/100 g. The vitamin C content of test sample of *vada* was found to be 0.81 mg/100 g and in control it was found to be 0.82 mg/100 g.

The β-carotene content of *wadiyan* supplemented with 5 percent level of dehydrated curry leaves was found to be 191.76 µg/100 g and for control it was found to be 18.20 µg/100 g. The vitamin C content of *wadiyan* supplemented with 5 percent level of dehydrated curry leaves was found to be 0.40 mg/100 g which was significantly higher than that of control i.e. 0.36 mg/100 g. Khatoon *et al.* (2011) [13] reported the β-carotene content of *idli* supplemented with 5 percent level of dehydrated curry leaves was 308.3 µg/100 g, at 3 percent incorporation of curry leaves whereas in control sample it was 180µg/100 g.

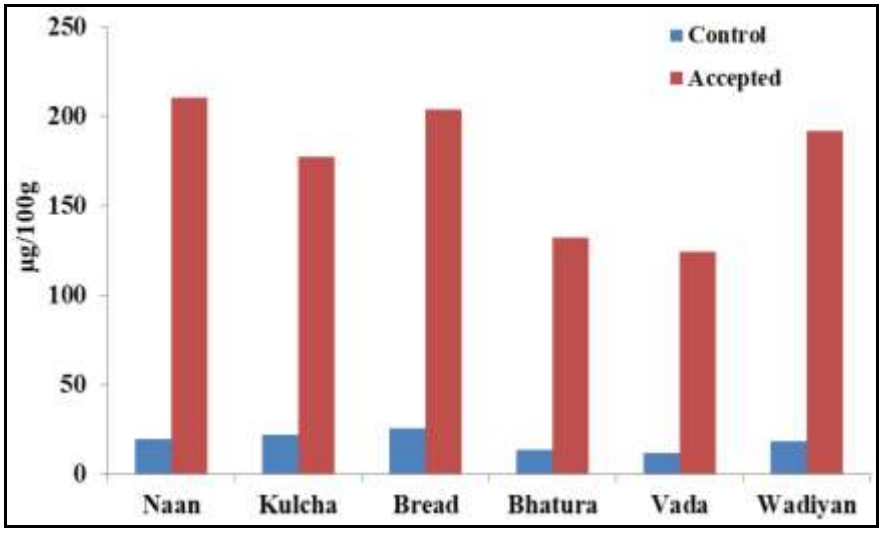

Fig 1: β-Carotene content of developed products

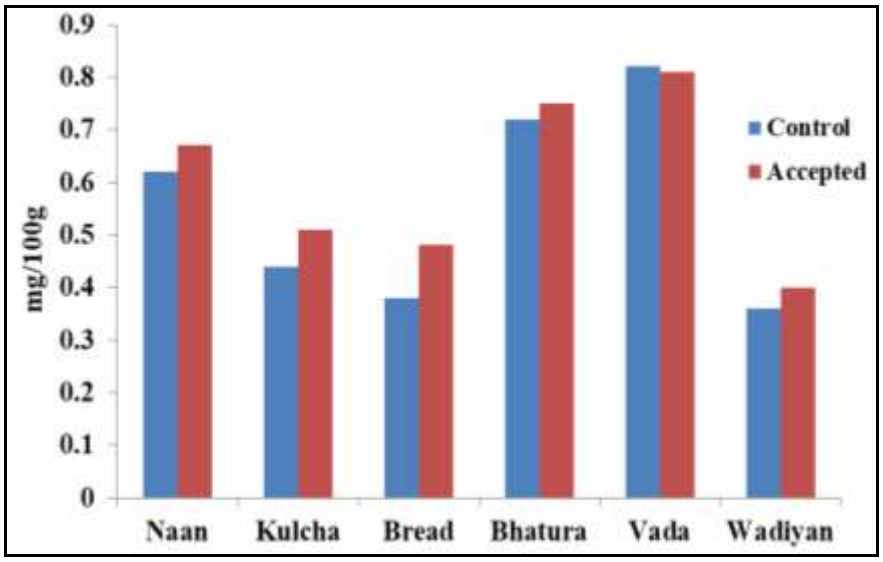

Fig 2: Vitamin C content of developed products

***In-vitro* starch and protein digestibility of developed products**

In-vitro starch and protein digestibility of highly acceptable fermented food products with their control samples has been represented in Fig 3. The test sample of *naan* supplemented with 5 percent level of dehydrated curry leaves had 70.25 percent *in-vitro* starch digestibility as compared to control sample i.e. 68.66 percent. Riat (2007) [17] reported that *naan* had 70.27 percent *in-vitro* protein digestibility and 68.82 percent *in-vitro* starch digestibility.

In-vitro starch digestibility of test sample of *kulcha* (T_1) was found to be 75.43 percent and for control sample it was found to be 75.94 percent. The *in-vitro* protein digestibility of test sample of *kulcha* supplemented with 2.5% (T_1) level of dehydrated curry leaves was found to be 70.45 percent and for the control sample it was found to be 69.50 percent. Riat (2007) [17] reported *in-vitro* starch and protein digestibility of *kulcha* 77.55 percent and 70.54 percent respectively. *In-vitro* protein digestibility of control sample of bread was found to be significantly higher i.e. 73.78 percent than that of test sample (T_2) of bread i.e. 69.61 percent. *In-vitro* starch digestibility of test sample of bread was found to be significantly higher (67.27%) than that of control (64.91%). The values of *in-vitro* protein and starch digestibility of bread were found to be 73.72 percent and 66.35 percent respectively (Riat 2007) [17]. *In-vitro* starch digestibility of test sample of *bhatura* (T_1) was found to be 67.30 percent which is significantly higher than that of control sample i.e. 66.32 percent. *In-vitro* protein digestibility of test sample of *bhatura* supplemented with 2.5 percent (T_1) level of dehydrated curry leaves was found to be 71.15 percent and for the control sample it was found to be 71.48 percent whereas Riat (2007) [17] reported that *bhatura* had 72.55 percent *in-vitro* protein digestibility and 67.15 percent *in-vitro* starch digestibility.

The test sample of *vada* (T_1) supplemented with 2.5 percent level of dehydrated curry leaves had 63.48 percent *in-vitro* starch digestibility while the control sample had 64.34 percent. *In-vitro* protein digestibility of test sample (T_1) of *vada* was found to be 80.91 percent and for control sample it was 81.63 percent. *In-vitro* protein digestibility of control sample of *wadiyan* was found to be 81.30 percent and for test sample (T_2) it was 82.96 percent which was significantly higher than that of control. *In-vitro* starch digestibility of test sample (T_2) of *wadiyan* was found to be 59.23 percent and for control it was found to be 60.38 which was significantly higher than that of test sample. Riat (2007) [17] reported *in-vitro* protein and starch digestibility to be 82.3 percent and 61.06 percent respectively.

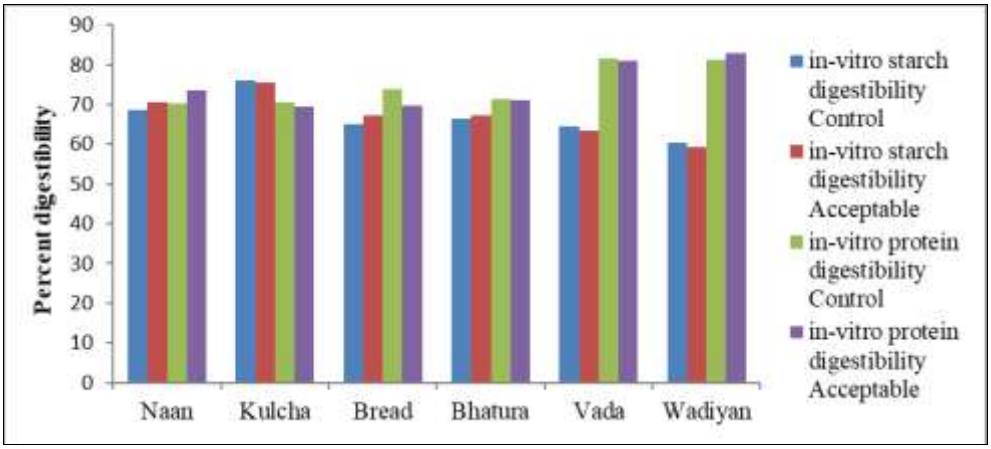

Fig 3: *In-vitro* starch and protein digestibility of developed products

Conclusion

The products namely *naan*, bread and *wadiyan* developed by using 5 percent level and *kulcha*, *bhatura* and *vada* supplemented with 2.5% level of dehydrated curry leaves were found to be highly acceptable. Fermented food products developed by using dehydrated curry leaves were found to have significantly higher calcium content ranging from 103.34 to 219.30 mg/100 g. The amino acid contents i.e. lysine (170 to 573 mg/100 g), tryptophan (119 to 267 mg/100 g) of supplemented food products were also found to be on higher side. Fermented food products developed by using dehydrated curry leaves were found to have significantly higher β-carotene content ranging from 124.17 to 210.58 µg/100 g. By keeping in view the nutritional benefits, the dehydrated curry leaves can be utilized for development of highly nutritious fermented food products and it can be economical alternative to overcome micro-nutrient deficiencies among the vulnerable sections of community

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