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Studies on nutritional and sensory qualities of foxtail millet *chakli*

MY Namitha[1], UD Chavan[2], PM Kotecha[3], SB Lande[4]
[1-4] Department of Food Science and Technology, Mahatma Phule Krishi Vidyapeeth. Maharashtra, India

Abstract
Foxtail millet is a non-glutinous and non-acid forming millet which contains, resistant starch, complex carbohydrates, water soluble gums and β-glucan which helps to reduce weight and type-2 diabetes. Foxtail millet can be utilized to prepare a niche product *chakli.* Different combination of foxtail millet flour and *chakli* mix were prepared and best combination was selected based on 9 points hedonic scale method of sensory evaluation and best combination of foxtail millet *chakli* was 100% foxtail millet flour *chakli*. Moisture, lipid, crude protein, ash, crude fibre, total carbohydrates, calcium, iron and phosphorous content of best treatment was 2.98%, 18.40%, 11.38%, 3.25%, 6.24%, 63.99%, 30.12 mg/100 g, 2.70 mg/100 g and 289.20 mg/ 100 g respectively. Textural parameter of foxtail millet *chakli* i.e compression and crushing force was 11.4 N and 30.26 N respectively.

Keywords: foxtail millet, *Chakli*, nutritional parameters, textural parameters and sensory evaluation

Introduction
Foxtail millet belongs to the family Poaceae and subfamily Panicoideae. It is a Self-pollinating crop with chromosome number 2n = 18. Foxtail millet produces 6 million tonnes of food mainly in southern Europe and in temperate, sub-tropical Asia. (Maratee, 1993). It is grow mainly in Southeast Asia, China, Europe and North America. In India Rajasthan, Karnataka, Maharashtra, Andhra Pradesh and Chattisgarh are the main foxtail millet growing states. It is planted in late spring and grains are going to harvest after 75-90 days. It is known as Navane in Kannada, Kangji in Hindi and Kang or Rala in Marathi. Foxtail millet has several varieties and they are growing in various states.

Foxtail millet is non glutanious and non-acid forming, so it can be easily digestible and produce soothing effect. Foxtail millet contains resistant starch, complex carbohydrates, water soluble gums, β – glucan which helps to reduce the weight and type - 2 diabetes. Foxtail millet is rich in dietary fibre which contains hexose, pentose, cellulose and pectinacious material (Malleshi, 1986) [7]. Approximately 50% of fat present in foxtail millet is PUFA (Sridhar and Lakshminarayan 1994) [14]. Nutritional value of foxtail millet per 100g is: protein 12.3 g, fat 4.3 g, minerals 3.3 g, fibre 8 g, phosphorous 290 mg, energy 331 K. cal (Gopalan *et. al.*, 2004) [6]. Health benefits of foxtail millets includes, it can be used by celiac disease patients because it doesn't contain gluten and it helps to reduce diabetes, weight loss and heart disease because of complex carbohydrates and resistant starch present in it. Magnesium present in it helps to reduce migraine and heart attack, niacin reduces cholesterol level and phosphorous helps for fat metabolism and tissue repair.

Murukku is a savoury crunchy snack from the Tamil/Kerala cuisine of India and Sri Lanka. It is very popular in all over India which is typically made from rice and urad dhal flour and is sometimes called as *chakli* if contains bengal gram flour (en.m.Wikipedia.org/wiki/*murukku*). *Murukku* are exclusively south Indian niche product but different versions of *murukku* are made in western India in the name of *chakli* produced out of channa dal and sold as packaged savory (Masshoudh 2011). In olden days *murukku* used to serve during deepavali but now days it is consuming all over the year. Ingredients used for the *murukku* preparation are rice flour, urad dhal, chilli powder, jeera, ajwan, turmeric, salt and oil (Prakash and Chopra 2016) [10]. Deep fat frying and spices present in it makes it taste rich and texture crunchy.

Materials and Methods
Ingredients for preparation of *Chakli*
The dehusked foxtail millet grains required for the present study were obtained from the local market of Hassan, Karnataka. Other ingredients such as green gram, black gram, bengal gram, rice and masala were obtained from local market of Rahuri.

Methods

Procedure for preparation of *chakli*

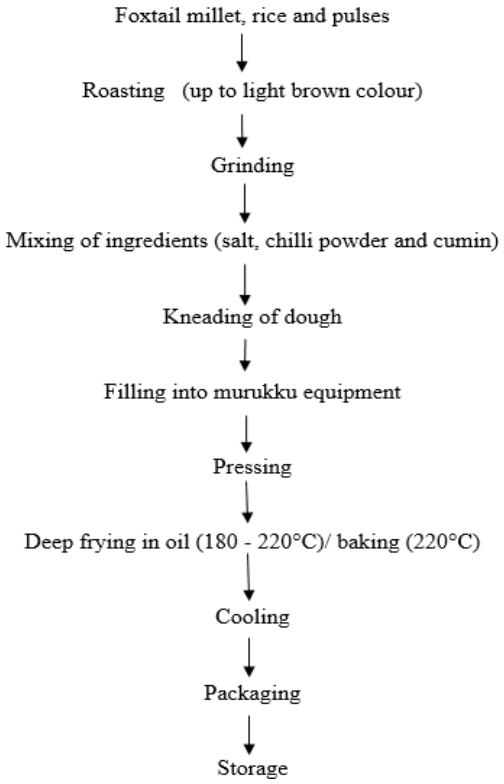

Fig 1: Method for the preparation of foxtail millet *chakli*

Table 1: Various combinations of foxtail millet flour and *Chakli* mix (pulse mix)

Treatment	Foxtail millet flour (%)	*Chakli* mix (R + B + U+ G) (%)
T_0 (control)	00	100
T_1	25	75
T_2	50	50
T_3	75	25
T_4	100	00

Whereas, R = Rice, B = Bengal gram dal, U = Urad dal, G = Green gram dal

Table 2: Best recipe for preparation of foxtail millet *Murukku (Chakli)*

Sr. No.	Ingredients	Quantity
1	Foxtail millet flour (g)	100
2	Salt (g)	2
3	Chilli powder (g)	3
4	Cumin (g)	5
5	Hot water (ml)	100
6	Oil (used for frying) (ml)	100

Physico-chemical analysis of raw material and *chakli*

Sensory evaluation was done by the method given by Amerine *et al.,* (1965) [2]. The methods described in A.O.A.C. (1990) [3] were used to determine crude protein, crude fibre, ash and crude fat. A.A.C.C (2000) [2] method was used to determine the moisture content. Calcium and iron were analyzed using atomic absorption spectrometry (AAS) method given by A.O.A.C. (2000) [3]. Phosphorous content was also determined by A.O.A.C. (2000) [3]. Carbohydrates content was determined by the method given by Raguramulu *et al.,* (1983) [11] Texture analysis was done using INSTRON texture analyzer by the method given by Gaines, (1991). All chemical constituents and organoleptic parameter were analysed by using more than 4 replications. The results obtained in the present investigation were statistically analysed by using Factorial Completely Randomized Design given by Rangaswamy, (2010) [12]. Products were stored in LDPE and aluminium foil packaging material at ambient temperature for the period of 35 days and evaluation was done for nutritional and sensory parameters at the interval of 7 days.The nutritional quality parameters were analyzed up to 28 days.

Results and discussion

Sensory evaluation of fried foxtail millet *Chakli*

Sensory scores of the treatments of *chakli* are given in Table 3. Sensory evaluation was done using 9 points hedonic scale. The colour and appearance scores of the *chakli* was lowest in T_0 i.e. 6.00 and highest in T_4 i.e. 8.00. The flavour scores of *chakli* was lowest in T_1 i.e. 6.16 and highest in T_4 i.e. 8.00. The texture scores of *chakli* was lowest in T_0 i.e. 6.00 and highest in T_4 i.e. 8.66. The taste scores of *chakli* was lowest in T_0 i.e. 5.30 and highest in T_4 i.e. 8.20. The overall acceptability scores of *chakli* was lowest in T_0 i.e. 6.00 and highest in T_4 i.e. 8.16. The best score for colour and appearance, flavour, texture, taste and overall acceptability was observed for the treatment T_4. So T_4 along with T_0 treatments were selected for storage study.

Table 3: Sensory evaluation of *Chakli* for treatment finalization*

Treatments	Colour and appearance	Flavour	Texture	Taste	Overall acceptability
T_0 (control)	6.00	6.30	6.00	5.30	6.00
T_1	7.16	6.16	6.08	5.83	6.08
T_2	7.33	6.50	7.00	6.50	6.75
T_3	7.83	7.33	7.83	7.66	7.66
T_4	8.00	8.00	8.66	8.20	8.16
Mean	7.26	6.86	7.10	6.70	6.93

*These are the average value of 10 replications. Highest value is 9 points

T_0 = 100% Chakli flour mix (control)
T_1 = 75% Chakli flour mix + 25% Foxtail millet flour
T_2 = 50% Chakli flour mix + 50% Foxtail millet flour
T_3 = 25% Chakli flour mix + 75% Foxtail millet flour
T_4 = 100% Foxtail millet flour

Nutritional value of fried foxtail millet *Chakli*

The nutritional value of fried *chakli* is presented in Table 4. The moisture content was more in control when compared to treatments. The lipd content of control (20.50%) was more when compared to treatments (18.40%). It means that absorption of oil is more in control when compared to treatments. Crude protein content of the control was more when compared to treatment because in control we used pulses which are rich in protein when compared to foxtail millet. Ash content of treatment was more when compared to control because polishing is higher in rice and pulses than foxtail millet. Crude fibre content was higher in treatment (6.24%) than control (1.50%) because foxtail millet is rich in complex carbohydrates which add to crude fibre content. Increasing fibre content in human diet by various food products is very important for reducing various nutritional disorders. High fibre diet helps in maintaining good health by reducing cholesterol, constipation etc. Total carbohydrates content was more in treatment when

compared to control because protein, lipids and moisture contents were less when compared to control. Calcium content in both the product was similar. Foxtail millet is a good source of calcium. Phosphorous and iron contents were also more in control when compared to treatment. Chavan *et.al* (2016) reported that sorghum *chakli* of different seven varieties contains 14.72% protein, 2.79% total sugars, 38.60% fat, 3.34% crude fibre and 2.71% ash (these are the mean values of all the varieties).

Table 4: Nutritional value of fried foxtail millet *Chakli*

Nutritional parameter	*Chakli* control	Foxtail millet *chakli*	Mean
Moisture (%)	3.42	2.98	3.20
Lipid (%)	20.50	18.40	19.45
Crude protein (%)	14.22	11.38	12.80
Ash (%)	2.90	3.25	3.08
Crude fibre (%)	1.50	6.24	3.87
Total carbohydrates (%)	58.96	63.99	61.48
Calcium (mg/100g)	59.75	30.12	44.94
Phosphorous (mg/100g)	290.50	289.20	289.85
Iron (mg/100g)	5.80	2.70	4.25

*Results are mean value of 4 replications

Textural parameters of foxtail millet *Chakli*

Textural parameters of *chakli* are presented in below Table 5. In that hardness value was more in foxtail millet *chakli* when compared to control. For crushing force control was more than foxtail millet *chakli*. It means that to compress small piece of sample treatment takes more force and to break large quantity of same sample control required more force. These results indicated that foxtail *chakli* were more crunchy and crispy. This type of characteristic is very good for consumer point of view. Therefore whole foxtail millet flour *chalki* was more acceptable than the traditional (control) *chakli*.

Table 5: Textural parameters of foxtail millet *chakli*

Treatments	Hardness (N)	Crushing (N)
Control (fried) *chakli*	8.87	60.92
Foxtail millet *chakli* (fried)	11.40	30.26
Mean	10.14	45.59

***** All observations are mean value of 5 replications

Organoleptic evaluation of foxtail millet *chakli* stored at ambient condition

Organoleptic evaluation of foxtail millet *chakli* stored at ambient condition is presented in Table 6. Fried products were stored in LDPE and aluminium foil packaging material at ambient temperature for the period of 35 days. Colour and appearance scores of Products stored in LDPE packaging materials were decreased gradually from 8.31 to 4.00 in T_1P_1 and from 8.40 to 4.00 in T_2P_1 during the storage period of 35 days. The scores of products stored in aluminium foil packaging material were reduced from 8.31 to 5.00 in T_1P_2 and 8.40 to 4.00 in T_2P_2 during the storage period of 35 days. Flavour value of products stored in LDPE packaging materials were decreased gradually from 8.57 to 3.00 in T_1P_1 and from 8.63 to 4.00 in T_2P_1 during the storage period of 35 days. The scores of products stored in aluminium foil packaging material were reduced from 8.57 to 3.00 in T_1P_2 and 8.63 to 4.00 in T_2P_2 during the storage period of 35 days. Texture value of products stored in LDPE packaging materials were decreased gradually from 7.57 to 6.00 in T_1P_1 and from 8.14 to 6.00 in T_2P_1 during the storage period of 35 days. The scores of products stored in aluminium foil packaging material were reduced from 7.57 to 6.00 in T_1P_2 and 8.14 to 7.00 in T_2P_2 during the storage period of 35 days. Taste value of products stored in LDPE packaging materials were decreased gradually from 7.80 to 4.00 in T_1P_1 and from 8.26 to 3.00 in T_2P_1 during the storage period of 35 days. The scores of products stored in aluminium foil packaging material were reduced from 7.80 to 4.00 in T_1P_2 and 8.26 to 3.75 in T_2P_2 during the storage period of 35 days. Overall acceptability scores of products stored in LDPE packaging materials were decreased gradually from 8.16 to 4.25 in T_1P_1 and from 8.57 to 4.25 in T_2P_1 during the storage period of 35 days. The scores of products stored in aluminium foil packaging material were reduced from 8.16 to 4.50 in T_1P_2 and 8.57 to 4.50 in T_2P_2 during the storage period of 35 days. The overall acceptability scores are indicating that there is major difference in colour and appearance, flavour, texture taste and overall acceptability value of *murukku (chakli)* during storage period in decreasing manner. Aluminium foil got good scores when compared to LDPE. Statistically values are at par with each other. Foxtail millet *murukku (chakli)* showed higher level of overall acceptability than control during storage period. The product and packaging material interaction effect also showed higher overall acceptability score for foxtail millet *murukku (chakli)* than control during storage up to 28 days. These results indicated that foxtail millet *murukku (chakli)* and control can remain in acceptable condition up to 28 days. Similar results were found in little millet *chakli* prepared by Singson *et al.*, (2014) [13].

Table 6: organoleptic evaluation of foxtail millet *sev* stored at ambient condition

Parameter	Colour and appearance		Flavour		Texture		Taste		Overall acceptability	
Days	0	35	0	35	0	35	0	35	0	35
Treatments										
T_1	8.31	4.50	8.57	2.99	7.57	6.00	7.80	4.00	8.16	4.38
T_2	8.40	4.00	8.63	4.00	8.14	6.50	8.26	3.38	8.57	4.38
SE	0.011	0.013	0.010	0.014	0.009	0.010	0.009	0.012	0.012	0.013
CD@5%	0.035	0.039	0.031	0.045	0.028	0.032	0.028	0.037	0.037	NS
Packaging material										
P_1	8.36	4.00	8.60	3.50	7.86	6.00	8.03	3.50	8.37	4.25
P_2	8.36	4.25	8.60	3.49	7.86	6.50	8.03	3.88	8.37	4.50
SE	0.011	0.019	0.010	0.011	0.009	0.010	0.009	0.012	0.012	0.013
CD@5%	NS	0.039	NS	NS	NS	0.032	NS	0.037	NS	0.038
Interaction										
T_1P_1	8.31	4.00	8.57	3.00	7.57	6.00	7.80	4.00	8.16	4.25
T_1P_2	8.31	5.00	8.57	3.00	7.57	6.00	7.80	4.00	8.16	4.50

T_2P_1	8.40	4.00	8.63	4.00	8.14	6.00	8.26	3.00	8.57	4.25
T_2P_2	8.40	4.00	8.63	4.00	8.14	7.00	8.26	3.75	8.57	4.50
Mean	8.36	4.25	8.60	3.50	7.86	6.25	8.03	3.69	8.37	4.38
SEm	0.016	0.018	0.014	0.021	0.013	0.015	0.013	0.017	0.017	0.018
CD@5%	NS	0.054	NS	NS	NS	0.045	NS	0.053	NS	NS

Maximum score out of 9. Results are mean value of 10 replications. NS = Non-Significant
T_1 = 100% Chakli mix, T_2 = 100% Foxtail millet flour, P_1 = LDPE, P_2 = Aluminium foil.

Nutritional parameter of foxtail millet *murukku (chakli)* stored at ambient condition

Nutritional parameters of foxtail millet *murukku (chakli)* are discussed in Table 7. Fried products were stored in LDPE and aluminium foil packaging material at ambient temperature for the period of 35 days. Moisture content of products stored in LDPE packaging materials were increased gradually from 3.42% to 3.61% in T_1P_1 and from 2.99% to 3.20% in T_2P_1 during the storage period of 28 days. The scores of products stored in aluminium foil packaging material were reduced from 3.42% to 3.57% in T_1P_2 and 2.99% to 3.17% in T_2P_2 during the storage period of 28 days. Ash content of products stored in LDPE packaging materials were decreased gradually from 2.90% to 2.88% in T_1P_1 and from 3.25% to 3.23% in T_2P_1 during the storage period of 28 days. The results of products stored in aluminium foil packaging material were reduced from 2.90% to 2.87% in T_1P_2 and 3.25% to 3.23% in T_2P_2 during the storage period of 28 days. Lipid content in the products stored in LDPE packaging materials were decreased gradually from 20.51% to 20.41% in T_1P_1 and from 18.40% to 18.30% in T_2P_1 during the storage period of 28 days. The lipid content of product stored in aluminium foil packaging material was reduced from 20.51% to 20.43% in T_1P_2 and 18.40% to 18.32% in T_2P_2 during the storage period of 28 days. The crude protein content of products stored in LDPE packaging materials were decreased gradually from 14.22% to 14.13% in T_1P_1 and from 11.38% to 11.28% in T_2P_1 during the storage period of 28 days. The crude protein content of products stored in aluminium foil packaging material were reduced from 14.22% to 14.15% in T_1P_2 and 11.38% to 11.30% in T_2P_2 during the storage period of 28 days. The crude fibre content of products stored in LDPE packaging materials were decreased gradually from 1.52% to 1.47% in T_1P_1 and from 6.24% to 6.19% in T_2P_1 during the storage period of 28 days. The crude fibre content of products stored in aluminium foil packaging material were reduced from 1.52% to 1.47% in T_1P_2 and 6.24% to 6.20% in T_2P_2 during the storage period of 28 days. Present results are indicating that there is no difference in moisture, ash, lipid, crude protein and crude fibre content of the sample during storage period. Statistical values are showing that there is no effect of packaging material on products. Statistically values are at par with each other. Similar results were found in little millet *chakli* prepared by Singson *et al.*, (2014) [13]. Some other nutritional parameters of foxtail millet *murukku (chakli)* are discussed in Table 8. The total carbohydrates content of products stored in LDPE packaging materials were increased from 58.96% to 59.00% in T_1P_1 and from 63.99% to 64.03% in T_2P_1 during the storage period of 28 days. The total carbohydrates content of products stored in aluminium foil packaging material were changed from 58.96% to 58.98% in T_1P_2 and 63.99% to 63.98% in T_2P_2 during the storage period of 28 days. The calcium content of products stored in LDPE packaging materials were decreased gradually from 59.75 mg/100g to 59.69 mg/100g in T_1P_1 and from 30.12 mg/100g to 30.06 mg/100g in T_2P_1 during the storage period of 28 days. The calcium content of products stored in aluminium foil packaging material was reduced from 59.75 mg/100g to 59.70 mg/100g in T_1P_2 and 30.12 mg/100g to 30.06 mg/100g in T_2P_2 during the storage period of 28 days. The iron content of products stored in LDPE packaging materials were decreased gradually from 5.80 mg/100g to 5.74 mg/100g in T_1P_1 and from 2.69 mg/100g to 2.65 mg/100g in T_2P_1 during the storage period of 28 days. The iron content of products stored in aluminium foil packaging material were reduced from 5.80 mg/100g to 5.75 mg/100g in T_1P_2 and 2.69 mg/100g to 2.66 mg/100g in T_2P_2 during the storage period of 28 days. The phosphorous content of products stored in LDPE packaging materials were decreased gradually from 290.50 mg/100g to 290.00 mg/100g in T_1P_1 and from 289.20 mg/100g to 288.50 mg/100g in T_2P_1 during the storage period of 28 days. The phosphorous content of products stored in aluminium foil packaging material were reduced from 290.50 mg/100g to 290.03 mg/100g in T_1P_2 and 289.20 mg/100g to 288.40 mg/100g in T_2P_2 during the storage period of 28 days. The peroxide value of products stored in LDPE packaging materials were increased from 2.81 to 23.57 (meq peroxide/kg oil) in T_1P_1 and from 3.23 to 11.40 (meq peroxide/kg oil) in T_2P_1. The peroxide value of products stored in aluminium foil packaging material were increased from 2.81 to 21.09 (meq peroxide/kg oil) in T_1P_2 and 3.23 to 10.03 (meq peroxide/kg oil) in T_2P_2. Present values are indicating that there is no major difference in total carbohydrates, calcium, iron and phosphorous content of *murukku (chakli)* during storage period and there is major difference in peroxide value of *murukku* (*chakli*) during storage period. This drastic increase in peroxide value indicates that oxidation of fatty acids occurred during storage period. This means product is spoiled at the end of the 35 days. In both the packaging material there is increase in the peroxide value but less in aluminium foil when compared with the LDPE. Similar results were found in little millet *chakli* prepared by Singson *et al.*, (2014) [13].

Table 7: Nutritional parameter of foxtail millet *murukku (chakli)* stored at ambient condition

Parameter	**Moisture**		**Ash**		**Crude protein**		**Lipid**		**Crude fibre**	
Days	**0**	**28**	**0**	**28**	**0**	**28**	**0**	**28**	**0**	**28**
Treatments										
T_1	3.42	3.59	2.90	2.88	14.22	14.14	20.51	20.42	1.52	1.47
T_2	2.99	3.19	3.25	3.23	11.38	11.29	18.40	18.31	6.24	6.20
SE	0.005	0.003	0.003	0.003	0.009	0.008	0.004	0.007	0.005	0.003

CD@5%	0.013	0.009	0.008	0.009	0.025	0.024	0.013	0.020	0.015	0.008
Packaging material										
P_1	3.21	3.41	3.08	3.06	12.80	12.71	19.46	19.36	3.88	3.83
P_2	3.21	3.37	3.08	3.05	12.80	12.73	19.46	19.37	3.88	3.84
SE	0.005	0.003	0.003	0.003	0.009	0.008	0.004	0.007	0.005	0.003
CD@5%	NS	0.009	NS	NS	NS	NS	NS	NS	NS	NS
Interaction										
T_1P_1	3.42	3.61	2.90	2.88	14.22	14.13	20.51	20.41	1.52	1.47
T_1P_2	3.42	3.57	2.90	2.87	14.22	14.15	20.51	20.43	1.52	1.47
T_2P_1	2.99	3.20	3.25	3.23	11.38	11.28	18.40	18.30	6.24	6.19
T_2P_2	2.99	3.17	3.25	3.23	11.38	11.30	18.40	18.32	6.24	6.20
Mean	3.21	3.39	3.08	3.05	12.80	12.72	19.46	19.36	3.88	3.83
SEm	0.006	0.009	0.004	0.005	0.012	0.008	0.006	0.009	0.007	0.004
CD@5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Results are mean value of 4 replications. NS = Non-Significant

T_1 = 100% Chakli mix, T_2 = 100% Foxtail millet flour, P_1 = LDPE, P_2 = Aluminium foil

Table 8: Nutritional parameter of foxtail millet *murukku (chakli)* stored at ambient condition

Parameter	**Total carbohydrates**		**Calcium**		**Iron**		**Phosphorous**		**Peroxide value**	
Days	**0**	**28**	**0**	**28**	**0**	**28**	**0**	**28**	**0**	**28**
Treatments										
T_1	58.96	58.99	59.75	59.69	5.80	5.75	290.50	290.33	2.81	22.33
T_2	63.99	63.99	30.12	30.06	2.69	2.66	289.20	289.45	3.23	10.71
SE	0.008	0.006	0.007	0.009	0.005	0.006	0.013	0.008	0.012	0.013
CD@5%	0.025	0.020	0.021	0.027	0.014	0.019	0.038	0.024	0.035	0.039
Packaging material										
P_1	61.48	61.50	44.94	44.87	4.25	4.20	289.58	289.75	3.02	17.48
P_2	61.48	61.48	44.93	44.88	4.25	4.21	289.85	290.03	3.02	15.56
SE	0.008	0.006	0.007	0.009	0.005	0.006	0.013	0.008	0.012	0.013
CD@5%	NS	NS	NS	NS	NS	NS	NS	0.024	NS	0.039
Interaction										
T_1P_1	58.96	59.00	59.75	59.68	5.80	5.74	290.50	290.00	2.81	23.57
T_1P_2	58.96	58.98	59.50	59.70	5.80	5.75	290.50	290.03	2.81	21.09
T_2P_1	63.99	63.99	30.12	30.06	2.69	2.65	289.20	288.50	3.23	11.40
T_2P_2	63.99	63.98	30.11	30.06	2.69	2.66	289.20	288.40	3.23	10.03
Mean	61.48	61.49	44.93	44.88	4.25	4.20	289.85	289.89	3.02	16.52
SEm	0.012	0.009	0.007	0.013	0.007	0.009	0.018	0.010	0.016	0.018
CD@5%	NS	NS	NS	NS	NS	NS	NS	0.033	1.08	0.22

Results are mean value of 4 replications. NS = Non-Significant

T_1 = 100% Chakli mix, T_2 = 100% Foxtail millet flour, P_1 = LDPE, P_2 = Aluminium foil

Conclusion

These results indicated that foxtail millet *chakli* prepared from 100% foxtail millet flour was having better organoleptic properties when compared to the other treatments. Foxtail millet *chakli* was crunchy and crispy in nature. It was having good nutritional properties when compared to control. So foxtail millet can be utilized in the preparation of niche products such as *chakli*.

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