Research Article

Acceptability, Nutritional Assessment and Storage Stability of Oat Based Gluten Free Instant *Dhokla*

Bhawna Mehta* and Sudesh Jood

Department of Foods and Nutrition, College of Home-Science, CCS Haryana Agriculture University, Hisar

Abstract

The aim of the study to develop five types of gluten free *dhokla* by using instant mixes i.e bengal gram flour (40%), mung bean flour (20%) and linseed powder (5%) in 60 per cent processed (malted, flaked, roasted and popped) and unprocessed oat flour. The developed *dhokla* were subjected to sensory evaluation. It showed that Type-I (unprocessed oat flour based mix), Type-II (malted oat flour based mix) and Type-III (flaked oat flour based mix) *dhokla* were found acceptable whereas *dhokla* made from Type-IV and Type-V mixes were least acceptable. The highly acceptable *dhokla* was selected for their nutritional composition and showed that Type-II (malted oat flour based mix) *dhokla* had maximum protein and *in vitro* availability of Ca, Fe and Zn. Total minerals were found to be non-significantly higher in Type-I *dhokla*. Type-II *dhokla* had higher *in vitro* protein digestibility, starch digestibility and DPPH free radical scavenging activity.

Keywords: Instant mixes, organoleptic acceptability, nutritional composition, Available minerals

***Correspondence**

Author: Bhawna Mehta

Email: bhawna.mehtaa2013@gmail.com

Introduction

Celiac disease is an autoimmune inflammatory disease of the small intestine that can occur in genetically predisposed people due to ingestion of gluten (a protein found in wheat, rye and barley [9] which leads to damage in the small intestine villi (small finger like projections). The function of intestinal villi is to promote the nutrient absorption, as the villi get damaged, nutrients cannot be absorbed properly in the body leading to malabsorption of several important nutrients such as iron, folic acid and calcium, fat soluble vitamins and many other manifestations. It usually develops with in the first three years of life, however, it may occur even in adulthood. Currently this disease affects one in 100 individuals world wide or 1 to 2 per cent of the general population in developed and developing countries. It is estimated that 80 per cent of cases remain undiagnosed because of minimal or absence of gastrointestinal complaints and lack of awareness of the condition. In recent years, celiac disease is recognized much more frequently in India not only in children but also in adults [23,5]. Celiac disease can be treated by avoiding of gluten ingestion. It was also reported that the only dietary treatment for celiac disease is to follow a gluten free diet. Gluten free diet heals intestinal damage, improves nutritional deficiency symptoms and also reduces the risk of developing many of the serious long term complications related to untreated celiac disease [24]. Patients following a strict gluten free diet often suffer from various nutritional deficiencies such as vitamin A deficiency, iron deficiency, β- complex vitamins deficiency etc. and also the adults with celiac disease following a strict gluten free diet have significantly lower weight, body mass index and lean body mass than the normal subjects.[22, 15]

Oat is the only cereal containing a globulin or legume like protein avenalins, as the major (80%) storage proteins. It is currently a very popular coarse cereal in consumer demand due to its unique nutritional and health properties [18] but long before this, it was used only for brewing and animal feed purposes and to some extent as human food. They are excellent source of different dietary fibre compound of mixed linkage (1→3), (1→4) β-D glucan, arabinoxylans and cellulose. Soluble fibre of oat has been reported to reduce elevated blood cholesterol, triglycerides and glucose levels and thereby reducing the risk of degenerative diseases [16, 37] whereas insoluble dietary fibre helps in preventing the colorectal cancer. Besides this, oats contain relatively high level of protein, minerals, unsaturated fatty acids, vitamins, antioxidants (avenanthramides, tocotrienols and tocopherols) and phenolic compounds [34, 25]. Keeping these facts in view, the present study was carried out to use blends/mixtures of processed and unprocessed oat flour in combination with bengal gram flour, mung bean flour and linseed powder for preparation of gluten free *dhokla* suitable for patients with celiac disease.

Material and Methods

Procurement of selected oat variety

One oat variety (OS-346) was procured from the Forage Section of the Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar, whereas rice, mung bean and linseed samples were purchased from local market. All the samples were cleaned and stored in plastic containers till further use. The oat grain samples were processed by using various processing techniques.

Processing of oat grains

Different processing methods were used to process the oat grains:

Malting

The seeds were manually cleaned and steeped in tap water in ratio of 1:3 (w/v) grains for 12 h at room temperature. At the end of the period, the seeds were drained, spread separately and were allowed to germinate for 48 h covered with damp cotton cloth to optimize most suitable time for germination for maximum nutrient availability and digestibility. Water was sprinkled at 12 h interval to facilitate the germination process. The seed samples were dried in hot air oven at 60^{o}C till constant weight and then root-lets were removed by hand braising. The dried samples were ground into fine powder and stored in air tight containers for further analysis.

Roasting

Roasting invariably improves the flavour and shelf life of the product. The seeds were manually cleaned and roasted in a *karahi* until they become brown and then kept for cooling. Then the samples were ground to fine powder and stored in air tight polythene bags for further analysis.

Popping

Popped grain is a crunchy, porous and precooked product. Popping invariably improves texture and flavour. Popping was done first by soaking the grains in tap water in a ratio of 1:3 for 12 h. Then dried at room temperature in open for 12 h and puffed in traditional iron *karai* using sand at 200-250^{o}C and then kept for cooling. The samples were ground to fine powder and stored in air tight containers.

Flaking

Flaking is done to prepare instant foods for Breakfast. Flakes were prepared by soaking the grains in tap water in a ratio of 1:5 for 12 h. Then pressure cooked the oat grains for 20 min and then pressed by rollers and finally dried in hot air oven at 50 ± 5^{o} C. Then the samples were ground to fine powder and stored in air tight containers.

Preparation of Instant dhokla Mix

The unprocessed and processed oat grains and mung bean were subjected to milling to obtain flour. Linseed seeds were roasted and ground to obtain fine powder

Mixed oat flour, bengal gram flour, mung bean flour and linseed powder. Added *eno*, citric acid, sodium bicarbonate, sugar, turmeric powder and salt. Mixed all ingredients properly. Then packed and sealed in polyethylene pouches.

Added curd (50g) and water (100ml) to the *dhokla* mix. Prepared batter with proper mixing. Greased a pan for steaming and poured the mixture into the greased pan and steamed for 7-8 minutes. When ready, took it out on plate and cut into 2”x2” square pieces. Heated oil in a frying pan, added mustard seeds and allowed to crackle, add curry leaves, green chillies, pinch of salt, sugar, water and cooked for 5 minutes. Poured this water on pieces of *dhokla* to make it soft and spongy.

Organoleptic evaluation of oat based gluten free instant dhokla

Instant *dhokla* were subjected to sensory evaluation with respect to color, appearance, aroma, texture, taste and overall acceptability by a panel of 10 semi trained judges, using 9 point hedonic scale.

Nutritional Evaluation of oat based gluten free cookies

Proximate composition such as moisture, protein, crude fat, crude fibre and ash was determined by employing the standard method of analysis [4]. Total carbohydrates were estimated by the following calculation method : Total carbohydrates (%) = 100 – (Crude protein+crude fat+crude fibre+ash) Total energy was calculated theoretically by using the following conversion factors 4.0, 4.0 and 9.0 Kcal/ g for protein, carbohydrates and fat, respectively, according to the method described by Paul and Southgate [2].

Total minerals i.e calcium, iron, magnesium and zinc in acid digested samples were determined by Atomic Absorption Spectrophotometer [42]. Whereas, phosphorus was determined colorimetrically [8]. *In vitro* availability of minerals and iron in the samples were extracted according to method of Rao and Prabhavathi [6] and Calcium and zinc were extracted by the method of Kim and Zemel [14]. Total phenolic content was estimated by the method of Singleton and Rossi [41]. DPPH free radical scavenging activity was measured using DPPH [36].

Starch digestibility (*in vitro*) was assessed by employing pancreatic amylase and incubating at 37^{o}C for 2 hours. Liberated maltose was measured colorimetrically by using dinitrosalicyclic acid reagent [39]. Protein digestibility (*in vitro*) was assessed by employing pepsin and pancreatin [10]. The nitrogen contents of the sample and the undigested residue were determined using automatic KEL PLUS [4]. The digested protein of the sample was calculated by subtracting residual protein from the total protein of the sample.

Protein digestibility (%) = Soluble protein N/ Total protein N×100.

Shelf life of most acceptable developed oat based gluten free cookies

Sensory evaluation

Organoleptic evaluation of stored products were done for period of 3 months at interval of one month by a panel of ten semi trained judges for colour, appearance, aroma, texture, taste and overall acceptability using a nine-point Hedonic Scale.

Fat acidity

The fat acidity was determined by the standard method of analysis [4].

Statistical Analysis

The data were statistically analyzed for analysis of variance to determine the critical difference (CD) among different varieties. [35].

Results and Discussion

Organoleptic acceptability

Five types of *dhokla* developed from instant *dhokla* mixes which were prepared by addition of bengal gram flour, mung bean flour and linseed powder in unprocessed and processed oat flour (**Table 1**).

Table 1 Mean scores of organoleptic acceptability of oat based gluten free instant *dhokla*

Instant *Dhokla*	**Colour**	**Appearance**	**Aroma**	**Texture**	**Taste**	**Overall Acceptability**
Type-I	7.70±0.13	7.50±0.14	7.44±0.17	7.70±0.13	7.45±0.21	7.55±0.05
Type-II	7.48±0.17	7.31±0.13	7.33±0.15	7.52±0.15	7.90±0.16	7.50±0.10
Type-III	7.38±0.13	7.47±0.17	7.28±0.12	7.47±0.16	7.38±0.15	7.39±0.06
Type-IV	6.55±0.17	6.65±0.16	6.95±0.18	6.95±0.15	6.20±0.27	6.66±0.10
Type-IV	5.90±0.27	6.25±0.34	6.63±0.30	6.50±0.11	6.10±0.41	6.27±0.20
CD (P≤0.05)	0.50	0.61	0.58	0.46	0.81	0.35

Values are mean ± SE of ten independent determinations
Type-I : Unprocessed oat flour: Bengal gram flour :Mung bean flour: Linseed powder (60: 40:20:5)
Type-II : Malted oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60: 40:20:5)
Type-III : Roasted oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40: 20:5)
Type-IV : Popped oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60: 40:20:5)
Type-IV : Flaked oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60: 40:20:5)

Colour scores of all types of *dhokla* ranged from 5.90 to 7.70, with the highest (7.70) for *dhokla* prepared from (Type-I) *dhokla* mix based on unprocessed oat flour followed by (Type-II) malted (7.48), (Type-III) flaked (7.38), (Type-IV) roasted (6.55) and lowest in instant mix based on (Type-V) popped oat flour (5.90). Type-I, Type-II and Type-III *dhokla* were found in the category of 'liked moderately'. Whereas, *dhokla* prepared from (Type-IV and Type-V) mix based on roasted and popped oat flour scored poor scores which were 'liked slightly' to 'neither liked nor disliked' by the judges.

Mean score for appearance of *dhokla* prepared from Type-I instant mix (based on unprocessed oat flour) was 7.50, which was 'liked moderately' by the judges. Appearance scores of *dhokla* prepared from mixes (Type-II and Type-III) based on malted and flaked oat flour scored almost similar mean scores i.e 7.48 and 7.38, which were also 'liked moderately' by the judges. The obtained mean scores were 7.31 and 7.47, respectively. However, the *dhokla* prepared with mixes (Type-IV and Type-V) based on roasted and popped oat flour obtained lowest scores i.e 6.65 and 6.25 which were 'liked slightly' by the judges.

Mean scores of aroma of *dhokla* prepared using mixes (Type-I, Type-II and Type-III) based on unprocessed, malted and flaked oat flour were 7.44, 7.33 and 7.28, respectively. The aroma of three types of *dhokla* except the Type-IV and Type-V *dhokla* (mixes based on roasted and popped oat flour) were 'liked moderately' by the panelists. Whereas, Type-IV and Type-V *dhokla* (roasted and popped oat flour based mixes) were 'liked slightly' by the panelists. The obtained mean scores were 6.95 and 6.63 of Type-IV and Type-V *dhokla*.

Mean scores of texture of Type-I *dhokla* (based on unprocessed oat flour) was 7.70, which fell in the category of 'liked moderately'. Whereas, Type-II and Type-III *dhokla* (based on malted and flaked oat flour) got lower scores (7.52 and 7.47) as compared to Type-I *dhokla* but still fell in the category of 'liked moderately'. However, the *dhokla* which prepared from roasted and popped oat flour based mixes (Type-IV and Type-V) was 'liked slightly' by the panelists. The obtained mean scores were 6.95 and 6.50, respectively. Type-IV and Type-V *Dhokla* differed significantly from other three types of *dhokla*.

Taste score of *dhokla* ranged from 6.10 to 7.90, which were found in the category of 'liked moderately' to 'liked slightly'. Taste score of *dhokla* prepared from mixes (Type-I, Type-II and Type-III) based on unprocessed, malted and flaked oat flour were 'liked moderately' by the panelists. The obtained mean scores were 7.45, 7.90 and 7.38, respectively. *Dhokla* which prepared from malted oat flour (Type-II) based mix was found to be better in taste than *dhokla* which prepared from unprocessed (Type-I) oat flour based *dhokla* mix. Whereas, Type-IV and Type-V (roasted and popped oat flour based mixes) *dhokla* was 'liked slightly' by the judges. They scored almost similar mean scores i.e 6.20 and 6.10.

Overall acceptability scores of *dhokla* prepared from mixes (Type-I, Type-II and Type-III) based on unprocessed, malted and flaked oat flour were 7.55, 7.50 and 7.39 respectively, which fell in the category of 'liked moderately'. However, *dhokla* prepared from mix based on popped oat flour (Type-V)was not at par in terms of colour and *dhokla* which prepared from mixes based on roasted and popped (Type-IV and Type-V) oat flour were 'liked slightly' in terms of appearance, aroma, texture, taste and overall acceptability. Present findings are also supported by previous results of [33] and [38] who developed instant *dhokla* from instant mixes (soyabean, malted ragi, pearl millet, black gram, little millet, mung bean and bengal gram) were found acceptable. Lohekar and Arya [33] also reported that incorporation of malted ragi flour improved flavour and taste of instant *dhokla*. In the present study also malted and flaked oat flour based instant *dhokla* obtained higher scores.

Proximate composition

Moisture content of Type-I *dhokla* was 8.14 per cent. Whereas, moisture content of Type-II and Type-III *dhokla* was observed as 9.40 and 9.01 per cent, respectively. Non-significant difference was observed in the Type-II and Type-III *dhokla* (**Table 2**).

Table 2 Proximate composition (%) and energy (Kcal/100g) of oat based gluten free instant *dhokla* (on dry matter basis)

Instant *dhokla*	Moisture	Crude Protein	Crude fibre	Ash	Crude fat	Carbo hydrates	Energy
Type-I	8.14±0.14	20.44±0.63	7.26±0.13	2.40±0.01	5.36±0.06	63.54± 1.82	388.00±2.50
Type-II	9.40± 0.24	20.92± 0.59	6.34±0.08	2.26±0.03	4.68±0.12	66.01± 1.88	390.00±2.31
Type-III	9.01±0.11	20.68±0.50	6.38±0.10	2.05±0.01	4.73±0.02	65.95± 1.63	389.00±2.74
CD(P≤0.05)	0.69	NS	0.32	0.10	0.28	1.68	NS

Values are mean ± SE of three independent determinations; NS=Non-significant
Type-I : Unprocessed oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5)
Type-II : Malted oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5)
Type-III : Flaked oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5)

Crude protein contents of three types of *dhokla* were 20.44, 20.92 and 20.68, per cent respectively. Protein content was non-significantly (P≤0.05) higher in Type-II and III *dhokla* as compared to Type-I *dhokla.*

Crude fibre content of *dhokla* which prepared from mix based on unprocessed oat flour was 7.26 per cent, which was significantly (P≤0.05) decreased with the use of processing treatments like malting and flaking. *Dhokla* which prepared from Type-II and Type-III mix contained lower values of crude fibre i.e 6.34 and 6.38 per cent, respectively. Non-significant difference was noted in Type-II and Type-III *dhokla*. Type-I *dhokla* contained 2.40 per cent ash content, which significantly (P≤0.05) decreased in Type-II and Type-III *dhokla*. The values were 2.26 and 2.05 in Type-II and Type-III *dhokla*. Significant (P≤0.05) difference was observed among the values.

Fat content of all three types of *dhokla* ranged from 4.68 to 5.36 per cent, respectively, with highest (5.36%) in *dhokla* which prepared from Type-I mix and lowest (4.68%) in *dhokla* prepared from Type-II mix. Non-significant differences were observed in the values of Type-II and Type-III *dhokla*. Similar results were also reported by other workers in products made from malted and unprocessed mixes [12, 17and29] who reported that sprouted mixes had significantly higher amount of protein but lower amount of crude fat, crude fibre and ash contents as compared to unprocessed mixes. The increase in protein content could be due to a compensatory increase in free amino acids, peptides and non-protein nitrogenous constituents during germination. Fat and crude fibre degraded during malting/sprouting process [13].The decrease in oil content on sprouting may be attributed to their utilization in the sprouting process as energy source [40].

Carbohydrate content of all three types of *dhokla* were 63.54, 66.01 and 65.95 per cent, respectively. Significant difference was observed between Type-I and Type-II and III *dhokla.* Energy content of *dhokla* which prepared from Type-I mix was 388.00 Kcal/100g, respectively. However, the *dhokla* which prepared from Type-II and Type-III mix contained 390 and 389 Kcal/100g. Non-significant difference was observed in all three types of *dhokla*.

Total minerals

The Data presented in **Table 3** showed that calcium content of *dhokla* made with Type-I mix was 174.20 mg/100g. Whereas, *dhokla* made from Type-II and Type-III mix contained 172.34 and 171.47 mg/100g of calcium content. Non-significant difference was observed in all three types of *dhokla*.

Table 3 Total minerals (mg/100g) of oat based gluten free instant *dhokla* (on dry matter basis)

Instant *dhokla*	Calcium	Phosphorus	Magnesium	Iron	Zinc
Type-I	174.20±3.45	521.45±2.36	143.37±1.73	5.70± 0.00	4.71± 0.06
Type-II	172.34±1.72	519.51±1.66	141.72±2.12	4.97±0.02	3.95±0.07
Type-III	171.47±2.56	518.42±2.39	140.49±1.12	4.33± 0.04	3.54± 0.01
CD(P≤0.05)	1.67	2.32	1.56	0.10	0.02

Values are mean ± SE of three independent determinations; NS=Non-significant
Type-I : Unprocessed oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5)
Type-II : Malted oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5)
Type-III : Flaked oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5)

Phosphorus content of Type-I *dhokla* was 521.45 mg/100g. The values were 519.51 and 518.42 mg/100g, respectively, in Type-II and Type-III *dhokla.* Non-significant difference was observed among the values.

Magnesium content ranged from 140.49 to 143.37 mg/100g in three types of *dhokla*. Maximum (143.37 mg/100g) was observed in *dhokla* prepared from Type-I mix and minimum (140.49 mg/100g) in *dhokla* prepared from Type-III mix.

Iron content of all three types of *dhokla* were 5.70, 4.97 and 4.33 mg/100g respectively, with the highest in Type-I *dhokla* followed by Type-II *dhokla* and Type-III *dhokla*. All the values differed non-significantly (P≤0.05).

Type-I *dhokla* contained 4.71 mg/100g of zinc content which found to be non-significantly higher than Type-II and Type-III *dhokla*. *Dhokla* which prepared from Type-II and Type-III mix got lower contents i.e 3.95 and 3.54 mg/100g respectively. Maximum (4.71mg/100g) zinc content was found in Type-I *dhokla* and minimum (3.54 mg/100g) in Type-III *dhokla*.

It might be due to leaching out of minerals in soaking medium during germination and flaking process. Other workers also reported similar results which are in agreement with the present results [1 and 31]. Processing treatments like malting and flaking non-significantly decreased the minerals content [8]. Contrary to this, other workers reported that germination was found to increase the content of total minerals particularly calcium, iron and zinc [20 and 32].

Available minerals

Calcium per cent availability of all three types of *dhokla* were 54.35, 60.66 and 57.81 per cent, respectively. With the highest (60.66%) in Type-II *dhokla* followed by Type-III *dhokla* (57.81%) and lowest (54.35%) in Type-I *dhokla* (**Table 4**).

Table 4 Available minerals (%) of oat based gluten free instant *dhokla* (on dry matter basis)

Instant *dhokla*	Calcium	Iron	Zinc
Type-I	54.35±0.90	44.71±0.80	39.89±0.49
Type-II	60.66±0.67	51.24± 0.69	42.83±0.56
Type-III	57.81±0.60	49.49±0.37	40.44± 0.42
CD(P≤0.05)	3.29	2.88	0.65

Values are mean ± SE of three independent determinations
Type-I : Unprocessed oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5)
Type-II : Malted oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5)
Type-III : Flaked oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5)

Iron availability of *dhokla* prepared from Type-I mix was 44.71 per cent, which was significantly (P≤0.05) increased with the processing treatments like malting and flaking. *Dhokla* prepared from Type-II and Type-III mix had significantly higher iron availability. Zinc availability was 39.89 per cent in Type-I *dhokla*. Whereas other two types of *dhokla* exhibited 42.83 and 40.44 per cent zinc availability. Type-II and Type-III *dhokla* obtained significantly (P≤0.05) higher zinc availability than Type-I *dhokla*. Germination and flaking significantly improved the *in vitro* availability of minerals as germination and pressure cooking cause hydrolysis in anti-nutrient contents as they are known to form insoluble complexes with minerals and lowering their bio-availability [17 and 28].

In vitro digestibility and antioxidant activity

In vitro protein digestibility of all three types of *dhokla* were 65.45, 77.92 and 73.62 per cent, respectively, with highest (77.92%) was observed in *dhokla* prepared from malted (Type-II) oat flour based mix followed by flaked (Type-III) and lowest (65.45%) in unprocessed (Type-I) oat flour based mixes. In *vitro* starch digestibility was significantly (P≤0.05) higher in *dhokla* which prepared from Type-II and Type-III mix as compared to *dhokla* which prepared from Type-I mix. The values were 54.54, 66.65 ad 64.38 per cent, respectively in Type-I, Type-II and Type-III *dhokla.* Significant (P≤0.05) differences were observed among the values (**Table 5**).

Table 5 *In vitro* digestibility and antioxidant activity of oat based gluten free instant *dhokla* (on dry matter basis)

Instant *dhokla*	*In vitro* protein digestibility (%)	*In vitro* starch digestibility (mg/maltose/g)	Total phenolic (mg GAE/g)	DPPH free radical scavenging activity (%)
Type-I	65.45±1.82	54.54±1.76	1.80±0.01	11.80±0.58
Type-II	77.92±1.45	66.65±2.28	2.23±0.03	15.92±0.49
Type-III	73.62±2.67	64.38±1.56	1.96±0.00	13.93±0.56
CD(P≤0.05)	3.45	2.56	0.03	1.42

Values are mean ± SE of three independent determinations
Type-I : Unprocessed oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5)
Type-II : Malted oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5)
Type-II : Flaked oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5)

Improved protein digestibility on germination may be due to decrease in anti-nutritional factors like phytic acid and polyphenols and degradation of storage proteins and complex carbohydrates due to action of hydrolytic enzymes [11]. Enhanced in *vitro protein* and starch digestibility of ready to eat products prepared by using the flaking process [3]. As heat treatments may responsible for gelatinization of starch granules which becomes readily available for digestive enzymes and also anti-nutritional factors are destroyed due to heat treatment which are responsible for hindering the activity of hydrolytic enzymes such as amylase and protease [27]. As in present study also the products prepared from flaked oat flour/grits based blend exhibited significantly higher *in vitro* protein and starch digestibility as compared to the products made from unprocessed oat flour/grits based blend.

Total phenolic content of *dhokla* made from Type-I mix was 1.80 mg GAE/g. However, *dhokla* made from Type-II and Type-III mix had significantly (P≤0.05) higher phenolic contents as compared to Type-I *dhokla.* The values

were 2.23 and 1.96 mg GAE/g in Type-II (malted oat flour based mix) and Type-III (flaked oat flour based mix) *dhokla*.

Antioxidant activity was 11.80 per cent in Type-I *dhokla*. Whereas, the antioxidant activity of Type-II and Type-III *dhokla* were 15.92 and 13.93 per cent, respectively. Type-II (malted oat flour based mix) and Type-III (flaked oat flour based mix) *dhokla* had significantly higher activity as compared to Type-I *dhokla.* Significant differences were observed among the values. It has been reported that increase in phenolics during initial stage of germination is mainly to prevent seeds from oxidative damage [30 and 35]. Other workers also reported significantly higher antioxidant activity in malted/sprouted instant mixes than unsprouted mixes which might be due to increase in activity of antioxidant enzymes like superoxide dismutase, glutathione peroxidase, catalase etc [7]. These results are in agreement with the present results with respect of antioxidant activity of products prepared by using malted oat flour/grits based mixes

Effect of storage on overall acceptability of oat based gluten free instant dhokla

Overall acceptability mean scores of *dhokla* prepared from fresh (0 day) stored all the three types of *dhokla* mixes were 7.55, 7.50 and 7.39, respectively (**Figure 1**) which decreased with increase in storage period i.e 30, 60 and 90 days. However, overall acceptability scores of *dhokla* prepared from stored Type-I (7.83), Type-II and III (6.86 and 6.74) *dhokla* mixes were still found in the acceptable category up to 90 days of storage.

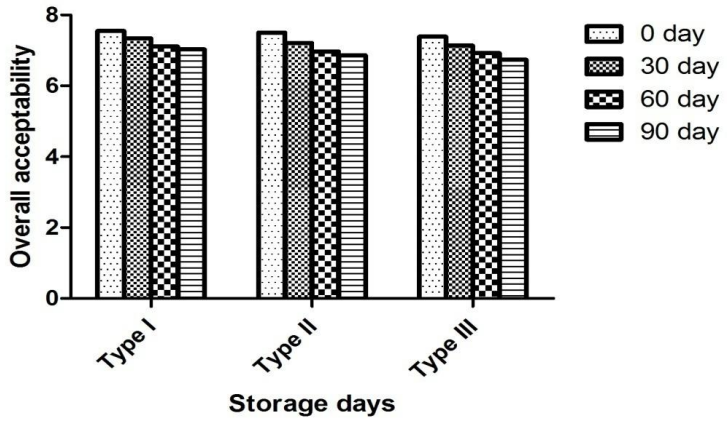

Figure 1 Effect of storage on overall acceptability of oat based gluten free instant *dhokla*

[Bars represents mean± S.E of ten independent determinations; Type-I: Unprocessed oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5); Type-II : Malted oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5); Type-III: Flaked oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5)]

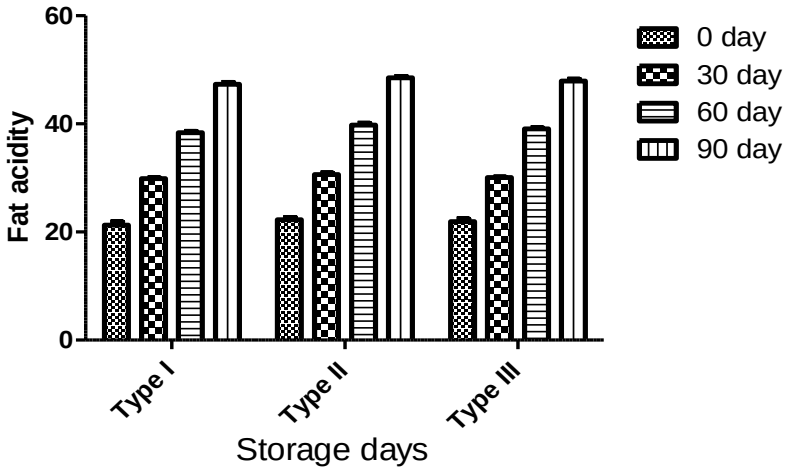

Figure 2 Effect of storage on fat acidity of oat based gluten free instant *dhokla*

[Bars represents mean± S.E of three independent determinations; Type-I : Unprocessed oat flour: Bengal gram flour: Mung bean flour: Linseed powder(60:40:20:5); Type-II : Malted oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5); Type-III : Flaked oat flour: Bengal gram flour: Mung bean flour: Linseed powder (60:40:20:5)]

The data presented in **Figure 2** presented that fat acidity content was 21.25 mg KOH/100g in *dhokla* prepared from 0 day stored (fresh) *dhokla* mix (Type-I) which was found to be increased with increase in storage intervals i.e 29.88, 38.37 and 47.32 mg KOH/100g, respectively on 30, 60 and 90 days of storage. Similar trend was also observed in case of *dhokla* which prepared from Type-II and III stored mix. Fat acidity of other two types of *dhokla* prepared from 0 day stored (fresh) Type-II and Type-III *dhokla* mixes exhibited 22.29 and 21.91 mg KOH/100g, respectively. The contents were found to be increased significantly on increasing the storage periods. The values were observed in the range of 30.62 to 48.53 and 30.07 to 47.92 mg KOH/100g, respectively in *dhokla* prepared from stored mix based on malted and flaked oat flour up to 90 days of storage. However, fat acidity contents of *dhokla* prepared from three types of stored mixes were found within the permissible limit.

Conclusion

It may be recommended from the present results that *dhokla* prepared from processed oat flour were found to be nutritionally superior and organoleptically acceptable by the panelists as compared to *dhokla* based on unprocessed oat flour. Hence, the developed gluten free *dhokla* would be beneficial for patients suffering from celiac disease

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