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Research paper

Development of Shelf-Stable Instant Savoury Sponge Cake (Dhokla)

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ABSTRACT

Instant dhokla was developed using the optimised composition of both unfermented and fermented battters consisting of bengal gram dhal, salt, citric acid, chilli: ginger paste etc. Both unfermented (100 min) and fermented (120 min) dhoklas were dried in a fluidized bed drier, packed in metallised polyester (MP 12μ, LD/LLD 150 μ) pouches, stored at ambient conditions (15-37° C) to establish their stability. Protein and total ash contents were found more in fermented dhokla than the unfermented one. During storage, peroxide and thiobarbituric acid values were found significantly ($p<0.05$) less with significantly ($p<0.05$) higher values of free fatty acid values in fermented dhokla in comparison to unfermented dhokla. Dhokla prepared from unfermented batter received higher acceptance in terms of texture and rehydration characteristics. Both the type of dhoklas were found stable and acceptable for 6 months at ambient temperature conditions (15-37° C).

Keywords: Instant dhokla, fermented, unfermented, lipid oxidation, rehydration, texture, stability

Dhokla, a traditional fermented product known to have its origin in the state of Gujarat, is consumed as a breakfast, snack or a main course item. It tastes slightly sweet and tangy (Shobha *et al.* 2019) with a spongy and a juicy texture. Dhokla is traditionally prepared from the fermented batter consisting of rice or semolina and chick pea (Lohekar and Arya, 2014) as fermentation is the traditionally practiced method for the various food preparations. Dhokla preparation using wheat semolina with bengal gram flour has also been reported (Reddy *et al.* 1983).

Ready to eat fermented dhokla is a highly perishable item with a limited shelf-life. Hence need to be consumed on the day of its preparation. In addition, preparation of traditional dhokla is a lengthy process as it requires long time soaking of dhal and overnight fermentation of the batter to get desired texture.

Changes in life style, rapid urbanization, increased working women population, inadequate time for the preparation of foods, hectic schedule etc., has led to the growing demand for instant foods (Mogra and Chaudhary, 2014) and today wider varieties of the same are attracting the global consumers. Instant foods are simple, fast, convenient, and requires minimum preparation time before consumption (Dhiman *et al*. 2017). Currently these foods are serving the global population with good taste and greater efficiency and can be seen in every kitchen shelves and has become a boon to the working population as it saves time and energy.

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Various types of value added dhoklas and instant dhokla mixes viz, probiotic dhokla (Suman and Khetarpaul, 2018) antinutrient reduced dhokla (Sharma *et al.* 2018), maize dhokla (Shobha *et al.* 2019), horse gram dhokla (Ganapathyswamy and Lakshmanan, 2021), cereal -legume based dhokla mix (Mahajan And Chattopadhyay, 2000), dhokla mix using pumpkin flour (Usha Ravi *et al.* 2010), dhokla mix based on buck wheat and pumpkin flour (Jaiswal and Abraham, 2017), gluten free dhokla mix (Mehta and Jood, 2018), millet dhokla mix (Ransumithila and Saravanakumar, 2019), dhokla mix using germinated brown rice (Sathe *et al*. 2020) etc, have been successfully developed and reported.

However, the development and studies on the stability of instant dhokla is rather scanty. Therefore the current study was under taken with an aim to develop shelf stable instant dhokla (Unfermented and fermented) with good rehydration properties and better sensory characteristics. The uniqueness of the present investigation is the preservation of instant dhokla over the above reported dhokla mixes, wherein the retention of porous texture during processing and storage as well as rehydration properties are novel and critical aspects of the research achievement.

MATERIALS AND METHODS

Materials

Bengal gram flour, wheat semolina, turmeric powder (MTR brand), salt (Tata brand), green chillies, ginger were purchasesd locally from the market of Mysore, Karnataka.

Curd (Nandini brand) was procured from Mymul, Mysore, Karnataka.

Analytical grade (AR) chemicals were used for all the experiments conducted in the study.

Methods

Raw material preparation

Preparation of green chilli- ginger paste

Green chillies were thoroughly cleaned and rinsed in deionized water before use. Ginger was washed thoroughly in tap water to remove the adhering mud and rinsed in deionized water. The skin of the ginger was scraped off and the cleanest portion of the rind was taken for use.

Ginger and chillies were cut in to pieces and equal parts of both were ground to make chilli ginger paste.

Process for dhokla preparation

Preparation of unfermented dhokla

Optimized formulation of the ingredients required for the preparation of unfermented dhokla consisting of bengal gram flour (720 g), wheat semolina (180 g), salt (30 g), turmeric powder (4g), green chilli ginger paste (120 g), curd (500 g), water (700 ml) and citric acid (6 g), were mixed together to get thick batter consistency. Leavening agent (60 g, Eno fruit salt) was added, mixed well and immediately the batter was poured into a greased rectangular tray (440 × 350 × 65 mm) and steamed for 15 min. Dhoklas were cooled after steaming and cut in to uniform size of 40 × 40 × 35 mm.

Preparation of fermented dhokla

For the preparation of fermented dhokla, bengal gram dhal (720 g) was soaked for 4 hr, ground to a thick paste with an addition of 1200 ml water, mixed with wheat semolina (180g), salt (40g), turmeric powder (4 g), chilli ginger paste (120g) and kept for overnight fermentation (app 16 hr) at 30° C. Fermented batter was used for the preparation of dhokla as explained above.

Drying of dhokla

Both unfermented and fermented dhoklas were dried in a fluidizded bed drier (M/s Alliance Engineering Company, Mumbai) at 70° C. The hot air was allowed to pass through the perforated bed, letting the product to flow in the shear of air and mass reduction was noted down at different intervals of time. Drying of both unfermented and fermented dhokla took 100 and 120 min respectively to achieve the moisture content between 8 -9%.

Rehydration of dhokla

Both unfermented and fermented dhoklas were immersed in 100 ml cold water containing 8g sugar and 1g salt. Unfermented dhokla took 5 min and fermented dhokla took 6.5 min for complete rehydration.

Physico chemical methods of analysis

Measurement of colour

The CIE (L^*, a^*, b^*) color values of instant dhoklas were measured using mini scan XE plus, (Model 45/0-s, Hunter Associates Laboratory, Inc., Reston, VA, USA) colour meter having D-65 illuminant and 10^o observer, taking black and white tiles as standard references. Mean values of the triplicate readings have been reported.

Texture profile analysis

The texture profile analysis of instant dhoklas were carried out using texture analyser (Model: TA HD +, Stable Micro Systems, UK) with 50 kg load cell and P75 probe. Instant dhokla after rehydration was slightly pressed between the tissue paper to absorb excess of water and mounted on a heavy duty platform. The test speed was set at 1 mm/sec and pre and post test speeds were maintained at 2 mm/sec. The compression of the probe was set at 20 mm distance to get TPA curve.

Bulk density measurement

The average mass of the dehydrated dhoklas were determined by taking the weights of dhoklas (5 No's) of approximately same size and the volume of the same was measured. The ratio of the mass per volume of the dhokla was taken as bulk density and expressed as g/cc.

Analysis

Moisture, free fatty acids and peroxide value of instant dhokla was determined as per the method of AOAC, (1984). Thiobarbituric acid value was carried out as per the method described by Tarledgis *et al.* (1960). Browning was estimated by the method of Khan *et al.* (2014). Porosity was determined as per the method of Usha Ravi *et al.* (2010). Total acidity was carried out as per AOAC (1970) methods. pH was measured using microprocessor based digital pH meter (Model: Cyber Scan , PH 1500, Eutech Instruments, India).

Sensory evaluation

Sensory evaluation of rehydrated dhokla samples were performed by 15 trained panel of judges and asked them to grade the product as per 9 point hedonic scale in terms of colour, aroma, taste, texture and over all acceptability, grading 9 for extremely liked sample and 1 for extremely disliked sample (Lawless and Heymann, 1998).

Statistical analysis

The values reported are the mean of three replicates and statistical analysis of the data were performed using 2 way analysis of variance (ANOVA). The significant differences among the means were carried out using Duncans multiple range tests at $P<0.05$ significance levels using statistical software (Statistica, Ver. 7.1 Series 1205).

RESULTS AND DISCUSSION

Dhokla prepared using the methods mentioned were dehydrated and evaluated for proximate composition (Table 1).

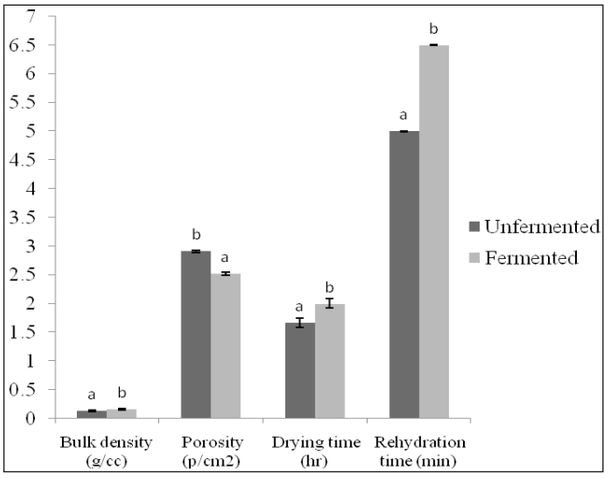
Table 1: Proximate composition of Instant dhokla

Attributes (%)	Unfermented dhokla	Fermented dhokla
Moisture	8.74[a]	8.59[a]
Crude Fat	4.89[a]	5.02[a]
Crude protein	18.07[a]	18.36[a]
Total Ash	6.25[a]	6.55[b]
Carbohydrate (By difference)	61.69[a]	61.48[a]
Energy (kcal)	363.05 [a]	364.54[a]

Values with different superscripts in a row differ significantly (p<0.05).

It can be seen from the table that, between unfermented and fermented dhokla, moisture content did not vary

much. Unfermented dhokla had 8.74% moisture while fermented one showed 8.59% moisture. In case of protein, fermented dhokla showed slightly higher protein content (18.36%) in comparison to unfermented one (18.07%). Increase in protein content might be due to the utilization of carbohydrate present in the product or the accumulation of microbial biomass during fermentation (Nkhata *et al.* 2018). Total ash content was found significantly more ($p<0.05$) in the fermented dhokla (6.55%) than the unfermented one (6.25%). The reason might be the increased bioavailability of minerals upon fermentation or the loss of dry matter by fermenting microbes due to the degradation of proteins (Day and Morawick, 2018). Unfermented and fermented dhokla had a carbohydrate content of 61.69 and 61.48% with a calorific value of 363.05 and 364.54 kcal/100g respectively.



Values with different alphabets on the bar graph differ significantly ($p<0.05$).

Fig. 1: Physical changes in Instant dhokla

It is clear from the Fig. 1 that, unfermented dhokla showed significantly ($p<0.05$) higher porosity (2.91cm^2) and less bulk density (0.13g/cc) than the fermented dhokla which showed 2.55 cm^2 porosity and bulk density of 0.17g/ cc. The above data clearly indicates the inverse relationship between porosity and bulk density. Results obtained for porosity are in agreement with those reported by Usha Ravi *et al*. (2010) for pumpkin flour dhokla. Drying and rehydration time significantly ($p<0.05$) varied between unfermented and fermented dhokla. Fermented dhokla being less porous took higher time for drying (2 hr, 120 min) and 6.5 min for rehydration. On the other hand, unfermented dhokla took 100 min (1hr :40 min) and 5 min for drying and rehydration respectively. There is a direct relationship between porosity and rehydration characteristics, and products with high porosity exhibits good rehydration characteristics which significantly affects the textural and quality characteristics of the dry products (Rodriguez *et al.* 2012) .

pH and acidity are important parameters that influence the shelf-life and quality of foods. In present study (Table 2), microbial fermentation of the dhokla batter has reduced the p^H of the batter from 5.30 to 4.87 with an acidity value 0. 26%. The fresh unfermented dhokla had a p^H of 6.05 with a titratable acidity of 0.34%.

Table 2: Physico-chemical properties of Instant dhokla

Attributes	Unfermented dhokla	Fermented dhokla
Weight (g)	7^a	8^a
Volume (cu cm)	56^a cu cm	51.2^b cu cm
pH	6.05^b	4.87^a
Acidity %	0.34^b	0.26^a

Values with different superscripts in a row differ significantly ($p<0.05$).

Lipid oxidation is one of the major causes for the deterioration of foods, as lipid breakdown to form wide range of oxidation products (Kubow 1992) during storage and is one of the key issues related to the food quality in terms of shelf-life. Chemical changes of instant dhokla with regard to changes in PV, FFA, TBA, browning index and carotenoid contents are represented in Table 3. Initial moisture content in both unfermented and fermented instant dhokla were found closer and observed in the range of 8.59 to 8.74%. During storage up to 8 months, significant increase ($p<0.05$) in the moisture content was observed in both the type of dhoklas and it increased from 8.74 to 9.88% in unfermented dhokla

Table 3: Changes in moisture, free fatty acids, thiobarbituric acid value, browning index and carotenoid content of unfermented and fermented Instant dhokla during storage at ambient conditions (15-37° C)

Parameters	Dhokla Types	Storage Period (Months)				
		0M	2M	4M	6M	8M
Moisture (%)	Unfermented	8.74^{ab}	8.82^{abc}	9.11^{cd}	9.45^{e}	9.88^{f}
	Fermented	8.59^{a}	8.66^{ab}	8.87^{bc}	9.26^{de}	9.55^{g}
PV (meq O_2/kg fat)	Unfermented	6.86^{a}	8.45^{c}	12.66^{e}	16.89^{h}	22.23^{j}
	Fermented	6.41^{b}	7.75^{d}	11.82^{f}	15.91^{g}	20.59^{i}
FFA (% Oleic acid)	Unfermented	1.18^{a}	1.72^{b}	2.38^{c}	2.99^{d}	3.70^{e}
	Fermented	1.28^{a}	1.84^{b}	2.49^{c}	3.11^{d}	3.99^{e}
TBA (mg Malonaldehyde/kg sample)	Unfermented	0.22^{a}	0.28^{b}	0.42^{d}	0.57^{f}	0.72^{h}
	Fermented	0.20^{a}	0.32^{c}	0.41^{d}	0.53^{e}	0.67^{g}
Browning (OD)	Unfermented	0.049^{a}	0.051^{a}	0.073^{d}	0.091^{f}	0.152^{g}
	Fermented	0.055^{b}	0.062^{c}	0.077^{e}	0.094^{f}	0.165^{h}
Carotenoids (µg/g)	Unfermented	12.10^{g}	10.67^{f}	9.11^{d}	7.44^{b}	6.22^{a}
	Fermented	11.85^{g}	10.52^{f}	8.76^{e}	6.84^{c}	6.01^{a}

Values with different superscripts in rows differ significantly ($p<0.05$).

and 8.59 to 9.55% in fermented dhokla. However, between the unfermented and fermented dhokla, moisture content was found insignificant ($p>0.05$) up to 6 months of storage. Initially and during storage, the rate of oxidation assessed in terms of PV and TBA of fermented dhokla was found less than the unfermented one and during storage also, followed the same trend. PV and TBA increased from 6.41 to 20.59 meq O_2/kg fat and 0.20 to 0.67 mg malonaldehyde/ kg sample and 6.86 to 22.23 meq O_2/ kg fat and 0.22 to 0.72 mg malonaldehyde/ kg sample in fermented and unfermented dhokla respectively. But on the contrary, the formation of FFA was found more in fermented dhokla (1.28 % oleic acid) as compared to the unfermented one (1.18% oleic acid). Increase in lipid hydrolysis and decrease in the formation of peroxides and thiobarbituric acid value was also reported by Chen *et al.* (2017) for Harbin dry sausages during bacterial fermentation. Fermented dhokla exhibited more browning and reached to a maximum value of 0.165BI on storage than the unfermented one (0.152BI). Fermentation of the batter facilitated the release of glucose from polysaccharides and formation of total free amino acids competes with the bound lysine to react with reducing sugars causing increase in browning (Yiltiras *et al.* 2022). Initially, the carotenoid content of both the dhoklas were found in the range of 11.85 to 12.10 µg/g and as expected with the progression of oxidation, it decreased significantly ($p<0.05$) to 6.01 µg/g in fermented dhokla and 6.22 µg/g unfermented dhokla respectively.

Texture profile analysis is a commonly employed testing protocol for studying the shelf life of food systems. The textural properties vary widely with the type of the product and storage conditions. In the current study on the textural properties of instant dhokla, hardness was observed less in unfermented dhokla than the fermented one, indicating more spongy and fluffy texture of unfermented dhokla. Hardness increased from 8.20N to 10.83N and 8.89N to 11.43N in unfermented and fermented dhokla respectively during storage at ambient conditions (Table 4). Springiness, the elastic property of the food recorded a significant decrease ($p<0.05$) in both the type of dhoklas and the decrease was from 0.71 to 0.49 and 0.69 to 0.47 in unfermented and fermented dhokla respectively. Gumminess and chewiness

Table 4: Changes in texture of unfermented and fermented Instant dhokla during storage at ambient conditions (15-37° C)

Parameters	Dhokla Types	Storage Period (Months)				
		0M	2M	4M	6M	8M
Hardness (N)	Unfermented	8.20^{a}	8.42^{ab}	9.23^{d}	10.12^{e}	10.83^{f}
	Fermented	8.89^{bc}	9.18^{cd}	9.94^{e}	10.76^{f}	11.43^{g}
Springiness	Unfermented	0.71^{f}	0.67^{ef}	0.60^{d}	0.55^{bcd}	0.49^{a}
	Fermented	0.69^{ef}	0.65^{ef}	0.58^{d}	0.52^{abc}	0.47^{a}
Gumminess	Unfermented	3.94^{a}	4.57^{b}	5.52^{c}	6.49^{d}	7.34^{e}
	Fermented	4.62^{b}	4.77^{b}	5.75^{c}	7.32^{e}	8.46^{f}
Chewiness	Unfermented	0.48^{a}	0.54^{b}	0.60^{c}	0.64^{d}	0.68^{e}
	Fermented	0.52^{b}	0.52^{b}	0.58^{c}	0.68^{e}	0.74^{f}

Values with different superscripts in rows differ significantly (p<0.05).

Table 5: Changes in CIE colour values of unfermented and fermented Instant dhokla during storage at ambient conditions (15-37° C)

Colour Attributes	Dhokla Types	Storage period (Months)				
		0M	2M	4M	6M	8M
L*	Unfermented	86.56^{e}	86.21^{e}	85.75^{d}	85.10^{c}	84.20^{b}
	Fermented	85.23^{c}	85.10^{c}	84.64^{b}	84.02^{b}	83.18^{a}
a*	Unfermented	4.04^{a}	4.28^{ab}	4.59^{b}	5.05^{c}	5.75^{d}
	Fermented	4.14^{a}	4.39^{ab}	4.67^{b}	5.15^{c}	5.69^{d}
b*	Unfermented	25.95^{f}	25.42^{e}	24.84^{d}	24.19^{bc}	23.84^{b}
	Fermented	25.75^{f}	25.12^{de}	24.30^{c}	23.70^{b}	23.22^{a}

Values with different superscripts in rows differ significantly (p<0.05).

found to increase in both the type of dhoklas due to the increase in hardness during storage. Gumminess and chewiness varied significantly (p<0.05) between 3.94 to 7.34 to and 0.48 to 0.68 respectively in unfermented dhokla and 4.62 to 8.46 and 0.52 to 0.74 respectively in fermented dhokla.

Colour being, one of the important sensory parameters, is related to the acceptance of the food even before being consumed (Markovic *et al*. 2013). CIE colour values of instant dhokla are indicated in the Table 5. Lightness index (L*) was found more in the unfermented dhokla (86.56) and less in the fermented dhokla (85.23) when they were fresh. A little longer period of drying might be the reason for the slight darkening of the fermented product thus reducing its lightness in comparison to unfermented one . The same trend was continued during storage also and at the conclusion of the storage period, the lightness index (L*) decreased significantly (p<0.05) to 83.18 in fermented dhokla and 84.20 in the unfermented one. Decrease in lightness index was also observed by Maskan (2001) due to the browning of heat sensitive pigments during drying (Maskan *et al.* 2001). a* value which indicates redness increased significantly (p<0.05) in both the type of dhoklas during storage showing slightly more in the fermented product. However, the increase in a* value was not found significant between them. The decrease in b* value during storage of instant dhokla indicated increase in browning due to the maillard reaction and as expected the decrease was observed more in case of fermented dhokla than the unfermented one.

Table 6: Changes in sensory attributes of unfermented and fermented Instant dhokla during storage at ambient conditions (15-37° C)

Attributes	Dhokla Types	Storage period (Months)				
		0M	2M	4M	6M	8M
Colour	Unfermented	8.42^{d}	8.20^{d}	7.74^{c}	7.42^{b}	7.18^{a}
	Fermented	8.30^{d}	8.12^{d}	7.61^{c}	7.30^{ab}	7.08^{a}
Aroma	Unfermented	8.39^{f}	8.22^{f}	7.91^{e}	7.51^{cd}	6.89^{b}
	Fermented	8.35^{f}	8.17^{f}	7.70^{cde}	7.42^{c}	6.40^{a}
Taste	Unfermented	8.45^{e}	8.35^{e}	7.84^{d}	7.32^{c}	6.76^{b}
	Fermented	8.39^{e}	8.21^{e}	7.77^{d}	7.24^{c}	6.41^{a}
Texture	Unfermented	8.44^{e}	8.19^{e}	7.70^{d}	7.44^{c}	6.85^{b}
	Fermented	8.20^{e}	7.74^{d}	7.21^{c}	7.01^{b}	6.32^{a}
OAA	Unfermented	8.42^{f}	8.28^{f}	7.75^{e}	7.38^{cd}	6.52^{b}
	Fermented	8.32^{f}	8.10^{f}	7.53^{de}	7.12^{c}	6.22^{a}

Values with different superscripts in rows differ significantly ($p<0.05$).

Results of sensory evaluation of instant dhokla obtained as mean scores of colour, aroma, taste, texture and over all acceptability (OAA) are represented in Table 6. The scores of colour, aroma and taste parameters revealed that, initially both the type of dhoklas were found sesorilly superior, though the texture of fermented dhokla was found slightly harder than the unfermented one. Taste being one of the important sensory parameter suggests that, both the type of dhoklas received high acceptance initially and as the storage period increased, the acceptability with regard to taste decreased to 6.76 and 6.41 in unfermented and fermented dhoklas respectively. However, between unfermented and fermented dhokla, no significant changes were noticed in terms of colour, aroma and taste parameters up to 6 months of storage. But after 6 months of storage, both the type of dhoklas received a sharp decrease in both aroma and taste showing the onset of rancidity correlating well with the increased oxidation observed in them during storage (Table 3). Significant difference ($p<0.05$) in texture was also observed in both the dhoklas during 6 months of storage. Rehydrated fresh unfermented dhokla had an OAA score of 8.42, which significantly ($p<0.05$) decreased to 6.52, and the fermented one had an OAA score of 8.32 with a significant reduction ($p<0.05$) to a score of 6.22 after 6 months of storage. Since OAA score of 7 was considered as the lowest score for accepting the product which reveals more than 75% acceptability by the panellists, it was found that both the products remained acceptable for 6 months.

CONCLUSION

A highly acceptable easy to rehydrate instant dhokla can be prepared with superior sensory attributes using both fermented and unfermented batters. Dhoklas prepared from both the batters remained stable and acceptable up to 6 months of storage without much chemical and sensory changes. But after 6 months of storage, development of rancidity in both the dhoklas has affected the taste leading to the rejection of the samples though the products were microbiologically stable. Dhokla prepared from unfermented batter was more acceptable than the dhokla prepared from fermented batter due to its high porosity and sponginess. The products are light in weight and easily gets rehydrated in cold water, finds its suitability as a part of light weight ration in Armed Forces. The authentic and ethnic dhokla belonging to the Western and South -Western region of India can get a global market potential with the instant version due to its ease of preparation and marketable shelf-life.

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