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Enhancing the Nutritional, Textural and Sensory Characteristics of Horsegram Dhokla Mix

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A B S T R A C T

Legume-based fermented foods constitute an important part of the human diet in developing countries like India. Dhokla is a traditional fermented food of Gujarat prepared from chickpea. Dhokla as a healthy snack food is gaining popularity in the country owing to diversification of multicultural cuisine and trends towards healthy snacks. Exploring possibilities of utilisation of different pulses in place of chickpea in dhokla formulation poses endless opportunities for product development with enhanced taste and novelty. Among the pulses, horsegram is an underutilized legume crop with a varied array of nutritional quality and potential health benefits. Hence, the present study was aimed to develop dhokla at various levels of substitution of the base flour (chickpea flour) with horse gram flour (0 – 100% level of substitution). Sensory evaluation revealed that highly acceptable dhokla could be developed from horsegram (100%) without chickpea flour. To further add on to the convenience in the preparation process for dhokla, ready to use horsegram based convenience mix was standardized. The product development form the horsegram dhokla mix was recorded to be organoleptically acceptable on par with that of dhokla prepared from chickpea dhokla mix. The physiochemical, functional and textural properties of dhokla mix were evaluated. The dhokla prepared from horsegram was comparatively higher in protein (21.85g), calcium (239.12mg) and iron (6.89 mg) compared to chickpea dhokla. The horsegram dhokla mix also exhibited higher water absorption capacity (142.60) and emulsification capacity (61.20). The colour value of horsegram dhokla was less due to the seed coat colour of horsegram. The textural profile of dhokla *viz*., hardness, adhesiveness, springiness, cohesiveness, chewiness and resilience of dhokla was comparable to that of chickpea dhokla except for adhesiveness attribute wherein the horsegram dhokla recorded lower values. The processing of horsegram based dhokla rendered lower antinutrient content which may confer better nutrient bioavailability.

Introduction

Food legumes are considered as the second most important food crop next to cereals which plays major role in formulating a balanced diet. Recent interest focuses on investigating and utilizing the underutilized/neglected legumes for product development. Horsegram is one such underutilized legume for human consumption. It is extensively cultivated in Australia, Burma, India and Sri Lanka which is used mainly as animal feed. In India, horsegram is produced in Karnataka, Tamil Nadu, Andhra Pradesh and Maharashtra.[1]

Protein energy malnutrition is one of the nutritional deficiencies faced by most of the developing countries which is associated with deficiency in dietary protein. Horsegram, an underutilized pulse crop which is grown even in adverse climatic conditions with low inputs can be utilized as a potential source of protein to combat protein malnutrition. It is also considered as one of the highly nutritious vegetable pulse crops with ethno-medicinal values in India.[2] It is a rich source of protein, minerals, and vitamins. Besides nutritional importance, it has been linked to reduced risk of various diseases due to presence of non-nutritive bioactive substances. These bioactive substances such as phytic acid, phenolic acid, fiber, enzymatic/proteinase inhibitors have significant metabolic and/or physiological effects.[3]

In addition, lysine content in horsegram protein is higher than pigeon pea and chickpea protein making it a good complement to cereal based diet. It also has high non-digestible carbohydrate content with a potential in the dietary management of diabetes and this resistant starch is regarded as a prebiotic among the new generation of dietary fibre.[2] It is also used in the treatment of many health problems specially to treat diarrhoea, hemorrhage and hemorrhoids. Horse gram also helps in lowering cholesterol levels.[4] Hence, value addition in horsegram can be more fruitful in the market as there is a need for development of high quality convenience foods with enhanced shelf life.

Dhokla, a lactic fermented popular snack in North India is prepared from coarsely ground chickpea batter, steamed, diced, seasoned, and eaten by all age groups.[5] The speciality of dhokla is its delicate spongy texture and digestibility with improved nutritional quality and palatability.[6] The present investigation was undertaken towards standardization of convenient mix formulation of the traditional chickpea based fermented product, dhokla mix using horsegram and to study nutritional and sensory profile of the developed dhokla convenience mix.

Materials and Methods

Horsegram (Paiyur 2) and chickpea (VBN 4) were collected from Tamil Nadu Agricultural University Regional Research Station, Paiyur and Pulse Research Centre, Vamban, Tamil Nadu. The samples were cleaned and soaked for 6 h and dried at 70^0C for 6 h, ground in a commercial mill, and passed through 80 mesh screen sieve to obtained pulse flour. Other ingredients such as mint powder, ginger powder, pepper powder, chilli powder, citric acid and salt used for dhokla preparation were procured from local market.

Standardization of dhokla mix

The dhokla was standardized using the horsegram/chickpea flour as per the formulation elaborated in Table 1. It is mixed with mint powder, ginger powder, pepper powder, chilli powder, citric acid, sodium bicarbonate and salt as described in the following Flow chart. The batter was prepared with the Ready to Cook (RTC) dhokla mix

which was developed as given in the above table with addition of water in the ratio of 1:1.5. The batter was allowed to ferment for 2 hrs at room temperature, poured into greased dhokla moulds and steamed for 10-15 minutes. The dhokla was then cut into pieces and seasoned with mustard, chopped green chillies and curry leaves and subjected to sensory evaluation. Based on the sensory evaluation of the dhokla mix prepared from different proportions of pulses flour, 100 per cent horsegram flour was found to be highly acceptable and was used to standardize the dhokla mix.

Physico-chemical characteristics of dhokla prepared from horsegram flour

The dhokla was evaluated for the physical parameters such as cooking time, weight, height, porosity, diameter of dhokla steamer and diameter of dhokla. The chemical constituents like moisture, protein, fat, carbohydrate, total dietary fibre and minerals were analysed as per AOAC procedure.[7]

Functional properties of Dhokla mix

Water absorption capacity

Water absorption was reported as the percent increase in weight of the cooked sample (weight of cooked sample minus weight of dried sample) compared to the dry sample weight.[8]

Water/oil absorption capacity

About 0.5g sample was dispersed in 15mL of distilled water or oil in a culture tube and kept at a temperature of 30◦C. The dispersion was stirred occasionally, held for 1h and then centrifuged at750×g for15min.The supernatant was drained for 30min at 45◦ angle. The gain in weight was recorded as water or oil absorption (g kg−1).

Foaming Capacity

Foaming capacity (FC) was determined according to the method described by Onwuka.[9] Two grams of flour sample was weighed and added to 50 ml distilled water in a 100 ml measuring cylinder, The suspension was mixed and properly shaken to foam and the total volume after 30 s was recorded. The percentage increase in volume after 30 s is expressed as foaming capacity.

$$\text{Foaming capacity (\%)} = \frac{\text{Volume after whipping} - \text{Volume before whipping}}{\text{Volume after whipping}} \times 100$$

Emulsification capacity

Emulsification capacity (EC) was determined by the method of Kaushal.[10] Two grams of the composite blend was blended with 25 ml distilled water at room temperature for 30s. Thereafter, 10 ml of refined corn oil was added and the blending continued for another 30 s before transferring into a centrifuging tube. Centrifugation was done at 640 x g for 5 min. The volume of oil separated from the sample after centrifuging was read directly from the tube. Emulsification capacity was expressed as the amount of oil emulsified and held per gram of sample

$$\text{Emulsification capacity (\%)} = \frac{\text{Height of emulsified layer}}{\text{Height of whole solution in the centrifuge tube}} \times 100$$

Colour measurements

Colour measurements were performed on cooked dhokla using a Hunter lab colour meter (Lovi bond tinto meter). L* values correspond to lightness/darkness with higher values corresponding to more lightness. a*

and b* values correspond to an object's colour dimensions, with a- values describing a sample's red to greenness, while b-values describe a sample's yellow to blueness. Larger a values indicate more redness and larger b values indicate more yellowness.[11,12]

Texture profile

Samples texture was determined by JSV-H1000 texture analyzer (Japan Instrumentation System Co., Ltd, Japan) using software "SOP-TEX V1.9". An aluminum cutting probe was used in a Texture Profile Analysis (TPA) with follow test setting *viz.*, starting position - 30 mm, stroke - 39mm, M-speed 70, T-speed - 200 and load limit - 400N. Force (tensile strength) at the break point was measured in sample and hardness (N) were calculated from ten average values.

Statistical analysis

Data were assessed by analysis of variance (ANOVA) using SPSS program version 16.0 and means were separated by Duncan's multiple range test with a probability ($P < 0.05$).[13]

Results and Discussion

The dhokla prepared from chick pea and horsegram were subjected to sensory evaluation. Based on sensory attributes, overall acceptability of dhokla prepared from horsegram score was 8.3 (like very much) by the panel of experts compared to 8.4 for the control sample.

There was a slight difference in the colour and appearance and texture of horsegram dhokla, whereas the flavour, taste and overall acceptability were on par with the chickpea dhokla being highly acceptable with the score of 8.4, 8.6 and 8.3 (Table 2). Based on the sensory evaluation of the dhokla mix prepared from horsegram flour was found to be equally acceptable as that of chick pea dhokla (Fig. 1 and 2).

Physico-chemical characteristics of horsegram dhokla mix

The cooking time for chickpea dhokla was 10 min compared to cooking time of 15min for horsegram dhokla. No variation was observed in the weight and volume of the batter on rehydration of the dhokla mix. After steaming, the weight and height of the product were 265-267g and 4.8-5.1cm respectively. The porosity of horse gram dhokla was 3.55cm^2 compared to a corresponding value of 4.25cm^2 for chick pea dhokla. The chemical characteristic of chickpea and horsegram dhokla mix was compared (Table 3).

The moisture, protein and carbohydrate content of dhokla from chickpea mix were 9.55, 20.82, 47.02 respectively and the corresponding values for horsegram dhokla mix was 9.65, 21.85, 56.78 % for respectively. The fat content of chickpea and horsegram dhokla mix were 2.10 g and 1.78 g, respectively. With respect to total dietary fibre content, the values of chickpea and horsegram mix were 14.56 and 7.20 g/100 g respectively. The calcium and iron content was high in horsegram mix (239.12 and 6.89 mg/100g respectively) compared to chickpea (44.80 and 5.12 mg/100g respectively). Statistically, there was a no significant difference in the nutrients of moisture, fat, calcium and iron among chickpea and horsegram mix.

Functional properties of Dhokla mix

The functional properties of dhokla mix prepared from horsegram and chickpea are presented in Table 4.

The water absorption capacity (WAC) of dhokla mix differed significantly ($P<0.05$)

between the two legumes and it was observed as 135.5 percent in chickpea dhokla mix and 142.60 percent in horsegram dhokla mix. Water absorption capacity represents the ability of a product to associate with water under conditions. The highest water absorption capacity of horse gram dhokla mix could be attributed to the presence of greater amount of hydrophilic constitutes like soluble fibre and low amount of fat content.[14]

The oil absorption capacity of dhokla mix helps in improving the mouth feel and flavour retention of dhokla.[15] Among the sample mixes, horse gram dhokla mix recorded lesser value of 82.22 percent and chickpea mix exhibited highest value and of OAC. The high OAC indicated the presence of large proportion of hydrophobic groups as compared with the hydrophilic groups on the surface of protein molecules.[16]

The foaming capacity of dhokla sample mix samples showed no significant difference and the values of chickpea and horsegram dhokla mix were 36.12 to 36.36 percent respectively. Foaming capacity depends on the nature of proteins because of their surface active property which plays a significant role in improving the texture, consistency and appearance of foods. Emulsifing capacity of the dhokla mix was recorded maximum in chickpea 63.64 whereas it was 61.20 ml/g in horse gram based dhokla mix. The low emulsion capacity of horse gram may be due to the low level of non-polar amino acid chains.

Determination of colour value of the dhokla

Colour is considered as a basic physical property for the judgment of the external quality of foods.[17] The first perception of a food product by consumer is its appearance and colour of the food product. Consumer acceptance of various food products may be altered over time if undesirable discolouration/maillard browning reactions occur.[18] In chickpea dhokla, the whiteness (L*), redness (a*) and yellowness (b*) values were observed as 25.36, 0.07 and 85.63 respectively compared to lower L* (12.22), a* (1.45) and b* (55.60) values in the horse gram based dhokla mix (Table 5).

Textural profile analysis (TPA test)

The texture of dhokla samples were analysed using 75mm compression probe in Texture Analyser (Model: JSV H1000, Japan Ltd). For TPA test, the dhokla samples were cooled to room temperature and were cut into an inch cube using an inch cubic mould. The cut piece was placed on the heavy duty platform and the test speed was set to 1mm/sec and the probe compressed 50% of the 12.5mm height of the dhokla to get the TPA of the dhokla. Based on the force deformation curves, several parameters like adhesiveness, springiness, cohesiveness, chewiness and resilience can be calculated. Values obtained represent standard calculations of curve attributes of TPA as described by Bourne and Lyon.[19,20]

All values are means of triplicate determinations± standard deviation (SD), Mean values with different superscripts between columns were significantly different where ($p \leq 0.05$, $p \leq 0.01$) by using Dunnets multiple range tests. Parameters with (-) like below indicates unit less (Table 6).

Hardness is measured as the peak force during compression in the first cycle. Hardness of chickpea and horse gram dhokla was 44.20N and 40.13N which indicated that the horse gram dhokla exhibited more resistance to compression than chickpea dhokla. This might be due to the high fibre content of horsegram which contributes to the porous texture of the dhokla. The adhesiveness of horsegram dhokla was 0.43^{e}±0.06 whereas chickpea dhokla showed slightly lesser value (0.40^{a}±1.02).

Table.1 Formulation for development of ready to Cook horsegram dhokla mix

Ingredients	T_0	T_1	T_2	T_3	T_4
Chickpea flour	100	75	50	25	-
Horsegram flour	-	25	50	75	100
Mint powder	0.1	0.1	0.1	0.1	0.1
Ginger powder	1	1	1	1	1
Chilly powder	1	1	1	1	1
Pepper powder	1	1	1	1	1
Citric acid	1	1	1	1	1
Sodium bi carbonate	1	1	1	1	1
Salt	2	2	2	2	2

Table.2 Mean sensory scores for horsegram dhokla

Treatments	Colour and appearance	Flavour	Taste	Texture	Overall acceptability
Chickpea	8.6±0.01	8.2±0.01	8.7±0.20	8.4±0.02	8.4±0.03
Horsegram	8.1±0.01	8.4±0.03	8.6±0.02	8.0±0.01	8.3±0.01

Table.3 Chemical constituents of dhokla mix

Nutrients	Chick pea	Horsegram	CD(P≤0.05%)
Moisture (%)	9.55±0.13	9.65±1.02	**NS**
Protein (g)	20.82±0.25	21.85±0.02	**1.62**
Fat (g)	2.10±0.01	1.78±0.11	**NS**
Carbohydrate (g)	47.02±0.11	56.78±0.25	**1.46**
Total Dietary fibre (g)	14.56±0.01	7.20±0.01	**1.07**
Insoluble fibre (g)	12.35±0.13	5.80±0.41	**1.72**
Soluble fibre (g)	2.21±0.02	1.40±0.02	**1.06**
Calcium (mg)	44.80±0.05	239.12±0.02	**NS**
Iron (mg)	5.12±0.05	6.89±0.02	**NS**

Values are mean± SE of three independent determinations
Figures in parentheses indicate per cent decrease (-) or increase (+) over control value

Table.4 Functional properties of the dhokla mix

Dhokla mix	WAC	OAC	FC	EC
Chickpea	135.53	122.40	36.36	63.64
Horsegram	142.60	82.22	36.12	61.20

Table.5 Colour measurement of dhokla

Level of incorporation	L*	a*	b*
Chickpea	25.36^{a} ±0.05	0.07^{a}±0.01	85.63^{e}±0.21
Horsegram	12.22^{d}±0.31	-1.45^{e}±0.04	55.60^{a}±0.64

Table.6 Textural profile analysis of dhokla

Level of substitution	Hardness (N)	Adhesiveness (N/sec)	Springiness (-)	Cohesiveness (-)	Chewiness (-)	Gumminess (-)	Resilience (-)
Chickpea	44.20^{a} ±0.01	0.40^{a}±1.02	0.87^{a}±0.01	0.52^{a}±0.01	23.06^{a}±0.09	24.30^{a}±0.60	0.36^{a}±0.01
Horsegram	40.13^{e}± 0.05	0.43^{e}±0.06	0.87^{e}±0.01	0.46^{e}±0.01	10.06^{e}±0.50	15.43^{e}±0.40	0.59^{e}±0.01

Fig.1 Flow chart - Processing of dhokla

Chickpea/Horsegram
↓
Horsegram
↓
Soaking
(6 hours)
↓
Washing
↓
Drying
(70°C for 6 hrs)
↓
Grinding
↓
Addition of spice powder & salt
↓
Mixing and packing

Fig.2 Dhokla prepared ready mix (a. Chickpea, b. Horsegram)

The springiness (0.87^{a}±0.01) was recorded same for chickpea and horsegram dhokla as the springiness of dhokla depends on the quantity of the dhal and spongy texture due to presence of protein in pulses.

The cohesiveness was maximum in chickpea dhokla and it was lesser in horsegram dhokla due to high fibre content which gets disintegrated by mechanical action. Chewiness of horsegram dhokla (10.06^{e}±0.50) recorded lower values than chickpea dhokla. Lower the chewiness yielded increased softness in dhokla. There was a significant difference in the gumminess and resilience between the chickpea and horsegram dhokla. Lower the resilience value shows that the product can recover faster from deformation and thus proves the firmness of the product.

Similar observations, that the values of the control idli offered more resistance to compression than that of soy okara fortified idli.[21] Thus the okara substituted samples were softer and easy to bite compared to control samples. The protein quality and foaming capacity of dhokla mix during fermentation had a positive influence on the textural parameters of dhokla, thereby increases sponginess of the product.

Fermentation is a food processing technique that can improve the quality and other health-promoting benefits of pulses. The functional property of dhokla was increased by replacing chickpea with horsegram. The results revealed that horsegram dhokla had excellent quality attributes, with an overall acceptability of 8.3/9.0 comapred to 8.4 for chickpea dhokla. Since, the product development offers simplicity and ease in preparation in the form of ready to use mix which offers convenience. Subsequent to the reconstitution of the ready to use dhokla mix, the further processing is based on the traditional method of preparation and hence its adaptability and marketing is promising. Present investigation has successfully converted horsegram, an underutilized pulse to nutritionally dense traditional popular snack food in the form of ready mix.

The convenience horsegram dhokla ready mix can easily target vulnerable population as nutritious food at affordable cost which will serve as an ideal vehicle to eliminate, control and eradicate protein malnutrition of the nation.

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