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Improving, handling, textural and sensory properties of water chestnut flat bread by use of guar gum and egg albumin

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Abstract
The effect of incorporation of varying levels of guar gum (0-2.8%) & egg albumin (0-2.8%) on the physicochemical and sensory properties of water chestnut flat bread were investigated. The results revealed that highest work of shear force was observed in T5 containing 2.8g of guar gum & 1.4g of egg albumin. The results indicated that with the increase in concentration of guar gum & egg albumin, the moisture content of the flat bread samples increased concomitantly. Sensory evaluation revealed that overall acceptability of samples incorporated with guar gum & egg albumin were higher compared to that of control samples. The higher overall acceptability values was observed in T6 (2.8g guar gum & 2.8g egg albumin), T7 (1.4g guar gum), T8 (2.8g guar gum), T10 (1.4g egg album) & T11 (2.8g egg albumin).

Keywords: handling, textural, sensory, water chestnut, guar gum, egg albumin

Introduction

Water chestnut is consumed as such after roasting or ground to obtain flour. Numerous health benefits of water chestnut encourage its use in many food preparations. It contains antioxidants, which may help reduce wrinkles and protect skin from ultraviolet rays (Haridasan and Ravi 2010) [15]. Many bioactive agents in water chestnut help reduce hair loss. People suffering from jaundice can also find the consumption of water chestnut as beneficial (Patel *et al.*, 2011). The juice extracted from water chestnut can serve to control diarrhea and dysentery (Walde *et al.*, 2015) [37], and the fruits are used to treat sore throat (Shalabh, 2012) [1, 33]. People facing undernourishment, can gain weight on regular consumption of water chestnut flour (Jasim *et al.*, 2015). The diet obtained from water chestnut flour is suitable for patients with rheumatic diseases (Demirkesen and Paciulli, 2010) [29]. Water Chestnut lowers blood glucose level and reduces insulin secretion, thereby possibly acting as effective food additives for the management of type 2 Diabetes (Midori *et al.*, 2014) [38]. Water Chestnut also contains polyphenols, which may help in the prevention of various degenerative human diseases (Evans and Scalbert 2002) [2], and the antiviral and antibacterial compounds help in strengthening the stomach and remove symptoms of weak spleen such as bad taste, feeling sick and fatigue (Vhotracharcho, 1987). High free radical scavenging properties are associated with protective effects against coronary heart disease, cancer, neurodegenerative diseases and osteoporosis (Hegazy and Bareh, 2014) [16].

Since water chestnut flour is characterized by the absence of gluten, it could be administered as a dietary intervention for treating patients with celiac disease or gluten associated allergies (Demirkesen 2011) [8]. However, the commercial application of water chestnut flour diet is limited by some technological defects that arise as a result of the absence of gluten, which plays a primary role in conferring texture and quality to the products containing it. Chestnut flour is a good source of essential fatty acids, but the main disadvantage of the chestnut flour dough is the low protein content and the absence of proteins with viscoelastic properties like gluten (Moreira *et al.*, 2012) [24]. For improving the elastic properties of Chestnut flour dough, various additives including hydrocolloids can be used, which can act as thickeners, stabilizers or gelling agents. Among the hydrocolloids, agar, hydroxylpropylmethyl cellulose (HPMC), xanthan gum, guar gum, etc. are the most commonly used. Guar gum is the powdered endosperm of the seeds of the *Cyamopsis tetragonolobus* which is a leguminous crop. It binds water, prevents ice crystals in frozen products, emulsifies, moisturizes, thickens, stabilizes and suspends many liquid–solid systems. Guar gum exhibits interesting properties to improve rheological and textural properties of foods and moisture retention capacity (Funami *et al.*, 2005) [11]. In relation to thermal properties of starchy products, Guar gum delays the starch gelatinization of doughs from wheat flour (Rojas, Rosell, and Benedito, 1999) [31] and chestnut flour (Moreira *et al.*, 2011a). Guar gum has also been used for increasing the dough yield in baked goods (Miyazawa *et al.*, 2006) [23].

Additionally, egg white is also added to the gluten-free products for improving technological properties. Egg whites promote foaming, heat setting and adhesion due to the composite of albumen proteins that create superior food-based foam (Mine, 1995; Ternes, 2001) [22, 36]. Egg white proteins have been extensively utilized as ingredients in food processing because of their unique functional, such as gelling and foaming. Egg white can coagulate and act as linkage with other ingredients (Mine 1995) [22]. Egg white is a conventional bread additive, used to improve color, enhance flavour and provide additional structure. Easily digested proteins found in eggs are ideal for recovering Celiac Diseases patients. The egg whites reduce initial gelatinization temperature, improve loaf structure and hinder the starch from completely gelatinizing during baking, reducing rate of retro gradation (Kobylanski *et al.*, 2004).

Considering the above mentioned factors, this study aimed at manufacturing water chestnut flour based flat bread (chapatti), employing varying concentrations of egg albumin and Guar gum so as to improve its textural, handling, and sensory properties.

Objectives

1. To prepare Water chestnut flat bread by using Guar gum, egg albumin and salt.
2. To improve handling, textural and sensory properties of Water chestnut flat bread.
3. To analyze the sensory and textural properties of Water chestnut flat bread.

Methods

Preparation of chapattis

Chapattis were prepared by following the method as reported by previous researchers (Cheng et.al 2015). The chapatti dough was prepared by mixing water chestnut flour with the pre-determined optimum amount of water, salt (2%), varying levels of guar gum and egg albumin. The dough was covered with a wet cloth and was set aside to rest for 15 minutes at room temperature (30 ± 1^0C). The dough was divided into equal portions and rolled into a round sheet (12 cm in diameter and about 2 mm in thickness). The chapattis were baked in an open pan at 210ºC for 150 seconds on each side. After baking, chapattis were subjected to pysico-chemical, and sensory analysis. Table 3.1 depicts the formulations used in chapatti preparation.

Table 1: Different formulation for chapattis preparation.

Treatment	Flour(g)	Guar gum(g)	Egg albumin(g)	Salt(g)	Water(ml)
T0	137.2	0	0	2.8	95
T1	134.4	1.4	1.4	2.8	95
T2	133	1.4	2.8	2.8	80
T3	133.7	2.1	1.4	2.8	85
T4	132.3	2.1	2.8	2.8	95
T5	133	2.8	1.4	2.8	90
T6	132.3	2.8	2.1	2.8	95
T7	135.8	1.4	0	2.8	95
T8	135.1	2.8	0	2.8	95
T9	134.4	2.8	0	2.8	95
T10	135.8	0	1.4	2.8	90
T11	134.4	0	2.8	2.8	85

Texture analysis of chapattis

Texture analysis of chapattis was evaluated by Texture Analyzer (Stable Micro Systems, Model TA-HDI, UK) using the Warner Bratzler blade Test. The hot Chapattis were cut into strips measuring 4cm × 2 cm were cut from each chapatti. The force required to cut the chapatti strip into two pieces was recorded. The speed was maintained at 1.7mm/s. Measurements were recorded in triplicate for each sample and average values were reported.

Moisture Content

Moisture content was determined by hot air oven method (AOAC Method 934.01). In this method 11 samples weighing (2 g) were taken separately in pre weighed crucibles and dried at 103^0 C for 1 hour. After drying, with crucible was weighed again and percentage moisture content was determined as per:

$$\%\ moisture\ content = \frac{W1 - W3}{W2}\ x\ 100$$

Where, W1 = weight of sample +crucible.
W2 = weight of sample.
W3 = weight of dried sample +crucible.

Sensory evaluation:

The chapatti samples were evaluated in terms of color and appearance, ease of tearing, pliability, mouth feel, taste and aroma, and overall acceptance by a total of 10 semi-trained panelists from the Institution of Home science in Department of Food Technology Division, University of Kashmir. The samples were evaluated based on a 9-point hedonic scale with 1 representing the least score (dislike extremely) and 9 as the highest score (like extremely). The samples were presented to the panelists in 3-digit coded sealed pouches. The panelists were instructed to rinse their mouth thoroughly with potable water in between samples evaluations and they were requested to taste the chapatti samples one by one.

Statistical analysis:

Results were expressed as mean ± standard deviation of the data in triplicates. One way analysis of variance was employed and the significant differences were analysed with Duncan's test.

Table 2: Texture analysis of water chestnut flat bread

Treatment	Hardness(n)	Work of shear force(n\sec)
T0	64.19 ± 1.91^{c}	147.88 ± 13.44^{e}
T1	121.52 ± 1.50^{g}	146.31 ± 0.26^{d}
T2	165.36 ± 5.09^{h}	231.29 ± 49.18^{f}
T3	102.54 ± 2.53^{f}	122.68 ± 4.44^{cde}
T4	102.21 ± 4.32^{f}	122.69 ± 0.77^{cde}
T5	181.02 ± 6.76^{i}	284.95 ± 25.56^{g}
T6	76.57 ± 2.56^{e}	102.98 ± 10.31^{abc}
T7	36.38 ± 0.74^{a}	75.22 ± 30.87^{a}
T8	64.44 ± 2.39^{c}	84.74 ± 1.88^{ab}
T9	45.06 ± 0.26^{b}	74.02 ± 0.92^{a}
T10	69.85 ± 1.09^{d}	110.91 ± 4.84^{bcd}
T11	70.06 ± 1.43^{d}	142.10 ± 1.93^{de}

Sensory Evaluation

The Sensory evaluation data in Table 4.2 shows that the flat bread made with water chestnut flour scored good range of overall acceptance. The highest score of color and appearance was observed in T4 with score of 7, as compared to control sample with score of 5 and there is no addition of guar gum and egg albumin in control sample. The overall acceptability of water chestnut flat breads decreased with reduction in the concentration of the added improvers. However, other parameters did not follow the generalized rule and variation was observed among the sensory parameters under analysis.

Crack formation was observed in the breads containing only chestnut flour. By addition of the guar gum, the color of the water chestnut flat bread was more acceptable as compared to that without the addition of the guar gum. T11 water chestnut flat bread was more acceptable in terms of ease of tearing with score of 6.66, pliability with score of 7.00, mouth feel with score of 7.00, taste and aroma with score of 7.00. In this formulation there is no addition of guar gum but 2.8 g of egg albumin was used, which improved these properties. Control sample flat bread prepared by using only water chestnut flour had lower taste and aroma as compared to bread prepared with water chestnut, guar gum and egg albumin (Sacchetti *et al.* 2004). This is because the intense flavor of chestnut is undesirable to some panelists. The intense flavor of chestnut flour is masked with the addition of guar gum and egg albumin, consequently improving the acceptability. This may also be due to the off-flavor formation as a result of Maillard reactions. (Sacchetti *et al.* 2004) found a similar result. Gums and egg albumin have previously also been held responsible for improving the product sensory quality (Lazaridou *et al.*, 2007). The flat bread prepared from whole water chestnut flour earned good response from the panel with overall acceptance in T6 with score of 7.0 as compared to T1 with lowest score of 5.3. At similar concentration or absence of egg albumin, higher addition of guar gum results in the reduction of pliabaility. However, compared to control, the addition of guar gum alone or in combination with egg albumin increases the pliability of the flatbreads. (Gijral *et al.* 2004) also reported an increase in pliability of chapattis with the addition of guar gum, as it acts as strong water binder effectively depriving the starch chain of usable water for recrystallisation and increasing extensibility. Flat bread made from water chestnut flour can be improved by addition of Guar gum (Demirkesen *et al.* 2010) [29]. It is concluded that the combination of guar gum and egg albumin improves the sensory properties of the flatbread under analysis.

Table 3: Sensory evaluation of water chestnut flat bread

Treatment	Colour and appearance	Ease of tearing	Pliability	Mouth feel	Taste and aroma	Overall acceptability
T0	5.00±1.73^{a}	6.00±1.00^{a}	5.00±1.00^{a}	5.33±1.52^{ab}	5.33±1.52^{ab}	5.33±0.72^{a}
T1	5.33±2.08^{a}	6.33±1.15^{a}	5.33±1.15^{a}	5.00±1.00^{ab}	5.00±1.00^{ab}	5.40±1.17^{a}
T2	5.66±1.52^{a}	5.66±0.57^{a}	5.00±1.00^{a}	5.33±0.57^{ab}	5.33±0.57^{ab}	5.46±0.57^{a}
T3	6.00±1.73^{a}	5.33±1.15^{a}	5.66±0.57^{a}	6.33±0.57^{ab}	6.33±0.57^{ab}	5.73±0.64^{a}
T4	7.00±0.00$^{a.}$	6.00±0.00^{a}	5.33±2.08^{a}	4.66±0.57^{a}	4.66±0.57^{a}	5.60±0.91^{a}
T5	5.66±1.15^{a}	6.33±0.57^{a}	6.00±1.00^{a}	5.00±1.57^{ab}	5.00±1.00^{ab}	5.66±0.75^{a}
T6	4.66±2.08^{a}	6.33±0.57^{a}	5.33±2.08^{a}	6.00±2.08^{ab}	6.00±1.00^{ab}	7.06±0.90^{b}
T7	6.66±1.52^{a}	6.33±1.15^{a}	6.33±1.00^{a}	6.00±1.15^{ab}	6.00±1.73^{ab}	6.26±1.00^{a}
T8	6.33±1.52^{a}	6.00±1.73^{a}	6.33±0.57^{a}	6.66±1.15^{ab}	6.66±0.57^{ab}	6.26±0.94^{a}
T9	5.33±2.08^{a}	6.00±1.73^{a}	5.66±1.52^{a}	6.00±1.73^{ab}	6.00±1.73^{ab}	5.80±1.74^{a}
T10	6.66±1.52^{a}	6.00±1.73^{a}	6.33±0.57^{a}	6.66±0.57^{ab}	6.66±0.57^{ab}	6.46±0.94^{a}
T11	6.66±1.52^{a}	6.66±0.57^{a}	7.00±1.00^{a}	7.00±0.00^{a}	7.00±0.00^{b}	6.86±0.50^{a}

Moisture Content

The moisture content profiles of all water chestnut flat bread are reported in Table 4.3. As is clear from the table significant differences are observed among the samples. Highest moisture content was obtained in flat breads T11 with the score of 34%. In this formulation 2.8g of guar gum was used and no egg albumin was added. Whereas lower moisture content was obtained in T4 with the score of 23%, in T4 2.1g of Guar gum and 2.8g of egg albumin was used. Significantly higher moisture contents were obtained in breads containing chestnut flour and Guar gum (Demirkesen *et al*., 2011) [8] as compared to control samples in which there is no addition of guar gum. Guar gums have water binding ability to prevent water loss during storage with the possible hydrogen bonding between fiber and starch (Sarbanis *et al.,* 2009). Water absorption is seen to increase with the addition of hydrocolloids owing to their hydrophilic nature. Hydrocolloids are expected to compete with starch for water uptake due to their high hydrophilic nature. In general, hydrocolloids help in retention of moisture in the product and hence render it softer and pliable. This explains higher moisture content in flatbreads with gum addition.

Table 4: Moisture content of water chestnut flat bread

Treatment	Moisture content (%)
T0	26.9000±0.1^{c}
T1	28.9000±0.1^{d}
T2	25.0000±0.45^{b}
T3	33.0000±0.43^{g}
T4	23.8000±0.2^{a}
T5	29.7333±0.25^{e}
T6	28.7667±0.20^{d}
T7	26.5667±0.83^{c}
T8	30.6333±0.32^{f}
T9	33.6000±0.78^{h}
T10	32.7333±0.25^{g}
T11	34.0000±0.34^{i}

Physical Analysis

Physical analysis of all water chestnut flat bread is reported in Table 4.4. As is clear from the table majority percentage of thickness reduction was recorded in T6, T7 and T11 with the score of 4.6. This could be due the presence of guar gum (2.8g) and egg albumin (2.1g) in T6, 1.4g of guar gum in T7 with no egg albumin and in T11 this percentage was due to the presence of Egg albumin (2.8g) alone, as no guar gum was added in this. The lower thickness reduction was in T2, T3 and T8 with the score of 3.3 in each treatment. T2 contains 1.4g of guar gum and 2.8g of egg albumin was used in T2, (2.1g) of guar gum and (2.8g) of egg albumin was used in T3 and in T8 there was no egg albumin in this level and only 2.1g of guar gum was used.

Diameter reduction was high in T2 with the score of 1.900, in this formulation 1.4g of guar gum and 2.8g of egg albumin were used, whereas lower percentage of diameter reduction was in T1 with the score of 0.3000, in this formulation of T1, 1.4g of guar gum and 1.4g of egg albumin were used.

Table 5: Physical analysis of water chestnut flat bread

Treatment	% of thickness reduction	% of diameter reduction
T0	4.00 ± 0.00^{a}	0.56 ± 0.05^{a}
T1	4.00 ± 0.00^{a}	0.30 ± 0.22^{a}
T2	3.33 ± 1.64^{a}	1.90 ± 0.86^{b}
T3	3.33 ± 1.50^{a}	0.80 ± 0.74^{a}
T4	4.33 ± 1.48^{a}	1.06 ± 0.71^{a}
T5	4.33 ± 1.46^{a}	0.80 ± 0.68^{a}
T6	4.66 ± 1.47^{a}	1.20 ± 0.65^{ab}
T7	4.66 ± 0.57^{a}	1.03 ± 0.28^{a}
T8	3.33 ± 1.15^{a}	0.36 ± 0.40^{a}
T9	4.00 ± 0.00^{a}	0.46 ± 0.33^{a}
T10	4.33±0.57±a	0.43 ± 0.29^{a}
T11	4.66±0.57±a	0.36 ± 0.27^{a}

Summary

Flatbreads were prepared from water chestnut flour, guar gum, egg albumin, salt and water in different formulations. While it was observed that the addition of guar gum and egg albumin overall increased the quality of flatbread compared to control, but it was also seen that higher concentration of gum added could pose negative effects on the quality. Among the treatments analyzed, hardness and shear force required increased with guar gum addition. However, the egg albumin added countered the negative effects that were seen due to guar gum addition. Sensory parameters also improved with the addition of improvers as evident by high score of overall acceptability and aroma compared to control. However, pliability decreased at high concentration of gum, probably due to the rigid network formation by gums. However the control samples were more brittle than the treated ones. Moisture percentage of the treated samples was also high compared to control sample, bringing softness in the product. From the results, therefore, it was seen that intermediate concentration of gum and egg albumin is better in improving quality, as the high and low concentrations improve certain qualities at the compromise of others. So, a balance of ingredients is to be considered for optimum quality.

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