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UNLEAVENED MULTIGRAIN FLATBREAD: INFLUENCE OF ADDITIVES ON RHEOLOGICAL, MORPHOLOGICAL, TEXTURAL AND SENSORY PROPERTIES

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In present study, effect of additives like hydrocolloids [guar gum, xanthan gum], polysaccharides [hydroxypropyl methylcellulose (HPMC)], emulsifiers [stearoyl-2 lactylate (SSL), glycerol monostearate (GMS)] and psyllium husk at the concentration ranging between 0.25 to 1% on the quality of multigrain flour, dough and *thalipeeth* was evaluated. Functional properties (WSI, WAI and degree of gelatinization) of multigrain flour were considerably improved with additives. *Thalipeeth* dough rheology and *thalipeeth* textural properties and microstructural feature were evaluated. Increase in dough stickiness and cohesiveness with the addition of additives resulted in increased elasticity which improves a rolling ability of dough and subsequently textural properties of *thalipeeth*. Improvement of *thalipeeth* extensibility indicating freshness and softness resulted in a high score of sensory acceptability after the addition of additives. The guar gum was contributed optimum in the improvement of overall quality of dough and *thalipeeth* such as high extensibility (4.45 mm), a significant increment in dough stickiness (36.87 gm) and cohesiveness (1.45 mm/sec). The microstructure of *thalipeeth* with guar gum showed proper gelatinization of starch due to good moisture retention properties of dough which resulted in uniform texture product. The guar gum at the concentration 0.75% w/w of multigrain flour gave the softest and attractive surface *thalipeeth*.

Keywords: Unleavened flatbread, Multigrain, Additives, *Thalipeeth*, Microstructure, Extensibility

INTRODUCTION

Traditional foods in India are an integral and fundamental part of Indian culture. *Thalipeeth* is an Indian traditional unleavened pancake prepared from multigrain flour (sorghum, wheat, chickpea, black gram, green gram, etc.) dough with added spices and seasonings. *Thalipeeth* is having more beneficial health properties such as low in fat, rich in proteins with hypoglycemic effect (1). Recently, extensive consumer demand for nutritional and hypoglycemic index food would certainly provide a platform for such type multigrain flatbread (*thalipeeth*) in the daily diet. In its preparation, multigrain flour, spices, chopped onions, coriander and water are mixed together to form a dough. This dough ball is spread (round shape) on muslin cloth over the flat surface by patting action. Because of the patting action, *thalipeeth* lacks uniform texture. A large amount of oil is required for the *thalipeeth* preparation in a traditional process that may lead to oxidative rancidity during storage. *Thalipeeth* becomes stale and causes the change in texture immediately after 5 to 6 h of its preparation; it's somewhat resemblance with *thepla* (2). Varieties of flatbread are available but differ in terms of ingredients, formulations, technology, and quality. Several modifications in the formulations have been made in the recent past in order to improve the quality and delicacy of flatbread food products such as *chapatti*, *paratha*, *phulka*, *puri* and *tandoori roti* (3). A variety of additives are used for flatbread improvement in textural properties, easy processing and

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overall product acceptability (4). Variety of additives such as carboxyl methyl cellulose, ascorbic acid, lecithin and sodium propionate on shelf life and improvement in sensory attributes of *chapatti* (5). In *chapatti* preparation, the addition of HPMC (0.5%) and guar gum (0.75%) improved the surface characteristics as well as the pliability and softness (6). Bread containing 70% rice flour and 30% chestnut flour with the addition of a mixture of xanthan gum and DATEM emulsifiers improved texture (hardness and specific volume), color and sensory values (7). The rheological and quality improvement was achieved in *puri* (traditional unleavened fried product) by the addition of 0.5% guar gum, Arabic gum, carrageenan, locust bean gum, xanthan gum, HPMC and CMC (8).

Thalipeeth is similar to the above kinds of unleavened flatbread and it contains more other ingredients such as roasted multigrain flour, seasoning and spices which provide high nutritional value and taste. Roasted multigrain flour has poor binding and thus the final *thalipeeth* has a brittle texture with rapid staling. In addition to this, patting is a necessary action in traditional *thalipeeth* preparation but it provides non-uniform appearance and texture. The rolling is one of appropriate option in flatbread preparation in order to form a uniform textured product. Multigrain flour dough needs some viscoelasticity for rolling by pin. Additives are capable of controlling both rheology and textural properties. As per current scenario, there is a need for the provision of ready to eat *thalipeeth* with longer shelf life in the market. In India, wheat is one of the daily staple foods and extensively consumed in the form of different flatbreads such as *chapatti, puri, paratha*, *phulka* and *tandoori roti* etc. *Thalipeeth* also belongs to the flatbread family and contains more nutritional value and taste due to the multigrain flour and seasoning. This has created a need for the mechanization of *thalipeeth* which then could be used for marketing in unit packs similar to *chapatti* and bread. The scientific information related to *thalipeeth* is scanty. Therefore, attempts were made to improve dough and *thalipeeth* quality with added additives and to evaluate their effect on functional properties of multigrain flour, dough rheology, tensile properties, sensory acceptability and microstructural features of *thalipeeth*.

MATERIALS

Whole grain of sorghum, wheat, chickpea, black gram and green gram were purchased from Agriculture Produce Market Committee (APMC), Vashi, Mumbai, India. Salt (Tata salt), red chili powder (Everest), cumin seed powder (Everest), turmeric powder (Everest), garlic ginger paste (Smith and Jones), onion and coriander leaves were procured from local market Mumbai, India. The dough additives including guar gum, xanthan gum, hydroxypropyl methylcellulose (HPMC) and psyllium husk [PH], sodium steroyl-2- lactate (SSL) and glycerol monostearate (GMS) were provided by Fine Organics, Mumbai, India.

METHODS

Preparation of Multigrain Flour

Multigrain flour was prepared using standard procedure previously explained by Arya and Gaikwad (2017). An individual roasting of sorghum, wheat, chickpea, green gram and black gram at controlled temperature 150 °C for 20 min on low flame until the development of brown color with pleasant flavor was done. Grinding of roasted grains was carried out in laboratory flour mill. For consistency in the flour quality; flour obtained was passed through 0.425 mm mesh, this roasted flour was known as *bhajani*. This was then stored in an airtight containers till its final usage.

X-Ray Diffraction

X-ray diffraction measurements were performed on 1 g samples of multigrain flour which were packed tightly in rectangular silicon cells. X-ray diffraction patterns were obtained with a diffractometer (Rigaku Miniûex) using monochromatic Cu-Ka radiation of 1.5406 A°. The diffractometer was operated at 30 kV, 15 mA and the spectra scanned over a diffraction angle (2 h) range of 2-40° with a scanning rate of 3°/min (9).

Effect of Addition of Additives on Water Solubility Index (WSI) and Water Absorption Index (WAI)

WSI and WAI were determined using a modification in the method (10). 2.5 g multigrain flour was suspended in 25 ml water at room temperature for 30 min, with intermediate stirring and then centrifuged at 3000 × g for 15 min (Remi Centrifuge, India). The supernatant was decanted into the reweighed evaporating dish and water was evaporated to constant weight to get dry solids (11).

WAI (g/g) = Weight of sediment/Weight of sediment

WSI is the weight of dry solids in the supernatant expressed as a percentage of the original weight of the sample, whereas WAI is the weight of residue obtained after removal of the supernatant per unit weight of original dry solids.

WSI (%) = Weight of dissolved solid in supernatant/ Weight of dry solids *100

Effect of Addition of Additives on Degree of Gelatinization by Chemical Method

The degree of gelatinization of the multigrain flour was determined (12). The dried multigrain flour samples (0.2 g) were dissolved in 98 ml water and 2ml KOH (10 M) was added and mixed for 5 minutes. The resulting solution was centrifuged to remove insoluble part of the sample. After centrifugation, 1 ml of the supernatant was removed and neutralized with 0.4 ml HCl (0.5 M) followed by addition of 10 ml distilled water. The eventual addition of 0.1 ml iodine reagent (1 g iodine and 4 g potassium iodide in 100 ml water) was added to form a blue color complex. The absorbance was measured at 600 nm.

Effect of Addition of Additives on Dough Rheology

Dough was evaluated for dough stickiness as explained by Arya and Madiwale (2012) using Chen-Hoseney dough stickiness rig test, with accessories such as 25 mm Perspex cylinder probe (P/25P), 50 kg load cell and SMS/Chen-Hoseney dough stickiness cell (A/DSC) in Stable Micro Systems Texture Analyzer (13). Following test set up was used for the analysis: Pre-Test Speed: 0.5 mm/s, Test speed: 0.5 mm/s, Post-Test Speed: 10.0 mm/s, Distance: 4 mm, Force: 40 g, Time: 0.1 s, Trigger Type: Auto-5 g, Data Acquisition Rate: 100 pps. The internal screw was rotated to move the piston and the sample chamber was increased to its maximum capacity. A small quantity of prepared dough was placed into the chamber and the excess dough was removed with a spatula so that it flushes with the top of the chamber. Extruder lid was a screw on. Then the internal screw was rotated little way to extrude a small amount of dough through the holes and this first extrusion was removed from the lid surface using a spatula. The screw once again was rotated to extrude a 1mm high dough sample. The Perspex cap was placed over the exposed sample surface to minimize moisture loss, whilst prepared dough surface was allowed to rest for 30 seconds to release the stress produced by extrusion. After the cover was removed and the cell was placed directly under the 25 mm cylinder probe attached to the load cell. The parameters obtained were dough stickiness and dough cohesiveness.

Preparation of Thalipeeth

Thalipeeth were prepared by using the standard procedure previously explained by Arya and Gaikwad (2017) with the incorporation of additives at concentrations (%) of 0.25, 0.5, 0.75 and 1. These included additives such as guar gum, xanthan gum, HPMC, PH, SSL and GMS. *Thalipeeth* was then cooled to room temperature. Three *thalipeeth* from four different sets of concentration for each additive were analyzed and averaged.

Effect of Addition of Additives on Thalipeeth Texture

The tearing force of *thalipeeth* was evaluated by using of TA-XT2i Stable Micro- systems texture analyzer according to the method described by Arya and Gaikwad (2017). *Thalipeeth* were cut into strips of speciûc length and width (3.5 cm× 7.5 cm). One strip at a time was placed between the sample clamps were properly aligned and set 25 mm apart, a load cell of 50 kg was used at cross head speed of 0.50 mm/ s to pull the *thalipeeth* strip apart until it ruptured. Due to tensile grip probe *thalipeeth* was tear. The force required to tear the *thalipeeth* strip was recorded.

Effect of Addition of Additives on Sensory Evaluation of Thalipeeth

Thalipeeth samples were submitted to a panel of ten trained research students of Institute of Chemical Technology to evaluate the sensory attributes (14). Selection of panelist on the basis of their sensory skills such as ability to accurately determine and communicate the sensory attributes as appearance, color, texture, mouthfeel, taste and overall acceptability in triplicate. The panelists were trained in sensory vocabulary and identification of particular attributes by evaluating *thalipeeth.* Nine point hedonic scale (9 = like extremely and 1 = dislike extremely) was used as rating scale. Before the testing session, assessors were asked not to eat, drink and smoke. Specific coding was used for different samples and served to panelists.

Effect of Addition of Additives on Scanning Electron Microscopy of Thalipeeth

Microstructural properties of the *thalipeeth* were studied using scanning electron microscope (JEOL Scanning System, Tokyo, Japan). Dried samples were placed on the sample holder with the help of a double scotch tape and sputter-coated with gold (2 min, 2 mbar). Finally, each sample was transferred to the microscope where it was observed at

15 kV and 9.75*10-5 Torr vacuum. Scanning electron micrographs with appropriate magniûcations were selected for presentation of results (7).

Statistical Analysis

All determinations were obtained in triplicate measurements and results were expressed as a mean ± standard deviation. The Statistical Package for Social Sciences (SPSS) for Windows version (16.0) (SPSS, 2012) was used to analyze the data (SPSS Inc., Chicago, IL). Statistical significance was declared at ($p < 0.05$).

RESULTS AND DISCUSSION

X-Ray Diffraction of Multigrain Flour

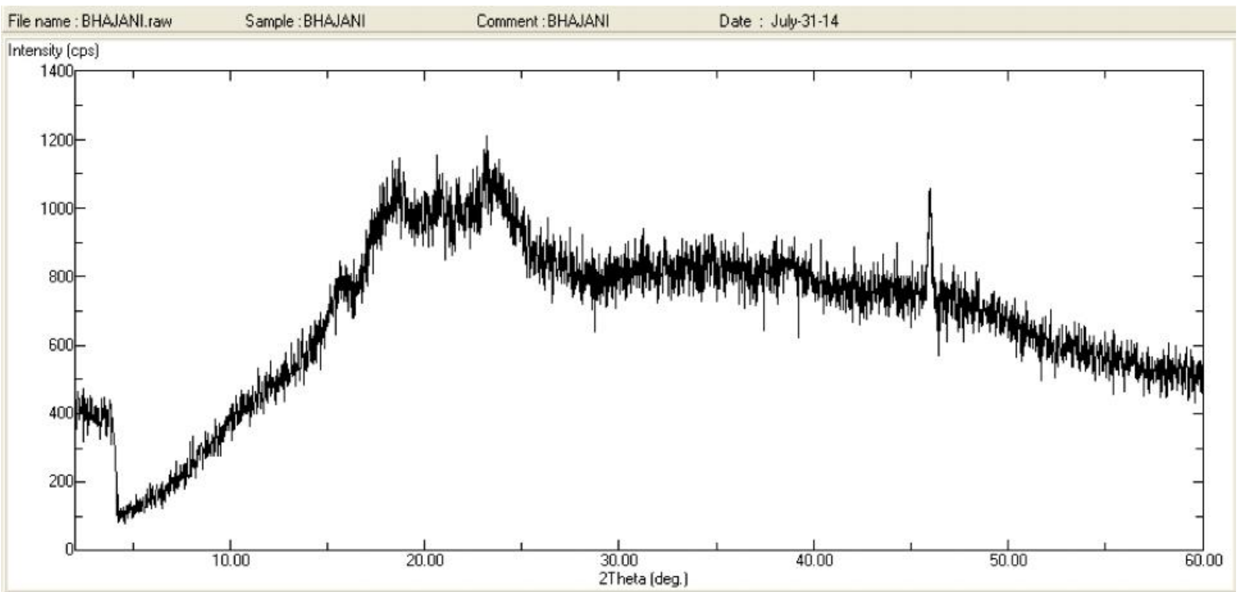
Multigrain flour was prepared by individual roasting of wheat, sorghum, chickpea, green gram and black gram followed by grinding operation. These operations can be responsible for denaturisation of basic constituents of food material such as type of starch or protein moieties. The XRD study is conducted here to evaluate the occurrence of change in basic constituents of selected grains (used in multigrain flour) after respective operations. Crystallization is of great significance for the stability of samples which can be determined by means of X-ray diffraction analysis. There are three recognized types of starch crystallinity patterns and these are commonly designated as A, B and C. Pronounced diffraction peaks at $2\theta = 15°$ and $23°$ have been observed for A-type starches which are observed in cereal starches. B-type X-ray pattern shows diffraction peaks at about $2\theta = 15°$ but absence $23°$ peak which exhibited by starches isolated from tubers while C-type crystallinity is a combination of A and B patterns. Figure 1 shows the diffractograms of multigrain flour. The X-ray pattern of

Table 1: WAI and WSI Values Obtained for the Prepared Multigrain Flour

Sample	WSI (%)	WAI (g/g)
Multigrain flour (control)	8.40±1.74^{a}	2.61± 0.23^{a}
Multigrain flour with Guar gum	14.13±2.27^{c}	3.23±0.20^{b}
Multigrain flour with Xanthan Gum	14.00±7.11^{c}	3.18±0.28^{b}
Multigrain flour with HPMC Gum	8.84±0.80^{a}	2.84±0.04^{abc}
Multigrain flour with PH	8.90±0.80^{a}	3.05±0.16^{bc}
Multigrain flour with SSL	11.73±4.63^{b}	2.70±0.20^{ac}
Multigrain flour with GMS	12.80±0.40^{b}	3.21±0.20^{b}

Note: All the values are Mean±SD of three determinations; Means followed by different letters in the same group differ Data significantly (p<0.05) by Duncan multiple range test.

Figure 1: XRD Study of Multigrain Flour



multigrain flour revealed C-type starch X-ray pattern. This was characterized by strong intensity peaks corresponding approximately to 2θ = 15°, 17° and 23°. The results revealed that multigrain flour preserved the basic constituents such as starch and legume in flour preparation process. Tharanathan and Mahadevamma (2003) reported that the

Table 2: Effect of Additives on Dough Rheology and Tensile Properties of *Thalipeeth*

Hydrocolloids	Level (%)	Dough Rheology		Tensile Properties	
		Dough Stickiness (g)	Dough Cohesiveness (mm/s)	Extensibility (mm)	Force (g)
Control	0	30.20±2.31[a]	1.01±0.08[a]	3.14±0.21[a]	418.00±12.42[a]
Guar gum	0.25	32.90±3.33[a]	0.93±0.11[a]	3.96±0.08[b]	415.77±9.60[c]
	0.5	35.07±1.50[b]	0.98±0.10[a]	4.30±0.23[c]	360.9±43.30[ab]
	0.75	36.87±2.14[b]	1.45±0.10[a]	4.45±0.05[c]	341.3±15.04[a]
	1	36.73±1.67[b]	1.16±0.02[a]	3.92±0.12[b]	393.6±6.11[b]
Xanthan gum	0.25	33.00±4.06[b]	0.95±0.08[a]	3.58±0.59[a]	394.00±9.80[b]
	0.5	35.23±1.46[ab]	1.10±0.08[a]	4.18±0.27[b]	401.00±10.81[b]
	0.75	37.36±2.11[ac]	1.32±0.09[a]	4.11±0.22[b]	419.06±13.02[a]
	1	37.60±0.62[c]	1.34±0.13[a]	4.10±0.18[b]	462.96±7.22[c]
HPMC	0.25	28.60±1.71[a]	1.04±0.07[a]	3.04±0.07[a]	342.76±27.12[b]
	0.5	31.6±1.85[ab]	1.41±0.14[a]	3.41±0.41[b]	351.36±38.93[ab]
	0.75	31.83±1.72[b]	1.56±0.15[a]	3.80±0.32[ab]	375.93±26.33[b]
	1	32.30±1.40[ab]	1.65±0.15[a]	4.18±0.17[a]	399.03± 11.90[b]
PH	0.25	25.33±1.00[b]	1.21±0.10[b]	3.04±0.09 [a]	443.50±27.56[b]
	0.5	29.56 ±0.75[a]	1.31±0.02[b]	3.86±0.13[c]	356..9±30.48[c]
	0.75	31.90±0.60[ac]	1.34±0.09[b]	3.45±0.23[b]	377.57±21.82[ac]
	1	32.46±0.61[c]	1.68±0.08[c]	3.20 ±0.05[ab]	392.7±19.96[ac]
SSL	0.25	26.73±1.56[b]	0.77±0.13[a]	3.20±0.04[a]	382.96±13.85[d]
	0.5	30.33±1.46[a]	0.85±0.03[a]	3.53±0.08[b]	375.06±8.31[b]
	0.75	30.43±1.33[a]	0.85±0.09[a]	4.09±0.11[c]	353.26±4.93[cd]
	1	30.10±0.40[a]	0.94±0.1[a]	3.88±0.27[b]	362.76±6.47[bc]
GMS	0.25	28.17±0.31[a]	1.03±0.06[a]	3.21±0.05[a]	387.50±8.38[b]
	0.5	29.47±0.80[a]	1.08±0.10[a]	3.45±0.08[b]	364.33±14.70[c]
	0.75	29.99±0.66[a]	1.14±0.03[a]	3.54±0.14[b]	361.86±2.55[c]
	1	30.58±0.68[a]	1.23±0.04[a]	4.11±0.11[c]	346.86±6.50[c]

Note: All the values are Mean±SD of three determinations; Means followed by different letters in the same group differ Data significantly (p<0.05) by Duncan multiple range test.

legumes are showing the presence of C-type of starches by X-ray diffraction study. The obtained results explain that cereals as well as legumes are presents in *thalipeeth* with maintained its inherent molecular arrangement. Our results are in accordance with the finding of Miao *et al.* (2009).

Effect ofAaddition of Additives on Water Solubility Index and Water Absorption Index

In particular, Water Solubility Index (WSI) and Water Absorption Index (WAI) are two properties linked to the estimation of the behavior of the materials. These properties can be modified by using additive entities like a binder, a stabilizer, emulsifier or a source of protein in various food systems (15). These are the important properties to assess the behavior of starch in food system containing water as an essential ingredient. WSI determines the number of free molecules leached out from the starch granule in excess of water whereas WAI is an indicator of the ability of flour to absorb water. WSI and WAI values obtained for the multigrain flour with additives are tabulated in Table 2. WSI was increased from 8.40 to 14.13%; this result revealed that the percentage of water-soluble solids increased with the addition of additives. The addition of highly hydrophilic gums and emulsifiers such as guar gum, xanthan gum, SSL and GMS increased WSI (14.13, 14, 11.73 and 12.80% respectively) as compared to control (without additives) (8.40%). Because of the gum was almost completely solubilized in the supernatant, indicating the high affinity of the gum for water (16); emulsifiers it improved the rate of hydration and water absorption in the dough (17). WAI is playing the key role in bulking and consistency of products, as well as in baking application (18). In the case of multigrain flour, WAI is mostly high because it contains various flours of cereals (carbohydrate) and legumes (protein). WAI is a volume occupied by the starch granules at the swelled condition in the presence of an excess of water which depends on rupturing of starch, protein content and pentosans content. The multigrain flour contains all above constituents in admirable quantity and hence WAI is mostly high in multigrain flour (19). In the present investigation, the addition of additives was also contributed for enhancement in WAI of multigrain flour by improving the water retention capacity. The addition of the additive (guar gum) significantly increases both WSI from 8.40% to 14.13% and WAI from 2.61 g/g to 3.23 g/g as compared to multigrain flour control (without additives). In the present study, we used roasted multigrain flour which is also contributed to enhancement of WSI and WAI (16). The roasting process responsible for the formation of porous structure in the endosperm with capillaries which might be responsible for the increase in the absorption (20).

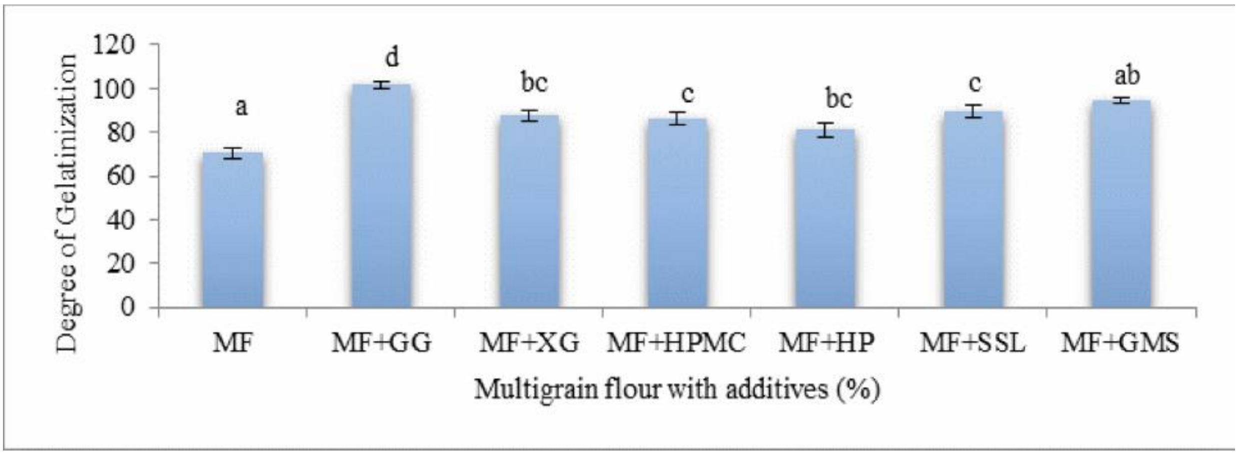
Effect of Addition of Additives on Degree of Gelatinization by Chemical Method

The effect of additives on the degree of gelatinization for multigrain flour dough by the chemical method is shown in Figure 2. Starch gelatinization is a process that breaks down the intermolecular bonds of starch molecules in the presence of water and heat, allowing the hydrogen bonding sites (the hydroxyl hydrogen and oxygen) to engage more water (21). Penetration of water increases randomness in the general structure of starch granules and decreases the number and size of crystalline regions. Crystalline regions do not allow water entry. The gelatinization of flour depends on time, the amount of water, different additive content and process (22). The degree of gelatinization of multigrain flour dough prepared from different additives is increased in the range 70 to 101%. These results were expected due to the hydroxyl group in the additives structure allows more water interaction through hydrogen bonding. The degree of gelatinization was lower for control multigrain flour sample as compared to the flour samples with additives (Figure 2). The reason behind this could be the presence of more crystalline regions in multigrain roasted flour. Hence there was difficulty in penetration of water which increased randomness in the general structure and thus decreases in the degree of gelatinization was observed.

Effect of Addition of Additives on Dough Rheology

The effect of additives on *thalipeeth* dough rheology (dough stickiness and dough cohesiveness) is summarized in Table 3. Dough stickiness is a vital quality factor which is related to the handling of the dough and mechanical ability. The dough stickiness was modified after addition of additives into the dough compared to control dough. Dough stickiness value for control dough was 30.20 g whereas the addition of additives resulted in increased dough stickiness from 30.20 to 37.60 g at the level of 0.25 to 1% respectively. Cohesiveness or strength measured as a rate at which material disintegrates under mechanical action. It also observed that the cohesiveness of dough was increased when added with the additive as compared to control dough which indicating additives also act as dough strengthens

Figure 2: Degree of Gelatinization of Multigrain Flour with and Without Additives



Note: Means followed by different letters in the same group differ Data significantly (p<0.05) by Duncan multiple range test.

(23). From the Table 3 it was observed that amongst all the additives, xanthan gum and guar gum brought about the remarkable enhancement in dough stickiness and yielded the strongest dough which can be attributed to the hydroxyl groups in the hydrocolloid structure, which allows more water interactions through hydrogen bonding. Additives followed the ascending order for both dough stickiness and dough cohesiveness values as: SSL (30.33, 0.94) < GMS (30.58, 1.23) < HPMC (32.30, 1.68) < PH (32.46, 1.68) < guar gum (36.87, 1.45) < xanthan gum (37.60, 1.34) (Table 3). Dough cohesiveness (strength) was increased with the addition of additives resulted in increased elasticity. Increased elasticity and viscoelastic characteristics of dough were helpful in rolling the dough by rolling pin which resulted in an improved texture of the *thalipeeth* as compared to the traditional process (hand patting). Analysis of variance (ANOVA) confirmed that a significant (p<0.05) effect was found for the stickiness and cohesiveness of dough prepared at the different levels of additives.

Effect of Addition of Additives on Textural Properties of Thalipeeth

Effect of various additives incorporated at different levels in *thalipeeth* on textural properties like extensibility (the distance of extension before rupture in mm) and force (force to tear in g) is shown in Table 3. Characteristics of food texture were carried out by the instrumental method of analysis at control conditions. It is advantageous in the objectivity and reproducibility of the experimental data. The texture is an important term for food (24). Control *thalipeeth* without additives showed an extensibility value was 3.15 mm and with added additives (0.25 to 1%) increased up to 4.44 mm. Several authors reported that additives are effectively used for improving the texture of different flatbreads like *chapatti* (23), *puri* (8) and south Indian *paratha* (25). Tear force is the textural quality of *thalipeeth* and its higher value indicates increased in hardness whereas decrease tear force value indicates increased the softness of *thalipeeth*. Control *thalipeeth* showing tear force values 418 g. whereas amongst all the additives; guar gum (0.75%) retained the softest texture with the tear force value 341.9 g followed by xanthan gum (394 g), PH (356.9 g), HPMC (342.7 g), GMS (346.8 g) and SSL (353.2 g). Guar gum has given softening effect in *thalipeeth* is mostly due to a possible inhibition of the amylopectin retrogradation and preferentially binds to starch (26). Also, guar gum may interfere with inter-chain amylose association, probably through gum–amylose association mediated by hydrogen bonding. Prepared *thalipeeth* with added additives was soft and extensible as indicated by the increased extensibility in mm and decreased force to tear in gm. There was the signiûcant difference (p<0.05) between the addition of additives (different levels) on textural properties of *thalipeeth*.

Effect of Addition of Additives on Sensory Evaluation of Thalipeeth

Consumer's quality perception of *thalipeeth* is determined by sensory evaluation. From Table 4, it can be observed that when additives were added in the range of 0.25 to 1.0

Table 3: Effect of Additives on Sensory Evaluation of *Thalipeeth*

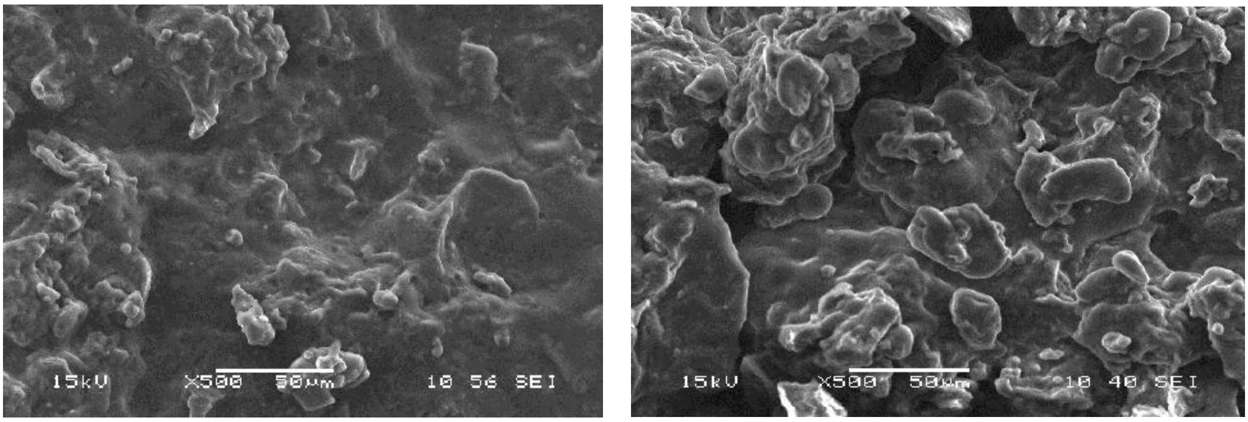
Additives	Level (%)	Appearance	Color	Texture	Mouth feel	Taste	OA
Control	0	6.43±0.46[ab]	5.98±1.02[a]	6.40±0.40[a]	6.05±0.79[a]	6.11±0.70[a]	6.61±0.40[ab]
Guar gum	0.25	6.75±0.63[b]	6.74±0.64[b]	6.85±0.52[ab]	6.90±0.69[b]	6.75±0.54[bc]	6.95±0.59[ab]
	0.5	6.73±0.49[ab]	6.74±0.52[b]	7.20±0.48[b]	7.10±0.45[b]	7.10±0.39[a]	7.05±0.59[b]
	0.75	7.80±0.36[c]	7.76±0.73[c]	8.13±0.67[c]	7.82±0.23[c]	8.02±0.66[d]	7.98±0.48[c]
	1	6.30±0.38[a]	6.55±0.61[b]	6.60±0.65[a]	6.90±0.69[b]	6.45±0.43[ab]	6.25±0.54[a]
Xanthan gum	0.25	6.70±0.50[a]	6.93±0.71[b]	7.15±0.74[b]	6.90±0.69[b]	6.70±0.48[ab]	7.00±0.66[bc]
	0.5	6.83±0.48[a]	6.85±0.51[b]	7.19±0.57[c]	7.00±0.68[b]	7.06±0.52[b]	7.25±0.28[c]
	0.75	6.60±0.93[a]	6.80±0.63[b]	7.16±0.50[b]	7.05±0.43[b]	7.00±0.40[b]	7.00±0.57[c]
	1	6.36±0.40[a]	6.60±0.51[a]	6.60±0.65[ab]	7.00±0.70[b]	6.70±0.88[ab]	6.40±0.73[a]
HPMC	0.25	7.11±0.46[b]	7.15±0.53[b]	7.13±0.50[bc]	7.11±1.08[c]	6.92±1.43[c]	7.15±1.20[c]
	0.5	7.00±0.80[ab]	6.74±0.62[b]	7.47±0.50[c]	6.80±0.94[b]	6.45±1.30[b]	6.60±0.93[b]
	0.75	6.96±0.73[ab]	6.62±0.74[ab]	6.68±0.48[ab]	6.95±1.10[ab]	6.85±1.20[a]	6.75±1.16[ab]
	1	6.99±0.62[ab]	6.65±0.74[ab]	6.31±0.48[a]	6.72±0.92[ab]	6.90±0.77[a]	7.09±0.79[a]
PH	0.25	6.70±0.67[b]	7.10±0.51[c]	6.95±0.55[bc]	7.00±0.57[b]	6.85±0.40[b]	6.80±0.42[bc]
	0.5	8.06± 0.19[c]	7.00±0.48[c]	6.92±0.68[c]	7.04±0.39[b]	7.02±0.42[b]	7.21±0.37[c]
	0.75	6.72±0.47[b]	6.50±0.70[bc]	6.90±0.51[ab]	6.80±0.42[b]	6.75±0.45[b]	6.60±0.51[b]
	1	6.21±0.15[a]	5.75±1.03[a]	6.35±0.70[a]	6.65±0.78[b]	6.10±0.45[a]	6.05±0.59[a]
SSL	0.25	6.70±0.67[a]	6.58±0.44[bc]	7.20±0.75[c]	6.93±0.36[b]	6.75±0.42[b]	6.99±0.42[b]
	0.5	8.10±0.72[b]	6.94±0.46[d]	7.06±0.50[b]	6.93±0.57[b]	8.10±0.20[d]	7.47±0.25[c]
	0.75	6.55±0.92[a]	6.77±0.65[c]	7.05±0.56[b]	7.05±0.43[b]	7.28±0.33[c]	6.94±0.21[b]
	1	6.17±0.20[a]	6.27±0.30[ab]	6.35±0.31[ab]	6.15±0.21[a]	6.65±0.53[b]	6.35±0.44[a]
GMS	0.25	6.40±0.38[a]	6.40±0.40[b]	6.70±0.30[b]	6.80±0.46[b]	6.50±0.33[b]	6.70±0.50[ab]
	0.5	6.90±0.31[bc]	6.80±0.27[bc]	6.70±2.95[c]	7.10±0.48[bc]	7.00±0.36[c]	7.10±0.4[bc]
	0.75	7.10±0.45[cd]	7.30±0.33[cd]	7.20±0.32[cd]	7.50±0.31[cd]	7.40±0.50[cd]	7.50±0.48[cd]
	1	7.31±0.31[d]	7.35±0.38[d]	7.50±0.55[d]	7.67±0.34[d]	7.83±0.59[d]	7.68±0.52[d]

Note: All the values are Mean±SD of ten determinations; Means followed by different letters in the same group differ Data significantly ($p<0.05$) by Duncan multiple range test.

%, the texture and OA was significantly improved than the control *thalipeeth*. The score indicated for appearance and colour of *thalipeeth* were not affected by the addition of any additives. The same result was reported by Parimala and Sudha (2012) who observed no effect on a colour of *puri* incorporated with additives (hydrocolloids such as guar gum, Arabic gum and HPMC). Texture belongs to organoleptic attribute which determined food palatability and has intense effects on consumer's approval of food products because people can enjoy eating with perceiving the change in texture. Textural values showed the highest sensory score for guar gum at 0.75% as compared with

Figure 3: Scanning Electron Miscopy of Control *Thalipeeth* (a), *Tthalipeeth* with Guar Gum (b)

(a) Control **(b) Guar Gum**



other additives with the increased softness of *thalipeeth*. *Puri* prepared with the addition of hydrocolloids also reflected in the higher sensory score for texture (8). From the result, it was observed that addition of additives such as GG, XG, HPMC, PH, SSL and GMS improved sensory properties of *thalipeeth* with the higher score of OA. Similar results were obtained while studying the *chapati* and *parotta* quality using different additives (6,25).

Effect of Addition of Additives on Microstructure of Thalipeeth

The microstructure of control *thalipeeth* and the *thalipeeth* prepared from dough treated with guar gum shown in Figure 3 a and b. In case of control *thalipeeth* (without additives) the starch granules are partially gelatinized. The lower water absorption capacity of the dough without additives may become the limitation in swelling and rupturing of the starch granules during baking; hence stiff and non-uniform structure is obtained. Srivastava *et al.* (2006) reported that the well-gelatinized starch granules were properly immersed in a continuous matrix formed by heating based protein denaturation during baking and formed uniform textured chapatti product.The microstructure of *thalipeeth* prepared from guar gum treated dough showed highly gelatinized starch granules which were prominently embedded within the protein matrix or coated by it. A thin film of protein was surrounded by spread granular structure. The guar gum has moisture retention properties which allow proper swelling and rupturing of starch granules. The guar gum also interfered with protein association on heating by occupying the space of proteins in the gluten network. Our results are accordance with the finding of Sudha and Rao (2009) they reported that control *puri* (without HPMC) starch granules seem to be coated and they are not distinctly seen. After addition of HMPC at 0.5% of HPMC, some of the starch granules are slightly seen whether the addition of HMPC (1%) shows most of the starch granules seem to be coated.

CONCLUSION

The multigrain flour, dough and *thalipeeth* quality by the addition of additives such as guar gum, xanthan gum, HPMC, PH, SSL and GMS were remarkably improved. Multigrain flour functional properties (WSI, WAI and degree of gelatinization) were significantly improved which would be contributed to easy processing and appropriate baking. Dough rheological parameters like dough stickiness and cohesiveness were improved and providing better quality dough resulting better development of *thalipeeth*. Textural characteristics (extensibility and tear force) of *thalipeeth* improved with respect to pliability, softness and overall sensory acceptability. Microstructural studies have shown proper gelatinization after incorporation of additives. Optimum improvement in overall quality of *thalipeeth* was brought about by guar gum as an additive, in the range of 0.75%.

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