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Optimization of bread firmness, specific loaf volume and sensory acceptability of bread with soluble fiber and different water levels

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ABSTRACT

There is an increasing interest in development of functional bakery products having therapeutic value other than nutrition. In present study, partially hydrolyzed guar gum (1–5%) was added to wheat flour to study its effect on dough rheology and bread quality. The effects of PHGG level along with varying water level in the bread dough were studied on bread crumb firmness, specific loaf volume and overall sensory acceptability of bread. The results of the study revealed that partially hydrolyzed guar gum increased the total dietary fiber content of bread to 3.78%. Hence, partially hydrolyzed guar gum can be utilized for dietary fiber fortification of bread with improved textural property and with equivalent sensory acceptability as compared to control bread.

1. Introduction

Increased awareness in health issues has led to increased development of functional foods with specific health benefits (Siro et al., 2008; Erzen et al., 2014; Fardet, 2015). Bakery products are widely consumed as staple food all over the world (Smith et al., 2004). In last few decades, bakery products have been explored extensively for development of functional foods via fortification of active ingredients such as dietary fiber, bioactive peptides, minerals, vitamins etc. to increase its therapeutic values. Guar gum is a seed galactomannan obtained from cluster bean or guar plant (Mudgil et al., 2011). Guar gum consists of complex carbohydrate which can be beneficial for human physiological functions. It helps in lowering cholesterol level, control diabetes and regulate bowel digestive system in human physiology. Guar galactomannan is composed of galactose and mannose units. When incorporated in diet, this galactomannan serve as a soluble dietary fiber because our intestinal secretions are unable to digest it. Water soluble nature of guar gum has placed it in category of soluble dietary fiber. Aqueous solution of native guar gum is very viscous even at low concentration of guar gum. Hence it cannot be incorporated as such in food products for dietary fiber supplementation as it affects the sensory as well as technological properties of the food products. Hence low viscosity guar gum is produced via enzymatic hydrolysis of guar gum and termed as partially hydrolyzed guar gum (Mudgil et al., 2012a). Partially hydrolyzed guar gum (PHGG) is a low viscosity water soluble gum similar in structure to native guar gum (Mudgil et al., 2012b). Enzymatic hydrolysis of guar gum reduces the chain length of polysaccharide and thus produces a low viscosity and low molecular weight guar gum (Mudgil et al., 2012c, 2012d, 2016). According to (AACC, 2001), dietary fiber is the edible plant carbohydrate that is undigested and unabsorbed in the human small intestine with complete or partial fermentation in the large intestine. Dietary fiber may include polysaccharides, oligosaccharides, lignin, and associated plant substances and may perform beneficial physiological functions such as laxation, blood cholesterol attenuation and blood glucose attenuation (AACC, 2001). Fiber fortification of bakery products is of considerable interest as it could contribute to increasing demand of daily fiber intake. In previous studies it has been reported that PHGG is tasteless, odorless and gives low viscosity (upto 10 cps) in water (Yoon et al., 2008). These properties make it a unique source of dietary fiber. Understanding the functions of ingredient and process variables would be a necessity for industrial production of soluble fiber fortified bread in order to attain optimum product quality. Fortification of dietary fiber in food products negatively affects the product's functional properties (Brennan and Samyue, 2004). Attempts have been made by scientists to improve

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nutritional properties of bakery products by incorporating legumes, proteins, fiber, etc (Ellis, 1985; Singh et al., 1996; Park et al., 1997; Knuckles et al., 1997; Gomez et al., 2003; Poltorak and Zalewska, 2007; Bagheri and Seyedein, 2011; Yadav et al., 2012; Mudgil et al., 2016).

Response surface methodology (RSM) is a statistical and mathematical technique used for development and optimization of processes. The fundamental principle of RSM is to relate product properties to regression equations which describe the interrelationship between process variables and product properties (Montgomery, 1984). It describes the effect of the independent variables, alone or in combination, on the process and also generates a mathematical model which describes interrelations between independent variables and dependent variables (Myers and Montgomery, 1995). The main objective of the present study was to understand the effect of PHGG level and water level on the physical (firmness and specific volume) and sensory (overall acceptability) properties of bread. Second order polynomial models were developed to obtain bread with optimum firmness, specific volume and overall acceptability.

2. Material and methods

2.1. Materials

Guar gum powder sample (food grade) was obtained from Hindustan Gums & Chemicals Ltd., Haryana, India. Guar gum powder was passed through 200 mesh sieve to obtain a uniform particle size fine powder and was stored under refrigerated conditions before analysis. All chemicals used in the study were of AR grade and were obtained from Central Drug House, India. Cellulase enzyme (activity: 4520 units/g) from *Aspergillus niger* was obtained from USB Corporation, USA. Refined wheat flour, compressed yeast, sugar, shortening and salt were procured from local market Hisar, India.

2.2. PHGG preparation and analysis

Enzymatic hydrolysis of native guar gum was performed to obtain partially hydrolyzed guar gum. Hydrolysis of guar gum was carried out using cellulase from *Aspergilus niger* at pH 5.6 in aqueous solution maintained at 50 °C (Mudgil et al., 2012a). After partial hydrolysis process, the cellulase enzyme was deactivated via heat treatment. The low viscosity aqueous solution of PHGG was then freeze dried and ground to powder and passed through 200 mesh sieve to obtain uniform particle size fine powder as that of native guar gum. Moisture, fat, protein and ash content were determined according to standard method of analysis (AOAC, 1990). Enzymatic method of Furda (1981) was employed to determine total dietary fiber (TDF), soluble dietary fiber (SDF) and insoluble dietary fiber (IDF) in PHGG.

2.3. Empirical rheology of wheat dough

Dough rheology or mixing characteristics of the wheat flour was studied using Microdoughlab. Wheat flour was fortified with partially hydrolyzed guar gum (PHGG) at 1–5% replacement levels on weight basis. Control and PHGG fortified wheat flour was transferred to the mixing bowl of Microdoughlab where dry mixing of the flour was carried out and then water addition was done automatically as set in the instrument protocol. The amount of water to be added in the flour was estimated by the instrument to reach the 500 FU line in Microdoughlab chart (Barak et al., 2014). The dough mixing was continued for 12 min for control and PHGG fortified flour samples. The mixing parameters determined by the Microdoughlab were arrival time (min), dough development time (min) and dough stability (min), respectively.

2.4. Bread preparation

Refined wheat flour was mixed with partially hydrolyzed guar gum at replacement levels of 1%, 1.59%, 3.0%, 4.41% and 5.0% (w/w). Control bread was prepared by refined wheat flour. For control bread, the test baking formula used was: flour (30 g, 14% moisture basis), compressed yeast (1.59 g), salt (0.45 g), sugar (1.8 g), fat (0.9 g), malted barley flour (0.075 g), and ascorbic acid (100 ppm, flour basis). Yeast was added in the form of suspension. The dough formed after mixing was placed in a baking pan and proofed for 90 min at 30 °C and 80% relative humidity (RH). Dough was molded after 52, 77 and 90 min in dough moulder. After final molding, the dough was placed in lightly greased pans and placed for final proofing for another 36 min at 30 °C and 80% RH. After final proofing, bread dough was then baked at 232 °C for 13 min. The loaves were removed from the pans and cooled at room temperature. Bread characteristics were tested 2 h after the loaves were removed from the oven. Effects of varying water levels 55%–65% (w/w) on PHGG supplemented breads were studied.

2.5. Bread firmness

Bread firmness was measured using Texture Analyzer TA-XT2i (Stable Microsystems, Surrey, UK) equipped with an aluminium 25 mm diameter cylindrical probe in accordance with AACC method 74-09 (AACC, 1995). Slices of 2 cm thickness were compressed to 50% of their original height at a crosshead speed of 1 mm/s. The resulting peak force of compression was reported as bread firmness. Three replicates from three different sets of baking were analyzed and averaged.

2.6. Bread specific volume

The breads were weighed after cooling and their volume (cm^3) was determined by rapeseed displacement method. The specific volume (cm^3/g) was calculated as loaf volume/bread weight.

2.7. Sensory evaluation

Sensory properties of bread were evaluated by a semi-trained sensory panel. Sensory analysis of bread was performed 2 h after the loaves were removed from the oven. Breads were served in white plates with codes. Panelists were asked to evaluate appearance, taste and texture. Overall acceptability of bread was calculated from the average of the above sensory parameters. A nine-point hedonic scale (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much and 9 = like extremely) was used by the panelists to evaluate sensory attributes of experimental bread.

2.8. Experimental design and statistical analysis

Response surface methodology was used for the optimization of variables in the present study. A central composite design (CCRD) was used to study the effect of two independent variables at five levels on response pattern and to determine the optimum combination of variables. Thirteen experiments were conducted to study the effect of processing parameters like PHGG level and water level on physical and sensory properties of bread such as firmness, specific volume and overall acceptability. The minimum and maximum values for PHGG level was set at 1% and 5% and water