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Cookie texture, spread ratio and sensory acceptability of cookies as a function of soluble dietary fiber, baking time and different water levels

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ABSTRACT

The aim of the study was to investigate the effect on physical and sensory quality of cookies on supplementation with partially hydrolyzed guar gum (PHGG) as soluble fiber at level of 1–5%. The effect of PHGG level, water level and baking time were studied on cookie spread factor, cookie hardness and overall sensory acceptability. The second order model obtained for spread factor, hardness and overall sensory acceptability of cookies revealed coefficient of determination of 0.9392, 0.9502 and 0.7582 respectively. Physical and sensory properties of cookie revealed significant changes with variation in PHGG level, water level and baking time. The optimized values for all the three independent variables i.e. PHGG level, water level and baking time were 2.21%, 4.81% and 8.81 min, respectively. This study revealed that partially hydrolyzed guar gum can be successfully incorporated in cookies for the enrichment of soluble dietary fiber.

1. Introduction

Globally, guar gum is used as thickener, stabilizer and texturizer in many processed food products such as tomato ketchup, ice cream, beverages, bakery and confectionery products. Guar gum consists of complex carbohydrate, which can perform beneficial functions in human physiology. It is beneficial in lowering cholesterol level, controlling diabetes and regulating bowel digestive system in humans (Slavin & Greenberg, 2003; Yoon, Chu, & Juneja, 2006; Yoon, Chu, & Juneja, 2008). Complex carbohydrate present in guar gum is galactomannan which consists of galactose and mannose units. When incorporated in diet this galactomannan serves as a soluble dietary fiber because it is not digested by our intestinal secretions and is water soluble in nature. Native guar gum in aqueous solutions is very viscous in nature. Hence it cannot be incorporated as such in a variety of food products as it affects the sensory as well as technological properties of products. Hence partially hydrolyzed guar gum is produced via enzymatic hydrolysis of guar gum. PHGG thus obtained, is a low viscosity water soluble gum (Mudgil, Barak, & Khatkar, 2014). Studies showed that PHGG is similar in basic molecular structure to native guar gum. Dietary fiber is the edible plant portions or analogous carbohydrates that are not digested and absorbed 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. Dietary fibers may perform beneficial physiological functions including laxation, blood cholesterol attenuation and blood glucose attenuation (AACC, 2001). Fortification of bakery products with soluble fiber is of considerable interest as it could contribute to increasing demand of daily fiber intake (Struck, Gundel, Zahn, & Rohm, 2016). In previous studies it has been reported that PHGG is tasteless, odorless and gives transparent solution in water with low viscosity upto 0.01 Pa s. These properties of PHGG make it a unique source of dietary fiber (Mudgil, Barak, & Khatkar, 2012). Preparation of dietary fiber fortified food products however, may pose problems as consumers often perceive fibers as having a strong flavor and being unpalatable, possessing a coarse texture and dry mouthfeel (Brennan & Samyue, 2004). Therefore, understanding of functions of ingredient and process variables would be a necessity for industrial production of soluble fiber fortified cookies in order to attain optimum product quality.

Response surface methodology (RSM) is a combination of statistical and mathematical techniques used for development, improvement, and optimization of processes. Its use leads to cost reduction and rapid and efficient process development. The

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fundamental principle of RSM is to relate product properties to regression equations which describe the interrelationship between input parameters and product properties. It describes the effect of the independent variables, alone or in combination, on the processes. In addition to analyzing the effects of the independent variables, it also generates a mathematical model which describes interrelations between independent variables and dependent variables. The purpose of the present study was to understand the effect of processing parameters such as PHGG level, water level and baking time upon the physical (Spread ratio and cookie hardness) and sensory (overall acceptability) properties of cookies. To study the interrelationship among processing variables and for their optimization, second order polynomial models were developed to obtain cookies with optimum properties such as spread factor, hardness and overall acceptability.

2. Material and methods

2.1. Materials

Commercial food grade guar gum sample was obtained from Hindustan Gums & Chemicals Ltd. Haryana, India. To obtain a uniform particle size fine powder, guar gum sample was passed through 200 mesh sieve and was stored under refrigerated conditions before analysis. All chemical of AR grade were obtained from Central Drug House, India. Cellulase enzyme (*Aspergillus niger*) was obtained from USB Corporation, USA. Refined wheat flour, sugar, hydrogenated vegetable shortening and salt were procured from local market Hisar, India.

2.2. PHGG preparation and analysis

Partially hydrolyzed guar gum was prepared by enzymatic hydrolysis of native guar gum. For enzymatic hydrolysis, 4 g of native guar gum was dispersed in 396 g of distilled water. The aqueous solution thus prepared was subjected to enzymatic hydrolysis using cellulase from *Aspergilus niger* at pH 6 and temperature 50 °C. The low viscosity guar gum aqueous solution obtained after enzymatic hydrolysis was subjected to pH neutralization, enzyme inactivation, filtration, freeze drying, grinding and sieving through 200 mesh sieve to obtain uniform particle size fine powder as that of native guar gum. Enzymatic hydrolysis of guar gum only reduces the chain length of polysaccharide and thus reduces the molecular weight (about 8000 Da) and viscosity (about 4 m.Pa.s) of guar gum. Moisture (925.08), fat (920.85), protein (920.87), ash (923.03), were determined using AOAC standard methods of analysis (AOAC, 1995). The total dietary fiber (TDF), soluble dietary fiber (SDF) and insoluble dietary fiber (IDF) content in samples were determined using AOAC Official Method 991.43 (AOAC, 1995).

2.3. Cookie preparation

Refined wheat flour of particle size greater than 150 μm was used for cookies preparation as it produces cookies of good quality (Barak, Mudgil, & Khatkar, 2014). Cookies were prepared by AACC 10-50D standard method with slight modifications. Refined wheat flour was mixed with partially hydrolyzed guar gum at replacement level of 1.0%, 1.81%, 3.0%, 4.19% & 5.0%. Control cookies were prepared using white flour. The ingredients in standardized formulation of cookies were 100 g of flour blend, 25 g of milk, 42 g of fat, 60 g of sugar, 4 g of water, 1.2 g of ammonium bicarbonate (ABC), 0.5 g of sodium bicarbonate (SBC). Ground sugar, fat, water, SBC and ABC were mixed for 2 min in a dough mixer at medium speed to get a uniform creamed mixture and then milk and flour blend were added and mixed for 3 min at medium speed. The dough obtained was sheeted on dough sheeter into a 10 mm thick sheet. It was cut into round shape with cutter and baked at 185 °C for 10 min. After baking, cookies were allowed to cool at room temperature for 3 h and then subjected to physical and sensory analyses. Effect of water level (4.0, 4.81, 6.0, 7.19 and 8.0%) and baking time 8–12 min on cookies supplemented with PHGG 1.0%, 1.81%, 3.0%, 4.19% & 5.0% were studied as described in Table 1.

2.4. Cookie spread factor

Diameter of control and PHGG supplemented cookies was measured with the help of a scale by laying down six cookies edge to edge. The diameter of six cookies was measured again after rotating each cookie to 90° and then the average value of cookie diameter was calculated. Six cookies were stacked on each other and their thickness was measured. Cookies were restacked in random order and thickness was measured again and then the average value of cookie thickness was calculated. Spread factor of cookies was measured from the ratio of average value of diameter and average value of thickness of cookies.

2.5. Cookie texture

Texture Analyzer (model TA-XT2i, Stable Micro systems, U.K) was used to measure hardness (as fracture force) of cookies via 3-point bending test using 3-point bending rig, trigger force of 25 g, and load cell of 50 kg. The textural studies were conducted at pre-test speed of 1.5 mm/s, test speed of 2.0 mm/s, post test speed of 10 mm/s, distance 10 mm and the distance between the two bottom supports was adjusted to 50 mm. The peak value of fracture force (maximum) was recorded as hardness at a point when the cookies were broken into two major pieces (Chakraborty, Singh, Kumbhar, & Singh, 2009). This peak force (g) at breaking point represented the breaking strength of cookie. Mean values in triplicates were reported as fracture force.

2.6. Sensory evaluation

Sensory properties of cookies were evaluated by panel of 25 semi-trained members using nine point hedonic scale (Gajera,

Table 1
Experimental design for partially hydrolyzed guar gum fortified cookies with respective coded variables (X) and response value (Y).

Run	X_1(%)	X_2(%)	X_3(min)	Y_1	Y_2 (g)	Y_3
1	3.00	4.00	10.00	6.12	6585.4	8.0
2	3.00	6.00	12.00	6.24	8720.5	8.0
3	4.19	4.81	11.19	4.37	9607.0	7.0
4	3.00	6.00	10.00	5.36	4981.8	7.0
5	1.81	7.19	8.81	4.70	4888.7	8.0
6	3.00	6.00	10.00	5.50	5305.1	6.5
7	3.00	6.00	10.00	5.90	4500.0	7.2
8	3.00	6.00	10.00	6.10	4887.5	6.8
9	1.81	7.19	11.19	7.56	4561.4	8.0
10	5.00	6.00	10.00	5.06	10118.2	7.5
11	4.19	4.81	8.81	7.17	5508.2	7.5
12	3.00	8.00	10.00	5.40	2147.6	7.0
13	4.19	7.19	11.19	6.02	4161.5	7.5
14	3.00	6.00	8.00	6.61	6692.4	7.7
15	4.19	7.19	8.81	4.95	8650.5	7.2
16	3.00	6.00	10.00	5.10	4384.3	6.4
17	1.81	4.81	11.19	6.81	9521.1	8.0
18	1.00	6.00	10.00	7.02	7362.9	8.7
19	1.81	4.81	8.81	9.14	4125.6	7.7
20	3.00	6.00	10.00	5.70	5605.1	7.4

Note: X_1(PHGG level), X_2 (water level), X_3 (baking time) for dependent response Y_1 (spread ratio), Y_2 (cookie hardness) and Y_3 (overall acceptability).