Flavor and texture attributes of foods containing β-glucan-rich hydrocolloids from oats

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ABSTRACT

Sugar cookies and peanut spreads were prepared with β-glucan-rich hydrocolloids from oats (Nutrim-OB (10 g β-glucan/100 g) and C-Trim20 (20 g β-glucan/100 g)). Products were evaluated for flavor and texture by a descriptive sensory panel. In cookies containing 10–30% Nutrim-OB, the cereal/grain flavor intensity was only significantly different than the control at the 30% level of flour replacement. Cohesiveness and moistness of the cookies increased with increasing amounts of Nutrim-OB, but no significant differences from the control were noted until 20% replacement. In cookies containing 10–30% C-Trim20, cereal/grain flavor intensity increased with increasing amounts of the hydrocolloid. Cardboard flavor also increased, but no significant differences were noted from the control until 20% replacement. Cohesiveness, density, and moistness of the cookies increased with increasing amounts of C-Trim20 with no significant differences until 20% replacement. Substituting 5% of the oil in the peanut spreads with Nutrim-OB did not significantly affect flavor of spreads. However, 9% substitution significantly decreased oily flavor and hardness increased. The use of 5–13% C-Trim20 as a replacement for oil in the spreads produced significantly more gumminess and hardness than the control. Favor of the spreads was not affected by the substitution of up to 9% C-Trim20.

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1. Introduction

From the mid-20th century, an emphasis on the concept of diet was placed on maintaining or enhancing good health due to global health concerns, high health care costs, an increasingly aging population, and so on (Arvanitoyannis & van Houwelingen-Koukaliaroglou, 2005). With this trend, there is a continuously growing popularity of dietary fibers that are shown to have beneficial health effects. Specially, β-glucan, a soluble dietary fiber rich in oats and barley, is receiving great attention since it reduces blood cholesterol level and the risk of heart-related diseases (Malkki & Virtanen, 2001). Moreover, the US Food and Drug Administration allows a health claim to be made on food labels containing 0.75 g of β-glucan per serving (FDA, 1997).

Over the past 15 years, hydrocolloids containing β-glucan from oats and barley have been developed including Oatrim (Inglett, 1993), Nu-TrimX (Inglett & Carriere, 2001), and barleytrim (Inglett, 1992). Not only can these products add to the health benefits of β-glucan, but they can also partially replace fat and/or flour in foods to reduce calories (Lee & Inglett, 2006; Lee, Kim, & Inglett, 2005). Additional oat-based β-glucan hydrocolloids have been developed lately by fractionating oat bran concentrates after steam jet-cooking. They include a product with 10 g β-glucan/100 g known as Nutrim-OB (oat bran) and a 20 g β-glucan/100 g product called C-Trim20 (Calorie-trim) (Lee & Inglett 2006).

A number of food ingredients have been tested as fat replacers so far. Examples of fat replacers include mono-diglycerides, micro-particulated protein, potato maltodextrin, Raftiline, Simplex, C*delight, and polydextrose (Armbrister & Setser, 1994; Zoulias, Oreopoulou, & Kounalaki, 2002; Zoulias, Piknis, & Oreopoulou, 2000). However, their applications are still limited mostly to baked or dairy products. In the case of flour replacements, only a few references are available in the literature. Soy protein and lupin flour were tested to replace wheat flour in breads (Dervas, Doxastakis, Hadjisavva-Zinoviadi, & Triantafillakos, 1999; Mohamed, Rayas-Duarte, Shogren, & Sessa, 2006) and cookies (Singh & Mohamed,
Once baked at 205°C for 11 min, the cookies were cooled down and stored at room temperature in plastic containers and refrigerated at least 24 h before sensory evaluations.

2.3. Sensory properties of cookies

A 15-member descriptive sensory panel experienced in evaluating flavor and texture of foods, was trained for the sensory analysis of cookies (Drewowski, Nordensten, & Dwyer, 1998; Szczesiak et al., 1963). Panel members were given all samples in a balanced complete block design over three testing days. At each testing session, panelists were given three cookies to evaluate. The flavors (cereal/grain, sweet, cardboard) of cookies were rated on a 0–10 intensity scale. Fresh wheat germ was used to represent the cereal/grain flavor; wet paper filters represented the cardboard flavor; and 5% sucrose represented sweet (Civille & Lyon, 1996). Also, their textures were rated on a 0–10 scale that indicated crumbly–gummy, light–compact, dry–moist, and tender–tough for cohesiveness, density, moistness, and chewiness, respectively, using the texture standards presented by Szczesiak et al. (1963). Reference standards were presented to panelists during four training sessions.

2.4. Peanut spread preparations

Peanut spreads were prepared from peanut flour and peanut oil with partial replacements of either ingredient by C-Trim20 or Nutrim-OB. The formulations for control peanut spread were 210 g peanut flour (defatted, lightly roasted; Golden Peanut Co., Alpharetta, GA), 213 g peanut oil (Golden Peanut Co., Alpharetta, GA), 50 g baker’s sugar (C&H Sugar Co. Inc., Crockett, CA), and 5 g flour salt (98% sodium chloride, 2% tricalcium phosphate) (Morton Salt; Fairport, OH). The composition of the peanut flour was protein (52.2 g/100 g), carbohydrate (34.7 g/100 g), moisture (7.8 g/100 g), ash (4.75 g/100 g), and total lipid (0.55 g/100 g). All ingredients were placed into a bowl of a food processor and mixed thoroughly at a high speed for 5–3 min. The spreads were then placed into plastic containers and refrigerated at least 24 h before sensory evaluations.

2.5. Sensory properties of peanut spreads

A 15-member descriptive sensory panel experienced in evaluating flavor and texture of foods, was trained for the sensory analysis of peanut spreads (Muergo-Gnanasekharan & Resurreccion, 1992; Szczesiak et al., 1963; Yeh, Phillips, Resurreccion, & Hung, 2002). Panel members were given approximately 2.5–3.0 g of peanut spread at room temperature on a plastic spoon that was placed in a 2 oz plastic souffle cup. Panel members received three samples at each testing session that were randomized by a balanced complete block design over three testing days. The flavors (sweet, oily/creamy, roasted peanut, starchy, flat/cardboard) were rated on a 0 (weak) to 10 (strong) intensity scale. Wet paper filters represented the cardboard flavor; 5% sucrose represented sweet; soybean oil represented oily; cooked and cooled paste of 10:1 corn starch to water represented starchy; and roasted peanuts represented roasted (Civille & Lyon, 1996). Textures (hardness, graininess, adhesiveness, cohesiveness, gumminess) of peanut spreads were rated on a 0 (low) to 10 (high) scale using the texture standards presented by Szczesiak et al. (1963). Reference standards were presented to panelists during four training sessions.

2.6. Statistical analysis

A completely randomized design was utilized to determine significant differences among samples from analysis of variance (ANOVA). Duncan’s multiple range test was also conducted for mean comparisons because there were no significant differences between blocks. Statistical significance was expressed as p < 0.05 unless otherwise indicated.
3. Results and discussion

3.1. Sensory properties of Nutrim-OB and C-Trim20 in cookies

Sensory properties of cookies were investigated and data are shown in Figs. 1 and 2. Flavor intensity scores for cookies with 0–30% Nutrim-OB (Fig. 1(a)) showed that cereal/grain flavor was the only attribute to have significant differences between samples. The intensity of cereal/grain flavor was significantly higher for the cookies with 30% Nutrim-OB than for any of the other samples. Other flavor scores did not vary significantly between samples, although cardboard flavor also increased and sweet taste decreased with increasing amounts of Nutrim-OB. The addition of Nutrim-OB also significantly affected texture (Fig. 1(b)). Cohesiveness and moistness of the cookies increased with increasing levels of Nutrim-OB addition. Sugar cookies made with 30% Nutrim-OB had significantly more cohesiveness and moistness than sugar cookies made with 0%, 10%, or 20% Nutrim-OB. The cookies with 10% Nutrim-OB were not significantly different than the control for all textural properties tested. In a previous study of fat replacement in cookies with Nutrim-OB (Lee et al., 2006), results showed that Nutrim-OB could be used to replace shortening up to 20% without significant textural properties. In addition, the substitution of shortening with Nutrim-OB caused the increase in the moisture content of cookie samples (Lee et al., 2006), which was also observed in the flour replacement.

Flavor intensity scores for cookies with 0–30% C-Trim20 are shown in Fig. 2(a). Cereal/grain flavor and cardboard flavor intensity increased with increasing amounts of C-Trim20; whereas the intensity of sweet taste decreased with increasing amounts of C-Trim20. Armbrister and Setser (1994) also found that sweet taste decreased with increasing amounts of fat replacers, which compared favorably with our results. Only the sugar cookies made with 30% C-Trim20 had significantly more cereal/grain flavor than the control. The control sugar cookies made with 0%, 10%, or 20% C-Trim20 were significantly sweeter than sugar cookies made with 30% C-Trim20. The cookies with 10% C-Trim20 had significantly less cardboard flavor than sugar cookies made with 20% or 30% C-Trim20. Texture attribute scores for cookies with 0–30% C-Trim20 are shown in Fig. 2(b). The attributes of cohesiveness, density, and moistness increased with increasing addition of C-Trim20; however, no significant differences between addition levels were noted for chewiness. Sugar cookies made with 20% or 30% C-Trim20 were significantly more cohesive, dense, and moist than sugar cookies.
made with 0% and 10% C-Trim20. No significant differences for cohesiveness and denseness were shown between sugar cookies made with 20% or 30% C-Trim20. Previously, C-Trim20 was evaluated as a fat replacer in a chocolate chip cookie, giving 45% less fat and 12% lower calorie (Woods & Navder, 2006). The sensory evaluation showed that fat replacement up to 75% level could produce the cookie samples with acceptable qualities. Therefore, fat replacement with C-Trim20 appeared to be more effective in reducing calories in foods without quality loss than flour replacement.

3.2. Sensory properties of Nutrim-OB and C-Trim20 in peanut spreads

The addition of Nutrim-OB and C-Trim20 were evaluated in peanut spreads as partial replacements for either peanut flour or peanut oil in the formulations. Flavor intensity scores for peanut spreads with Nutrim-OB replacement of peanut flour are shown in Fig. 3(a). The intensities of flat/cardboard and starchy flavors increased with increasing amounts of Nutrim-OB substitution for peanut flour. Overall, the intensities of oily, sweet, and roasted
attributes decreased with increasing Nutrim-OB addition. For most of the flavor attributes, substitution of 18% Nutrim-OB was needed before panelists detected significant differences from the control with 0% Nutrim-OB. In Fig. 3(b), texture attribute scores for peanut spreads containing Nutrim-OB replacement of peanut flour are shown. The attributes of adhesiveness, cohesiveness, hardness, and gumminess increased with increasing substitution of Nutrim-OB for peanut flour. Graininess decreased with increasing Nutrim-OB. The substitution of 13% Nutrim-OB was needed before panelists detected significant differences between this sample and the control with 0% Nutrim-OB for all attributes except graininess and adhesiveness.

Fig. 4(a) shows flavor intensity scores for peanut spreads with Nutrim-OB replacement of peanut oil. When 9% peanut oil in peanut spreads was replaced with Nutrim-OB, the intensities of flat/cardboard and starchy increased, whereas there were decreases in the intensities of oily, sweet, and roasted attributes. Only the substitution of 9% Nutrim-OB resulted in significant differences from the control with 0% Nutrim-OB. The use of 5% Nutrim-OB showed no significant differences between this sample and either the control or the ground peanuts. Texture attribute scores for peanut spreads with Nutrim-OB replacement of peanut oil are shown in Fig. 4(b). The attributes of cohesiveness and hardness increased significantly with increasing substitution of Nutrim-OB for peanut.
oil. Graininess decreased in the sample where 9% peanut oil was replaced with Nutrim-OB. The partial replacement of peanut oil with 9% Nutrim-OB was needed before panelists detected a significant difference between this sample and the control with 0% Nutrim-OB for hardness. No significant differences were noted between the control and all Nutrim-OB substitutions for adhesiveness. Thus, the peanut spreads containing Nutrim-OB exhibited comparable properties to the control when peanut flour and peanut oil were replaced up to 13% and 5%, respectively.

Fig. 5(a) shows flavor intensity scores for peanut spreads containing C-Trim20 replacement of peanut flour. The intensities of flat/cardboard and starchy flavors increased with increasing amounts of C-Trim20 substitution for peanut flour; whereas, the intensities of oily, sweet, and roasted attributes decreased with increasing C-Trim20. The similar textural tendency was observed between Nutrim-OB and C-Trim20. In general, the substitution of 9% and 13% C-Trim20 was needed before panelists detected significant differences between these samples and the control with 0% C-Trim20. The use of 5% C-Trim20 showed no significant differences compared to the control. Texture attribute scores for peanut spreads containing C-Trim20 replacement of peanut flour are in Fig. 5(b). The attributes of adhesiveness, cohesiveness, hardness, and gumminess increased with increasing substitution of C-Trim20 for peanut flour. Graininess between the samples was not significantly different. All samples with C-Trim20 were significantly more cohesive and gummy than the control. Samples with either 9% or

![Figure 5](https://example.com/figure5.png)
13% C-Trim20 were significantly more adhesive, cohesive, hard, and gummy than the control. These results could be favorably compared to those of Armbrister and Setser (1994) in the use of fat replacers in cookies. Cookies with 50% and 75% fat replacement resulted in more mouth coating than the control which is reflected in the adhesive and gummy attribute ratings.

In Fig. 6(a), flavor intensity scores for peanut spreads with C-Trim20 replacement of peanut oil are shown. The intensities of flat/cardboard and starchy flavors increased with increasing amounts of C-Trim20 substitution for peanut oil. However, the intensities of oily, sweet, and roasted attributes decreased with increasing C-Trim20. Samples with either 9% or 13% C-Trim20 had significantly more flat/cardboard and starchy flavor than the control. Samples with 13% C-Trim20 were significantly less oily, roasted, and sweet than the control. For texture attribute scores of peanut spreads with C-Trim20 replacement of peanut oil (Fig. 6(b)), the attributes of adhesiveness, cohesiveness, hardness, and gumminess increased with increasing substitution of C-Trim20 for peanut oil. Graininess decreased with increasing C-Trim20. All samples with C-Trim20 were significantly more adhesive, cohesive, hard, and gummy than the control. Samples with either 9% or 13% C-Trim20 were significantly less grainy than the control. Although β-glucan has been widely used in a variety of foods, it is recognized that a high amount of β-glucan provides tough, gummy, cohesive
4. Conclusion

This study showed that β-glucan-rich hydrocolloids, Nutrim-OB could partially replace flour up to the 20% level in cookies and C-Trim20 could be used to the 10% level without negatively affecting flavor and texture. The addition of 20% Nutrim-OB provided 0.12 g β-glucan per cookie. Also, each 22 g cookie made with 10% C-Trim20 contained 0.12 g β-glucan. In peanut spreads, Nutrim-OB could partially replace peanut flour up to 13% and oil up to 5% without undesirable changes in flavor and texture. The addition of 13% Nutrim-OB provided 0.42 g β-glucan per two tablespoon (32 g) serving of peanut spread. Peanut spreads (32 g) made with 9% C-Trim20 contained 0.56 g β-glucan. Furthermore, C-Trim20 (3.4 kcal/g) replacement of 9% peanut oil could reduce the calorie of peanut spreads by around 50 kcal/100 g. Even though this may not constitute a sufficient amount of β-glucan to make an FDA-approved health claim on a label, adding β-glucan-rich hydrocolloids to foods instead of fat/flour is a good way to improve health by increasing dietary fibers and reducing the calories.

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