International Journal of Arts & Sciences,
CD-ROM. ISSN: 1944-6934 :: 07(03):9–17 (2014)

EFFECTS OF RESISTANT STARCH AND FIBER-RICH APPLE AND APRICOT POWDERS ON LOW-FAT COOKIE QUALITY

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Resistant starch is a relatively new class of dietary carbohydrates, which is also considered as the carbohydrate-based fat replacers. Inadequate fiber intake has been found to be associated with diseases like diverticulosis, atherosclerosis, colonic cancer and appendicitis. Apricots and apples among the most promising foods with the physiologically important constituents such as dietary fiber. In order to investigate the effects of fruit powders addition on the low-fat cookie quality, apple or apricot powder (APL-P and APR-P) were used to replace wheat flour in the formulation of cookies at the levels of 10, 20, 30 and 40% (w/w) with 30% RSP to replace shortening. Results indicated that there were no significant differences between spread ratio values of the cookies supplemented with different levels of APL-P and control and they were all acceptable. However, APR-P supplemented cookies generally had a gradual increase in spread ratio values compared to the APL-P supplemented cookies above 10% level ($p<0.01$). The hardness values of the cookies generally increased significantly ($p<0.01$) with increasing APL-P levels. APL-P supplemented cookies generally had lower hardness values than APR-P supplemented ones. Overall sensory scores of the cookies supplemented with APR-P were not significanly different from those of the control and they were all acceptable. APL-P supplemented cookies generally had higher L* and lower a* than APR-P supplemented ones. TDF contents of the cookies increased with increasing fruit powder supplementation level. APR-P appeared to be a more suitable replacer than APL-P up to 30% level.

Keywords: Resistant starch, Apple powder, Apricot powder, Cookie quality, Dietary fiber.

Introduction

Reducing fat in diet has become a public health concern for consumers. However, fat is one of the ingredients that affect cookie texture, and contributes pleasing mouthfeel and positively impacts flavour intensity and perception. In the USA and Europe, daily fat consumption represents about 40% of total calory intake. Health specialists recommend that it should not exceed 30% of the total calories in a diet (Giese 1996).

Several fat replacers have been in use in bakery products. Carbohydrate-based fat replacers have been reported to imitate fat by binding water and to provide lubricity, body and a pleasing mouth sensation (Bath et al. 1992). According to the Champbell et al. (1994), substitution of fat had a greater impact on textural attributes of cookies than substituton of sugar or flour. Inglett et al. (1994) also concluded that replacement of 50% of fat by β-glucan and amylodextrins derived from oat flour resulted in cookies not significantly different from the full-fat ones, but at higher substitution levels overall quality was decreased.

Resistant starch (RS) is a relatively new class of dietary carbohydrates, which is also considered as the carbohydrate-based fat replacers (Voragen 1998). RS has been defined as the fraction of starch, which escapes digestion in the small intestine and may be fermented in the colon. RS is naturally found in cereal grains and in heated starch or starch-containing foods. It was reported that RS provides better appearance, texture and mouthfeel than conventional fibers as a food ingredient (Charalampopoulos et al. 2002). It has been shown to possess physiological benefits similar to soluble fibers (Haralampu 2000). Some research has shown that RS can be incorporated into yellow layer cakes, breads, biscuits, muffins and crackers (Eerlingen et al. 1994; Lin et al. 1994; Yue and Waring 1998; Brennan and Samyue 2004; Özboy-Özbaş et al. 2010).

Inadequate fiber intake has been found to be associated with diseases like diverticulosis, atherosclerosis, colonic cancer and appendicitis (Trowell 1972; Painter and Burkitt 1977; Walker et al. 1973). An increase in level of dietary fiber in the daily diet has been recommended (25-30 g/day).

Apricot (*Prunus armeniaca* L.) is one of the most popular stone fruits grown in some regions of Turkey which is the biggest apricot producer (538.000 metric tons/yr) (FAO 2002). Apricots among the most promising foods with the physiologically important constituents (dietary fiber, sorbitol, potassium, copper, and phenolic compouns). Since fresh apricot fruits have limited shelf-life, various dried forms of apricots are widely used. A new form of apricot as freeze dried powder retaining all important nutrients and flavor of fresh apricot might be promising alternative for the utilisation of apricots.

Apple (*Malus domestica*) is usually consumed in fresh form. Commercially apple is used mostly for extracton of apple juice. It is also well known that apples are good sources of fiber (Gorinstein et al. 2001). Fresh apples are very convenient for storage, transportation and consumption. However, there is a demand for new apple products such as freeze-dried apple powder which retains all nutrients (dietary fiber, antioxidants etc.) and flavor of fresh apple.

The objective of this paper was to study the effects of fruit powders addition on the low-fat cookie quality. To determine the effects of fiber-rich fruit powders on cookie quality and total dietary fiber content of the cookies, apple or apricot powder (APL-P and APR-P) were used to replace wheat flour in the formulation of cookies at the levels of 10, 20, 30 and 40% (w/w) with 30% RSP to replace shortening.

Materials and Methods

Materials

Apricots (cv: Hacıhaliloğlu) were obtained from Malatya province during the summer season of 2003 and they were non-sulphited. Golden delicious type apples were purchased from local market. Corn starch was obtained from Cargill Inc., Istanbul, Turkey. The commercial soft wheat flour (Örnek Flour Inc., Nevşehir, Turkey) used in this study consisted of 9.8% protein, 0.65% ash, 28% wet gluten and, 1.6% total dietary fiber. Only reagent-grade chemicals were used.

Production of the Resistant Starch Preparation (RSP)

Corn starch was suspended in 1.64 M HCl with a starch to acid ratio of 2:3 (w:v) and incubated at 40°C for 2 hr. After the incubation period, the pH of the suspension was adjusted to 6 with 10% NaOH (w:v). Then the sample was washed three times with distilled water and centrifuged (Heraus Labofuge, Germany) at 1000 rpm for 5 min. The washed sample was dried at 40°C and ground to pass through 212 µm sieve. For resistant starch formation, acid-modified starch sample was suspended in distilled water (1:10) and gelatinized at 85°C for 15 min. Then the sample was autoclaved at 121°C for 30 min and stored at 95°C for 2 days. The sample was dried at 50°C, ground and sieved (Köksel et al. 2008).

Preparation of Fruit Powders

Apricots and apples were first washed with tap water. The central part of the apples, containing the seeds and the kernels of the apricots were removed manually. After chopping, the samples were immediately dipped in a 1% citric acid solution for an hour to avoid enzymatic browning. Fruit samples were frozen at -30°C and freeze-dried (Armfield Inc., England-Model HA-3083/2) for the preparation of fiber-rich apple and apricot powders (APL-P and APR-P, respectively). Freeze-dried apple and apricot samples were ground by using a Waring blender to a particle size of 212-325 µm and stored in glass jars at −10 °C until analysis.

Analytical Methods

Moisture, protein (Nx5.7), ash (d.b.) and wet gluten contents of the soft wheat flour and moisture content of the RS preparation (RSP) were determined by using AACC Approved Methods (AACC International 2000). The RSP was analyzed for RS content (AOAC 1998), water binding capacity and solubility (Köksel et al. 2008) and fat binding capacity (Lin et al. 1974). Fruit powders (apple powder: APL-P and apricot powder: APR-P) were analyzed for moisture, protein (Nx6.25) and ash contents by using AOAC methods (AOAC 1998), and for water-holding capacity (Mongeau and Brasard 1982) and bulk density (Michel et al. 1988). Antioxidant properties of APL-P and APR-P were evaluated by determining total phenolic content, assessed by Folin method (Durmaz and Alpaslan 2007). Total dietary fiber (TDF) contents of soft wheat flour, APL-P, APR-P and the all supplemented cookies were determined by using AACC Approved Methods (AACC International 2000).

Cookie Preparation and Quality Determination

The cookie qualities of RSP including fruit powders (APL-P and APR-P) supplemented flours were determined by AACC Method No: 10.54; Baking Quality of Cookie Flour-Micro Wire-Cut Formulation (AACC International 2000). The formulation of the cookies are shown in Table 1 (control) and Table 2. RSP was used to partially replace shortening at the level of 30 (w/w) in the formulation. The RSP was added to the dry ingredients and blended manually with a spatula for 1 min. A control sample including 30% RSP was also prepared. Fruit powders (APL-P and APR-P) were used to replace wheat flour in the formulation of cookies at the levels of 10, 20, 30 and 40% (w/w) with 30% RSP to replace shortening. Four cookies were prepared per bake. The baked cookies were cooled at room temperature (30 min) and then they were wrapped in aluminum foil and allowed to stand at room temperature until analysis.

Table 1. Formulation of cookies.

Ingredients[a]	Weight (g)
Sucrose (fine granulating)	25.6
Brownulated granulated sucrose	8.0
Nonfat dry milk	0.8
Salt	1.0
Sodium bicarbonate	0.8
All-purpose shortening (fat)	32.0
High-fructose corn syrup	1.2
Ammonium bicarbonate	0.4
Deionized water	variable
Flour[b]	80.0

[a] Ingredients at 21±1 °C
[b] 13% moisture basis

Table 2. Addition levels of resistant starch (RSP), apple powder (APL-P), and apricot powder (APR-P) in cookie formula

RSP (30%) with APL-P Formula [a]		RSP (30%) with APR-P Formula	
APL-P/ F	RSP/S	APR-P/F	RSP/S
0/100	30/70	0/100	30/70
10/90	30/70	10/90	30/70
20/80	30/70	20/80	30/70
30/70	30/70	30/70	30/70
40/60	30/70	40/60	30/70

[a] F, flour; S, shortening

The quality parameters of the cookies were evaluated in terms of width (W), thickness (T), spread ratio (W/T), color and texture values. After cooling of the cookies for 30 min, width and thickness measurements of the cookie samples were taken using a caliper. CIE color values (L*, a* and b*) were measured with a Minolta Spectrophotometer CM-3600d (Japan). The L* value indicates the lightness, 0-100 representing dark to light. The a* value gives the degree of the red-green colour. The b* value indicates the degree of the yellow-blue colour. A texture analyzer (TA Plus, Lloyd Instruments, UK) equipped with a three-point bending jig was used for texture analysis and the maximum force (Newtons) required to break the cookie sample was determined 24 h after baking. The span between the supports was 40 mm. A load cell of 1,000 N was used. The sensory characteristics of the cookies were screened by a six-member panel that was well aware of the purpose of the investigation. The panel members individually evaluated appearance and taste of the cookies by giving scores ranging between 1 to 5, 5 being the most desirable. Then, the overall sensory scores were calculated as the mean of the appearance and taste scores for each bake (Köksel and Özboy 1999).

Statistical Evaluation

Data were analyzed for variance using the MSTAT statistical package (Anonymous 1988). When significant differences were found, the LSD (Least Significant Difference) test was used to determine the differences among means.

Results and Discussion

Properties of Resistant Starch Preparation

The results of the properties of resistant starch preparation (RSP) were given in our previously published paper in detail (Özboy-Özbaş et al., 2010). Properties of resistant starch preparation (RSP) generally agreed with the previously published data (Eerlingen et al. 1994; Yue and Waring 1998). Differences might be due to the type of starch and the procedure used for the formation of resistant starch. In this study, RS content of the RSP was found to be 15.3%, which is lower than the ones determined by Eerlingen et al. (1994) and Yue and Waring (1998). The water binding capacity (WBC) of RSP obtained in this study was found to be 187% which is almost equal to the one reported by Yue and Waring (1998) and lower than the one reported by Robertson et al. (2000). Solubility value of the RSP obtained in this study was found to be 2.4% which is lower than the ones reported (12.5-20.3%) for the starches from different corn types (Sandhu et al. 2004). Fat binding capacity (152%) of the RSP is lower than the previously reported values for the other dietary fiber sources (Abdul-Hamid and Luan 2000; Grover et al. 2003). The data revealed that RSP is rich in terms of RS and can be used to supplement cereal based foods in terms of RS.

Properties of Fruit Powders

The results of the properties of fruit powders were given in our previously published paper in detail (Özboy-Özbaş et al., 2010). The protein and ash contents of apple powder (APL-P) were found to be 3.4% and 3.08%, respevtively. The water holding capacity (WHC) and bulk density values of APL-P were found to be 6.6 g/g and 355 mg/cm^3, respectively. Apricot powder (APR-P) had a protein content of 2.8%, ash content of 3.23%, bulk density of 386 mg/cm^3 and WHC of 6.7 g/g. The TDF content of APL-P was found to be 22.8%, which is higher than the value reported by Li and Cardozo (1994), and within the range of the one reported by Lentowicz et al. (2003). The TDF content of APR-P was found to be 21.1% which is lower than the value reported by Li and Cardozo (1994). Total phenolic contents of APL-P and APR-P were found to be 1.327 and 0.763 μg GAE/g db, respectively. Total phenolic content of whole apple was reported to be 1.2 mg/100 g fresh fruit by Gorinstein et al. (2001). The data revealed that APL-P and APR-P samples are both rich in terms of total dietary fiber content and antioxidant power.

Effects of Fruit Powders on the Quality of Low-Fat Cookies

In order to investigate the effects of fruit powders addition on the low-fat cookie quality, apple or apricot powder (APL-P and APR-P) were used to replace wheat flour in the formulation of cookies at the levels of 10, 20, 30 and 40% (w/w) with 30% RSP to replace shortening. Spread ratio and hardness values, sensory properties and total dietary fiber contents of the APL-P and APR-P supplemented low-fat cookies are presented in Table 3.

Table 3. Effects of fruit powders (APL-P and APR-P) on spread ratio, hardness value, overall sensory score and total dietary fiber contents of the low-fat cookies

Fruit powder level (%)	Spread Ratio		Hardness (N)		Overall sensory score		TDF (%)	
	APL-P	APR-P	APL-P	APR-P	APL-P	APR-P	APL-P	APR-P
0	7.10a	7.10c	47.12e	47.12c	3.87a	3.87a	1.86a	1.86a
10	6.44b	6.70c	80.73c	97.98ab	3.37a	4.12a	8.68b	7.42b
20	6.39b	7.11c	96.45b	117.05a	3.37a	4.62a	11.75c	10.79c
30	6.40b	7.93b	108.88a	83.60b	3.87a	3.75a	15.01d	12.33d
40	6.08c	9.01a	69.92d	96.23b	4.00a	3.50a	19.20e	13.91e
LSD	0.05	0.45	2.77	20.54	2.01	2.18	0.90	0.10

Means followed by the different letter are significantly different using the LSD test ($p<0.01$)

TDF: Total dietary fiber; APL-P: Apple powder; APR-P: Apricot powder

Results indicated that there were no significant differences between spread ratio values of the cookies supplemented with different levels of APL-P and control and they were all acceptable. However, APR-P supplemented cookies generally had a gradual increase in spread ratio values compared to the APL-P supplemented cookies above 10% level ($p<0.01$). Increasing fiber addition generally reduces the spread ratio values of the high-fiber cookies (Özboy and Köksel 1997) and similar results were also obtained in cookies supplemented with brewer's spent grain and sugar beet fiber (Köksel and Özboy 1999; Özturk et al. 2002). Chen et al. (1988) investigated effects of spray-dried apple fiber compared to wheat and oat brans in cookies and demonstrated that as the concentration of apple fiber increased, the diameter of cookies decreased, and their thickness increased. On the contrary, the diameters of oat bran supplemented cookies did not change significantly as the addition level increased.

The hardness values of the cookies generally increased significantly ($p<0.01$) with increasing APL-P levels. APL-P supplemented cookies generally had lower hardness values than APR-P supplemented ones. Overall sensory scores of the cookies supplemented with APR-P were not significanly different from those of the control and they were all acceptable. The effect of incorporation of high-fiber fruit powders on total dietary fiber content of low-fat cookies was investigated for the first time. Total dietary fiber (TDF) contents of the cookies supplemented with APL-P and APR-P increased significantly ($p<0.01$) as the addition level increased. The TDF contents of the APL-P supplemented cookies were slightly higher than those supplemented with APR-P.

CIE color values (L*, a*, and b*) of APL-P and APR-P supplemented low-fat cookies are presented in Table 4. The color of the cookies is one of the characteristics which are firstly perceived by the consumer and affect the acceptability of the product.

Table 4. Effects of fruit powders (APL-P and APR-P) on color values of the low-fat cookies.

Fruit powder level (%)	L*		a*		b*	
	APL-P	APR-P	APL-P	APR-P	APL-P	APR-P
0	70.39a	70.39a	8.36c	8.36d	36.10bc	36.10b
10	65.92b	70.42a	11.30bc	9.97c	33.97c	33.91c
20	66.08b	64.86b	10.87ab	12.96b	34.86c	37.80a
30	63.58c	62.67c	13.06ab	13.59b	37.74ab	37.51ab
40	63.36c	63.67bc	13.77a	15.49a	39.16a	38.45a
LSD	1.93	1.88	2.59	1.20	2.13	1.56

Means followed by the different letter are significantly different using the LSD test ($p<0.01$)
L*:Lightness; a*: Redness; b*:Yellowness; APL-P: Apple powder; APR-P: Apricot powder

Although the Lightness (L*) of the cookies supplemented with both fruit powders decreased significantly ($p<0.01$), APR-P supplementation resulted in higher decreases in L* values. Cookies supplemented with APR-P generally gave higher a* values as compared to APL-P supplemented cookies at all levels. The replacement of flour by apple and apricot powders in wire-cut cookie formulation showed that the physical characteristics, total dietary fiber contents and textural properties of the cookies were significantly affected ($p<0.01$) and that APR-P appeared to be a more suitable replacer than APL-P up to 30% level.

Conclusion

One of the purpose of this study was to determine some functional properties of resistant starch preparation (RSP) and to investigate its effects on the quality of low fat cookies. RSP is rich in terms of dietary fiber (15.3%). Thus, it can be used to supplement cereal based foods such as cookies and cakes.

Another objective of this study was to determine the effects of fiber-rich fruit powders (apricot and apple powders) on the quality of low fat cookies produced by replacing the fat with RSP (30%). The data revealed that APL-P and APR-P are both rich in terms of total dietary fiber content and antioxidant power thus, they can be used to supplement cereal based foods such as cookies. APR-P supplemented cookies generally had higher spread ratio than the APL-P supplemented ones. Overall sensory scores of the cookies supplemented with APR-P were not different from those of the control and they were all acceptable. TDF contents of the cookies increased with incresing fruit powder supplementation level. Cookies supplemented with APR-P generally gave lower L* and higher a* values as compared to APL-P supplemented ones. As a result, the replacement of flour by apple and apricot powders in wire-cut cookie formulation showed that the physical characteristics, total dietary fiber contents and textural properties of the cookies were significantly affected ($p<0.01$) and that APR-P appeared to be a more suitable replacer than APL-P up to 30% level.

Acknowledgements

The authors wish to thank Inonu University Scientific Research Center for financial support (Project no: 2002/10). The authors would also like to thank Örnek Flour Inc. (Nevşehir, Turkey) for providing soft wheat flour, Aytaç Biscuit Co. (Kayseri, Turkey) for providing fine granulating sucrose, brownulated granulated sugar and all-purpose shortening, and Ülker Co. (Ankara, Turkey) for providing high-fructose corn syrup.

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