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EFFECTS OF RESISTANT STARCH AND APRICOT KERNEL FLOUR AND FIBER-RICH APRICOT AND APPLE POWDERS ON THE QUALITY OF LOW-FAT WIRE-CUT COOKIES

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A low-fat and high-fiber food is an important objective in today's food product development. Resistant starch (RSP) is a relatively new class of dietary carbohydrates, which is also considered as the carbohydrate-based fat replacers. Apricot kernels are rich in lipid, unsaturated fatty acids, and protein. Apricots among the most promising foods with the physiologically important constituents playing a role in many aspects of human health. A new form of apricot as freeze dried powder retaining all important nutrients and flavor of fresh apricot might be promising alternative for the utilization of apricots. Apple is also well known that apples are good sources of fiber. Thus, one of the objectives of this study was to determine the effects of resistant starch preparation (RSP) and combined effects of RSP/ apricot kernel flour (AKF) blends on the quality of low-fat wire-cut cookies and the suitability of using RSP and RSP/AKF blends to replace shortening in cookies. 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/AKF. Results of the study indicated that a slight increase in the spread ratios of RSP /AKF supplemented cookies were observed up to 20% level. The hardness of RSP and RSP/AKF supplemented cookies increased above 10% level. Sensory scores of RSP and RSP/AKF supplemented cookies were not different from the control. Total dietary fiber contents of RSP and RSP/AKF supplemented cookies increased with increasing level. Apricot powder (APR-P) supplemented cookies had higher spread ratios compared to the apple powder (APL-P) supplemented ones above 10% level. APL-P supplemented cookies had higher hardness and 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. With the production of high-fiber and low-fat cookies by the usage of RSP and AKF and fruit powders especially in cereal products are offered.

Keywords: Resistant starch, Apricot kernel flour, Apple powder, Apricot powder, Cookie quality.

Introduction

Dietary fat, and nutrients associated with dietary fat play a critical role in the health and functioning of the human body. On the other hand, dietary fat intake has been implicated in the causation of major diseases including coronary heart disease and cancer. Hence, current recommendations to improve health emphasise the reduction of fat intake. Reducing the amount of fat in every-day's diet has become a public health issue and a concern for most consumers. However, fat is one of the principal ingredients that affect cookie texture, and contributes pleasing mouthfeel and positively impacts flavour intensity and perception. Thus, low-fat products normally contain fat replacers and are produced using formula or processing modifications in bakery products.

Resistant starch (RS) is a relatively new class of dietary carbohydrates, which is also considered as the carbohydrate-based fat replacers (Voragen, 1998). Apricot (*Prunus armeniaca* L.) is one of the most popular stone fruits grown in some regions of Turkey which is the biggest apricot producer (795.000 metric tons/yr) in the world (FAO, 2013). A high-fiber and low-fat food is an important objective in today's food product development. Functional foods have physiologically active components beside their standard nutrient components, that are suitable for the preservation of normal health state and for the prevention of illnesses. Apricots and apples are being considered as good examples of functional foods. Apricots among the most promising foods with the physiologically important functions for the most crucial constituents (dietary fiber, sorbitol, potassium, copper, and phenolic compouns), with each of them playing a role in many aspects of human health. The chemical and nutritional properties of apricot kernel were studied by various investigators (Gabrial *et al.,* 1981; Ozcan, 2000; Ozkal *et al.* 2005; Alpaslan & Hayta, 2006). Apricot kernels are rich in lipid and protein (Femenia *et al.,* 1995; Iordanidou *et al.*, 1999; Alpaslan & Hayta, 2006). Apple (*Malus domestica* var. Golden Delicious) is usually consumed in fresh form. Apple pomace, a solid material that remains after extraction of juice from apple, is not being utilized at present for human consumption (Grover *et al.,* 2003). It is also well known that apples are good sources of fiber (Gorinstein *et al.,* 2001). In adequate fiber intake has been found to be associated with diseases like diverticulosis, atherosclerosis, colonic cancer and appendicitis (Trowell, 1972; Painter & Burkitt, 1977, Walker *et al.,* 1973). An increase in level of dietary fiber in the daily diet has been recommended (25-30 g/day).

Thus, the objectives of this paper were to determine the effects of fiber-rich apricot and apple powders (APR-P and APL-P, respectively) on the quality and total dietary fiber contents of wire-cut cookies, fat content of which replaced with RSP and AKF.

Materials and Methods

Materials

The commercial soft wheat flour was supplied from Örnek Flour Inc., Nevşehir, Turkey. Corn starch was obtained from Cargill Inc., Istanbul,Turkey. Apricots and apricot kernels (variety: Hacıhaliloğlu) were obtained from Malatya province during the summer season of 2003. Golden delicious type apples were purchased from local market.

Preparation of Fiber-Rich Apple and Apricot Powders, Resistant Starch and Apricot Kernel Flour

Apples from the type of Golden Delicious and apricots from the variety of Hacıhaliloğlu were used in this study. Fiber-rich apple and apricot powders (APL-P and APR-P, respectively) were produced according to Seker *et al.* (2009). Acid modification and resistant starch preparation (RSP) formation procedure were achieved according to Köksel *et al.* (2008). AKF was produced from apricot *(Prunus armenica* L.) according to Seker *et al.* (2010).

Analytical Methods

RSP and soft wheat flour were analyzed for moisture content according to standard method (AACC, 2000). Protein, ash and wet gluten contents of the soft wheat flour were determined by using AACC (2000). RSP was analyzed for RS content by using the enzymatic-gravimetric procedure Method 991.43 (AOAC, 1998). The RSP sample was also analyzed for water binding capacity (WBC), solubility (Köksel *et al.,* 2008), and fat binding capacity (Lin *et al.,* 1974). Apricot kernel flour was analyzed for moisture, protein (Nx6.25), ash and lipid contents (AOAC, 1998). Total dietary fiber (TDF) contents of soft wheat flour, AKF and RSP and cookies were determined by using AACC Method (2000). APL-P and APR-P were analyzed for moisture, protein (Nx6.25, db) and ash (db) contents by using AOAC methods (1998), and for water-holding capacity (Mongeau & Brasard, 1982) and bulk density (Michel *et al.,* 1988). Antioxidant properties of APR-P and APL-P were evaluated by determining total phenolic content, assessed by Folin method (Durmaz & Alpaslan, 2007).

Cookie Formulation and Evaluation

The high-fiber and low-fat cookie qualities were determined by using AACC Method No: 10.54 (Baking Quality of Cookie Flour-Micro Wire-Cut Formulation) (AACC, 2000) (Table 1). The quality parameters of low-fat high-fiber cookies were evaluated in terms of width (W), thickness (T) and spread ratio (W/T) values. CIE color values (L*, a* and b*) were measured with a Minolta Spectrophotometer CM-3600d (Japan). A texture analyzer (TA Plus, Lloyd Instruments, UK) was used for texture. The sensory characteristics of cookies were screened by a six-member panel that was well aware of the purpose of the investigation. 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.

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

Results and Discussion

Properties of Resistant Starch, Apricot Kernel Flour and Fiber-Rich Apple and Apricot Powders

Properties [dietary fiber (15.3%), water binding capacity (1.87 g/g), solubility (2.4%), fat binding capacity (152%)] of RSP generally agreed with the previously published data (Eerlingen *et al.,* 1994; Yue & Waring, 1998). The data revealed that RSP is rich in terms of dietary fiber and can be used to supplement cereal based foods.

The moisture content of apricot kernel sample was 4.2% which is almost equal to the one reported by Aydemir *et al.* (1993) and slightly higher than the one reported by Özkal *et al.* (2005). The protein and lipid contents of the apricot kernel sample were found to be 21.8% and 40.2%, respectively. The ash content of the apricot kernel sample was found to be 2.71%. The TDF content of apricot kernel sample used in this study was found to be 35.8%.

The protein and ash contents of APL-P obtained in this study were found to be 3.44% and 3.08%. The WHC value of APL-P obtained in this study was found to be 6.57 g/g and bulk density of the APL-P was found to be 355 mg/cm^3. APR-P sample had a protein content of 2.82%, ash content of 3.23%, bulk density of 386 mg/cm^3 and water holding capacity of 6.66 g/g. In this study, APL-P sample had a total dietary fiber content of 22.8%, which is higher than the value reported by Li & Cardozo (1994). The TDF content of APR-P obtained in this study was found to be 21.1% which is lower than the value reported by Li & Cardozo (1994). Total phenolic contents of APL-P and APR-P samples 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 thus, they can be used to supplement cereal based foods such as cookies and cakes.

Effects of RSP and RSP/AKF Supplementation on the Quality of Cookies

Spread ratio, hardness and color values, overall sensory scores and TDF contents of RSP supplemented cookies are given in Table 2. Spread ratio values of the RSP supplemented cookies decreased significantly ($p<0.01$) above 10% supplementation level. RSP supplementation above 10% caused lower but satisfactory spread ratio values including the 30% supplementation level. The hardness value increased significantly ($p<0.01$) above 10% supplementation level. The hardness value of the 10% RSP supplemented cookie was not significanly different from that of control. These results were in aggrement with the previous ones (Zoulias *et al.* 2002a, b).

RSP addition increased the lightness (L*) of the cookies which is not disagreeable in cookie quality. As the RSP addition level increased, a* values of the cookies decreased above 30% addition level and b* values of the cookies decreased at all addition levels significantly ($p<0.01$). However the changes in a* and b* values were not substantial to make the cookies unacceptable by consumers. Overall sensory scores of the RSP supplemented cookies were not significanly different from the control and they were all acceptable. Although the texture analysis showed that an increase in the addition levels of RSP resulted in an increase in hardness, it did not affect the overall sensory scores of the cookies. Total dietary fiber (TDF) contents of the cookies supplemented with RSP increased significantly ($p<0.01$) as the addition level increased.

Table 2. Spread ratio, hardness, color and overall sensory score values and total dietary fiber contents of RSP supplemented cookies

RSP Level (%)	Spread Ratio	Hardness (N)	L*	a*	b*	Overall Sensory Score	TDF (%)
0	7.10 a	47.1 d	70.4 c	8.4 a	36.1 a	3.9 a	1.9 d
10	7.41 a	47.3 d	72.4 b	8.6 a	32.7 b	3.9 a	2.5 c
20	6.45 b	77.8 c	72.6 b	8.2 a	31.7 c	3.5 a	3.1 bc
30	6.25 b	88.3 b	74.0 b	7.6 ab	30.3 d	3.8 a	4.5 ab
40	5.71 c	103.8 a	76.3 a	6.7 b	28.0 e	3.6 a	6.7 a
LSD	0.36	5.42	1.85	1.50	0.81	ns	1.07

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

RSP: Resistant starch preparation; L*:Lightness; a*: Redness; b*:Yellowness; TDF: Total dietary fiber

Spread ratio, hardness and color values, overall sensory scores and total dietary fiber contents of RSP/AKF supplemented cookies are given in Table 3. RSP/AKF supplemented cookies were prepared by reducing the shortening content in the cookie formula by 10 (5% RSP-5% AKF), 20 (10% RSP-10% AKF), 30 (15% RSP-15% AKF), 40% (20% RSP-20% AKF) and 50% (25% RSP-25% AKF). RSP was added with dry ingredients and AKF was added with shortening. A slight insignificant increase in the spread ratio values of RSP/AKF supplemented cookies were observed up to the 20% replacement level, but significant ($p<0.01$) decreases were observed with greater than 30% replacement. RSP/AKF supplemented cookies generally resulted in better spread ratio values than the RSP supplemented cookies at all additon levels except 10% level.

Table 3. Spread ratio, hardness, color and overall sensory score values and total dietary fiber contents of RSP/AKF supplemented cookies

RSP/AKF level (%)	Spread Ratio	Hardness (N)	L*	a*	b*	Overall Sensory Score	TDF (%)
0	7.10 ab	47.1 d	70.4 c	8.4 ab	36.1 a	3.9 a	1.9 f
10	7.15 a	49.1 d	72.1 bc	8.9 a	33.0 b	3.8 a	2.7 e
20	7.17 a	54.0 c	71.3 bc	9.4 a	33.2 b	4.4 a	5.5 d
30	6.71 b	55.8 c	72.7 abc	8.8 a	32.0 bc	4.0 a	8.4 c
40	6.25 c	61.1 b	72.8 ab	8.7 a	31.6 bc	4.0 a	10.9 b
50	5.89 c	89.0 a	74.9 a	7.5 b	30.6 c	3.8 a	12.3 a
LSD	0.42	5.11	2.33	1.12	1.89	ns	0.09

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

RSP: Resistant starch preparation; AKF: Apricot kernel flour; L*:Lightness; a*: Redness; b*:Yellowness; TDF: Total dietary fiber

The hardness of cookies increased significantly ($p<0.01$) with increasing RSP/AKF replacement above 10% level. The CIE L* and b* color values of RSP/AKF supplemented cookies have shown a similar trend with the color values of RSP supplemented cookies. The b*values of the cookies decreased significantly as RSP/AKF addition level increased ($p<0.01$). RSP/AKF supplemented cookies gave lower L* values than the RSP supplemented cookies at all addition levels. Overall sensory scores of the cookies supplemented with RSP/AKF were not significantly different from that of the control and they were all acceptable. Total dietary fiber (TDF) contents of the cookies supplemented with RSP/AKF increased significantly ($p<0.01$) as the RSP/AKF level increased.

Effects of Apricot and Apple Powders on the Quality of Low-Fat Cookies

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 4. Fruit powders (APL-P and APR-P) were used to replace wheat flour in the formulation of cookies at the levels of 10, 20 and 30% (w/w) with 30% RSP/AKF to replace shortening.

Effects of fruit powders on spread ratio, hardness value, overall sensory score and total dietary fiber contents of the low-fat cookies supplemented with APL-P were not significanly different from those of the control and they were all acceptable. However, APR-P supplemented cookies had a continuous and much higher increase in spread ratio values compared to the APL-P supplemented cookies ($p<0.01$). Cookies supplemented with APR-P gave better spread ratio values up to 30% addition level.

Table 4. Effects of fruit powders 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	6.71 a	6.71 b	55.8 c	55.8 a	4.0 ab	4.0 a	8.4 d	8.4 d
10	6.78 a	6.98 b	73.3 b	54.2 a	3.9 b	3.1 c	11.9 c	10.8 c
20	6.51 a	8.52 a	95.5 a	52.7 a	4.0 ab	3.3 bc	14.7 b	13.2 b
30	7.07 a	9.20 a	91.4 a	54.4 a	4.3 a	3.8 ab	17.7 a	15.9 a
LSD	ns	0.697	7.28	ns	0.40	0.76	1.17	1.24

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

Textural properties of the APL-P and APR-P supplemented low-fat cookies are presented in Table 4. The hardness value, which is related to the force necessary to break the cookie, increased significantly with increasing APL-P levels ($p<0.01$). APL-P supplemented cookies had higher hardness values than APR-P supplemented ones at all addition levels. The hardness values of the cookies supplemented with APR-P were not significanly different from those of the control and they were all acceptable.

Table 4 shows the sensory evaluation of low-fat cookies prepared with varying levels of APL-P and APR-P. Results indicated that as the addition level increased, overall sensory scores of the cookies supplemented with APL-P and APR-P were not significanly different from those of the control and they were all acceptable. 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 (Table 4). The TDF contents of the APL-P supplemented cookies were higher than those supplemented with APR-P.

Table 5 presents the L*, a*, and b* values which indicate the Lightness, redness, and yellowness of the cookies, respectively. Although the Lightness (L*) of the cookies supplemented with high-fiber fruit powders decreased significantly ($p<0.01$), cookies with APR-P had the highest decrease in L* values (Table 5). Cookies supplemented with APR-P generally gave higher a* and b* values as compared to APL-P supplemented cookies at all levels. Results indicated that color values of the cookies supplemented with both APL-P and APR-P were all acceptable, as the addition level increased.

Table 5. Effects of fruit powders 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	72.7 a	72.7 a	8.8 c	8.8 c	32.0 c	32.0 b
10	67.5 b	69.7 a	10.1 bc	10.0 bc	33.8 b	33.5 b
20	66.8 b	65.8 b	10.9 ab	11.4 b	33.8 c	33.7 b
30	62.3 c	59.9 c	11.9 a	14.0 a	35.4 a	35.9 a
LSD	3.30	3.16	1.46	1.93	1.56	1.78

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

Conclusion

One of the purpose of this study was to determine some functional properties of resistant starch preparation (RSP) and apricot kernel flour (AKF) and to investigate their effects on the quality of low fat cookies. RSP is rich in terms of dietary fiber (15.3%) and AKF is an important source of protein as well as fat and fiber. Thus, they can be used to supplement cereal based foods such as cookies and cakes. Greater spread ratio in cookie is desirable and indicate a better quality. Spread ratio of the RSP and RSP/AKF supplemented cookies decreased above 30% suplementation level. The RSP/AKF supplemented cookies generally resulted in better spread ratios than the RSP supplemented ones. Texture is also an important factor in cookies for the consumer acceptance. The hardness of the RSP and RSP/AKF supplemented cookies increased above 10% supplementation level. Although the texture analysis showed that an increase in the addition levels of RSP and RSP/AKF resulted in an increase in hardness, it did not affect the overall sensory scores of the cookies. RSP addition increased the L* value and decreased the a* and b* values of the cookies. RSP/AKF supplemented cookies gave lower L* values than the RSP supplemented ones. However the changes in color values were not substantial to make the cookies unacceptable by consumers. Total dietary fiber (TDF) contents of the RSP and RSP/AKF supplemented cookies increased with increasing addition level.

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/AKF. 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 had higher spread ratio and lower hardness values than the APL-P supplemented ones at all addition levels. Overall sensory scores of the cookies supplemented with APL-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.

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