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# Effects of Fiber-rich Apple and Apricot Powders on Cookie Quality

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**Abstract** Apple and apricot powders (APL-P and APR-P) were produced from apple and apricot fruits and they were used in cookie formulation at the levels of 10-40% (in flour bases). The APL-P and APR-P were rich in terms of total dietary fiber (TDF) and antioxidant power. The APR-P supplemented cookies had higher spread ratio and lower hardness values than the APL-P supplemented ones at all addition levels. The color values of the APR-P supplemented cookies were all acceptable. Overall sensory scores of the cookies supplemented with APL-P and APR-P were not significantly different from the control up to 20% addition. TDF contents of the supplemented cookies increased significantly with increasing addition level ($p<0.01$). The replacement of flour by APL-P and APR-P in wire-cut cookies showed that the physical characteristics and textural properties of the cookies were significantly affected ($p<0.01$) and APR-P appeared to be a more suitable replacer of flour than APL-P. Addition of both fruit powders upto 20% into the cookie formulation were evaluated as acceptable in terms of the sensory properties.

**Keywords:** apple powder, apricot powder, cookie quality, total dietary fiber

## Introduction

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 compounds), with each of them playing a role in many aspects of human health. Despite the fact that, among fruits, apricot is one of the least studied (1,2). Apricot (*Prunus armeniaca* L.) is a popular stone fruit grown in Turkey, Iran, Spain, Pakistan, France, Italy, India, New Zealand, China, and South America. Despite wide cultivation in many parts of the world, the favorable climatic and geographical factors in the Malatya-Elazığ region, of eastern Turkey, is particularly important for apricot production and processing. According to recent statistics, more than half of the country's 500,000 ton of fresh fruit and almost all sulphur-dried apricot production originates from this region. This figure is about 10% of world fresh apricot production. More importantly, about 80% of world dried apricot exports comes from this region (1,3,4). According to the reports of Food and Agriculture Organization (FAO) (5), Turkey is the biggest apricot producer in the world. Since fresh fruits of apricot are not subject to long preserving and are not convenient for transportation, usually various dried forms of apricots are widely used. It is also well known that insuitable drying applications (mechanical, technological, etc) might cause oxidation of many valuable constituents of apricots with the development of undesirable color, flavor, and a loss of nutrients. Since apricot has an important place in human nutrition as a functional food, an alternative new form of apricot as freeze dried powder retaining all important nutrients and flavor of fresh apricot might have promising importance in apricot consumption. None of the published reports describe the production of fiber-rich apricot powder or its functional properties. The information on the utilization and the effects of fiber-rich apricot powder in bakery products is also missing in the related literature.

Apple (*Malus domestica*) is a temperate region fruit and usually consumed in fresh form. Commercially apple is used mostly for extracton of apple juice. Apple pomace, a solid material that remains after extraction of juice from apple, is not being utilized at present for human consumption (6). The chemical and nutritional properties of apple fiber and apple pomace were studied by many research groups (7-11). Some attempts have been made to incorporate apple pomace in some baked products (8,12,13). Similarly, use of apple pomace as a source of dietary fiber in wheat bread and cakes were also investigated by Masoodi and Chauhan (14) and Masoodi *et al*. (15). It is also well known that apples are good sources of fiber (16). Although fresh fruits of apple are very convenient for storage, transportation, and consumption, an increasing demand for new apple products particularly for a product which will retain all important nutrients (dietary fiber, antioxidants, etc) and flavor of fresh apple, freeze-dried fiber-rich apple powder might be produced from freshly collected apples.

Inadequate fiber intake has been found to be associated with diseases like diverticulosis, atherosclerosis, colonic cancer, and appendicitis (17-20). Cereal brans, hulls of legumes, sugar beet fiber, and brewer's spent grain are some of the common sources which are used for fiber

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supplementation of foods. Despite brans and hulls being very rich sources of total dietary fiber, technologists and nutritionists have restricted themselves in making use of such materials in food products because of their phytate content and lack of soluble dietary fiber. Apples are good sources of fiber with a well-balanced proportion between soluble and insoluble fraction (16). On the other hand, it is well known that fruits and vegetables are rich in phenolic compounds which have antioxidant potential and should be consumed in daily diet for health promotion. Apple and apricot reported to have certain types of phenolic antioxidants (21). Thus, the objectives of this paper were to study some chemical and functional properties of fiber-rich apple and apricot powders and their effects on the quality and total dietary fiber contents of wire-cut cookies.

## Materials and Methods

**Materials** Golden delicious type apples were purchased from local market. Apricots (cv. Hacıhaliloğlu) were obtained from Malatya province during the summer season of 2003 and they were non-sulphited. The commercial soft wheat flour (Ornek Milling Co., Nevşehir, Turkey) used in this study consisted of 9.8% protein, 0.65% ash, 28% wet gluten, and 1.6% total dietary fiber (d.b.). Only reagent-grade chemicals were used.

**Preparation of apple and apricot 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 1 hr to avoid enzymatic browning. Fruit samples were frozen at –30°C and freeze-dried (Model HA-3083/2; Armfield Inc., Ringwood, England) 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 (N×5.7, d.b.), ash (d.b.), and wet gluten contents of the soft wheat flour were determined by using AACCI Approved Methods (22). Apple and apricot powder samples (APL-P and APR-P, respectively) were analyzed for moisture, protein (N×6.25, d.b.) and ash (d.b.) contents by using AOAC Methods (23), and for water holding capacity (24) and bulk density (25). Total dietary fiber (TDF) contents of soft wheat flour, fruit powders, and the fruit powders supplemented cookies were determined by using AACCI Approved Methods (22). For TDF analysis, dried and milled cookie samples were defatted by using petroleum ether (boiling range of 40-60°C) and sequential enzymatic digestion was applied by using heat stable α-amylase, protease, and amyloglucosidase (Sigma-Aldrich, St. Louis, MO, USA), to remove starch and protein. Then, enzyme digestate is treated with alcohol to precipitate soluble dietary fiber before filtering, and TDF residue is washed with alcohol and acetone, dried and weighed. TDF residue values are corrected for protein, ash, and blank. The tests were performed at least in duplicate and mean values are reported.

Antioxidant properties of APL-P and APR-P were evaluated by determining radical scavenging power and total phenolic content, assessed by 1,1-diphenyl-2-picrylhydrazyl (DPPH) test and Folin method, respectively. For preparation of extract, 1.5 g of freeze-dried sample was weighed in Erlenmayer and 30 mL of ethanol was added. After 20 min of stirring, suspension was filtered through Whatman No. 1 filter paper. Filtrates were prepared daily and stored at +4ºC until analysis. Radical scavenging power (RSP) was determined by the method of Durmaz and Alpaslan (26). Two mL of 0.025 g/L DPPH (Fluka, Denmark) solution were well mixed with 0.5 mL of different concentrations of sample solutions (containing 50, 100, 200, 300, and 500 μL of stock solutions plus ethanol) in spectrophotometer cuvettes. In blank, ethanol was used in place of the sample. Remaining purple color of DPPH was measured by using a spectrophotometer (Pharmacia LKB Novaspec II, Uppsala, Sweden) at 517 nm after 30 min incubation in darkness. RSP was calculated by the following equation:

$$\text{Radical scavenging power (RSP) (\%)} = \left[1 - \left(\frac{A_{S30}}{A_{B30}}\right)\right] \times 100$$

where $A_{S30}$ is absorbance of sample and $A_{B30}$ is absorbance of blank at the 30th min.

The total phenolic contents (TPCs) of the samples were determined by the Folin Ciocalteu-method (26). Briefly, 500-1,000 μL of samples diluted to 1 mL with ethanol was pipetted into a flask. The volume was adjusted to 46 mL with distilled water and 1 mL of Folin-Ciocalteu reagent (Merck, Darmstadt, Germany) was added. The mixture was left to stand for 3 min and 3.0 mL of 2% sodium carbonate were added. After 120 min incubation at ambient temperature with shaking, the absorbance was measured at 760 nm. The calibration curve was prepared with gallic acid, and the results were expressed as μg of gallic acid equivalents (μGAE)/g d.w.

**Cookie preparation and evaluation** The cookie qualities of APL-P and APR-P supplemented flours were determined by AACCI Approved Method No. 10.54 (22). The formulation of the cookies is shown in Table 1. Four cookies were prepared/bake. APL-P and APR-P were used to partially replace wheat flour in the formulation of wire-cut cookies at the levels of 10, 20, 30, and 40% (w/w, flour bases). A control sample including no fruit powder was also prepared.

**Table 1. Formulation of cookies**

| Ingredients[1)] | 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 (HFCS) | 1.2 |
| Ammonium bicarbonate | 0.4 |
| Deionized water | variable |
| Flour[2)] | 80.0 |

[1)]Ingredients at 21±1°C.
[2)]13% moisture basis.

The quality parameters of the cookies were evaluated in terms of width (W), thickness (T), and spread ratio (W/T), color, and texture values. After cooling the cookies for 30 min, width and thickness measurements of the cookie samples were taken using a digital caliper. CIE color values (L*, a*, and b*) were measured with a Minolta spectrophotometer CM-3600d (Osaka, japan). The L* value indicates the lightness, 0-100 representing dark to light. The a* value gives the degree of the red-green color, with a higher positive a* value indicating more red. The b* value indicates the degree of the yellow-blue color, with a higher positive b* value indicating more yellow. A texture analyzer (TAPlus; Lloyd Instruments, SegensworthEast, UK) equipped with a 3-point bending jig was used for texture analysis and the maximum force required to break the cookie sample (hardness, N) was determined 24 hr after baking. The span between the supports was 40 mm. A load cell of 1,000 N was used. The instrument was standardized against a white tile before use. The sensory characteristics of the cookies were screened by a 6-member panel that was well aware of the purpose of the investigation. The panel members individually evaluated appearance and taste of the products by giving the scores ranging between 1 to 5, 5 being the most desirable. Then, the overall sensory scores were calculated as the average of the appearance and taste scores for each bake (27).

**Statistical analysis** Data were analyzed for variance using the MSTAT statistical package (28). When significant differences were found the least significant difference (LSD) test was used to determine the differences among means.

**Table 2. Properties of apple and apricot powders**

| | Apple powder | Apricot powder |
|---|---|---|
| Moisture (%) | 5.2 | 5.1 |
| Protein (%, N×6.25) | 3.4 | 2.8 |
| Ash (%, d.b.) | 3.08 | 3.23 |
| Total dietary fiber (%, d.b.) | 22.8 | 21.1 |
| Water holding capacity (g/g) | 6.6 | 6.7 |
| Bulk density (mg/cm$^3$) | 355 | 386 |
| Total phenolics (μg GAE/g, d.b.) | 1.327 | 0.763 |

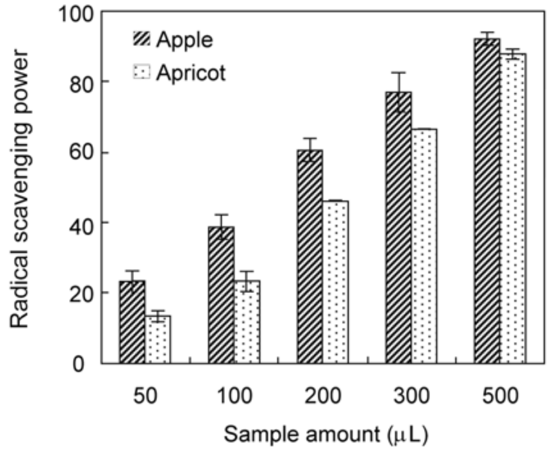


**Fig. 1. Comparison of the radical scavenging power of fiber-rich apple and apricot powder samples.**

## Results and Discussion

**Properties of apple and apricot powders** Moisture, protein, ash, and total dietary fiber (TDF) contents, water holding capacity, bulk density, and antioxidant properties (radical scavenging power and total phenolic contents) of apple and apricot powders (APL-P and APR-P) are presented in Table 2 and Fig. 1. To the best of our knowledge, none of the published reports describe the information on the chemical and functional properties of apple and apricot powders.

The protein and ash contents of APL-P were found to be 3.4 and 3.08%, respectively (Table 2). Due to its importance in foods, water holding capacity (WHC) 'the amount of water retained by a known weight of material under the conditions used' is measured by centrifugation and prefered to both water retention capacity (WRC) and water binding capacity (WBC). But WHC values are difficult to compare with the data in the literature because they are greatly affected by the measurement techniques and by the experimental conditions (29). The WHC and bulk density values of APL-P were found to be 6.6 g/g and 355 mg/cm$^3$, respectively.

The apricot is one of the most important fruits in terms of its nutritional properties. It is a good source of the vitamins i.e., riboflavin, niacin, and vitamin A as well as vitamin C and also rich in natural sugars and calcium. Since apricot is one of the least studied fruits, none of the published reports describe the production of fiber-rich apricot powder and its functional properties. In this study, 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 protein content of APR-P was found to be lower than the values reported by Haciseferoglu *et al*. (30) and Pala *et al.* (31). On the other hand, the ash contents of the apricots (cv. Hacıhaliloğlu) obtained by Haciseferoglu *et al*. (30) and Pala *et al*. (31) were slightly lower than the one reported in this study. Differences in results may be due to the variety of fruit used and the province that the fruits supplied. In the related literature, only the chemical composition (organic acids, sugars, minerals, etc.) of apricot puree (2) and the vitamin and selenium contents of apricot fruit of different varieties cultivated in different geographical regions (1) were investigated.

In this study, APL-P had a TDF content of 22.8%, which is higher than the value reported by Li and Cardozo (32), and within the range of the one reported by Leontowicz *et al*. (33). The TDF content of APR-P was found to be 21.1% which is lower than the value reported by Li and Cardozo (32). Results revealed that the APL-P had slightly higher dietary fiber content than the APR-P.

Radical scavenging power of APL-P was found to be within the range of the one reported by Leontowicz *et al*. (33). Antiradical activity increased almost linearly with increasing extract concentrations ($R^2$=0.99 and 0.98 for APL-P and APR-P, respectively). Total phenolic contents of APL-P and APR-P were found to be 1.327 and 0.763 μg GAE/g d.b., respectively. Total phenolic content of whole apple was reported to be 1.2 mg/100 g fresh fruit by Gorinstein *et al*. (16). Total phenolic content and antioxidant activity depend on the methods used. APL-P had higher radical scavenging power and total phenolic content than APR-P. The data revealed that APL-P and APR-P are both rich in terms of TDF content and antioxidant power thus, they can be used to supplement cereal based foods such as cookies and cakes.

**Effects of fiber-rich apple and apricot powders on the quality and dietary fiber contents of cookies** Spread ratio (W/T) value is one of the most important properties in evaluating the quality of cookies. It is also known that high spread ratios are desirable and indicate a good cookie quality. Spread ratio values of APL-P and APR-P supplemented cookies are presented in Table 3. Results of the study showed a significant increase in the spread ratio values of both APL-P and APR-P supplemented cookies ($p$<0.01) but APR-P supplemented cookies had a continuous and much higher increase in spread ratio values compared to the APL-P supplemented ones. Cookies supplemented with APR-P gave increased spread ratio values up to 40% addition level. There are several views on the mechanism by which the diameter of cookies (i.e., spread) is reduced when wheat flour is supplemented with non-wheat flours (34,35). It is known that during cookie baking, sugar increases the fluidity and allows the dough to spread as a function of gravity (36). Since there is not significant difference between the water holding properties of APL-P and APR-P, the increase in the spread ratio values of APR-P supplemented cookies might be related to the differences of composition in between APL-P and APR-P. It was also reported that increasing fiber addition reduced the spread ratio values of the high-fiber cookies (37) and similar results were also obtained in cookies supplemented with brewer's spent grain and sugar beet fiber (27,38). Chen *et al*. (7) investigated the 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 color of the cookies is one of the characteristics which are firstly perceived by the consumer and affect the acceptability of the product. CIE color values (L*, a*, and b*) of the APL-P and APR-P supplemented cookies are presented in Table 4. 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. Cookies supplemented with APR-P generally gave higher a* and b* values as compared to APL-P supplemented ones at all levels. Results indicated that color values of the cookies supplemented with both fruit powders were all acceptable, as the addition level increased.

**Table 3. Effects of apple and apricot powders on spread ratio values of the cookies**

| Addition[1)] (%) | APL-P | APR-P |
|---|---|---|
| 0 | 7.02[b2)] | 7.02[e] |
| 10 | 7.22[b] | 8.85[d] |
| 20 | 7.98[a] | 10.25[c] |
| 30 | 7.84[a] | 11.71[b] |
| 40 | 8.00[a] | 13.07[a] |
| LSD ($p$<0.01) | 0.29 | 0.62 |

[1)]APL-P, apple powder; APR-P, apricot powder.
[2)]Means followed by the different letter are significantly different using the LSD test.

Textural properties, overall sensory scores and TDF contents of the APL-P and APR-P supplemented cookies are presented in Table 5. The hardness values increased significantly with increasing APL-P and APR-P levels ($p$<0.01). APL-P supplemented cookies had higher hardness values than APR-P supplemented ones at all addition levels. As the APL-P and APR-P addition level increased, overall sensory scores of the cookies decreased significantly ($p$<0.01). Overall sensory scores of the APL-P and APR-P supplmented cookies were not significanly different from the control up to 20% addition level.

In the present work, the effect of incorporation of APL-P and APR-P supplementation on total dietary fiber content of 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 (Table 5). The TDF contents of the APL-P supplemented cookies were slightly higher than those supplemented with APR-P.

From the above studies, it could be concluded that the replacement of flour by APL-P and APR-P in wire-cut cookies showed that the physical characteristics and textural properties of the cookies were significantly affected ($p$<0.01) and that APR-P appeared to be more suitable replacer of flour than APL-P. Addition of both

**Table 4. Effects of apple and apricot powders on CIE color values of the cookies**

| Addition[1)] (%) | APL-P | | | APR-P | | |
|---|---|---|---|---|---|---|
| | L* | a* | b* | L* | a* | b* |
| 0 | 70.4[a,2)] | 8.4[d] | 36.1[d] | 70.4[a] | 8.4[c] | 36.1[e] |
| 10 | 61.6[b] | 12.9[c] | 41.7[c] | 59.1[b] | 14.8[b] | 43.8[d] |
| 20 | 51.7[c] | 14.5[b] | 44.6[b] | 54.8[c] | 17.7[a] | 49.8[c] |
| 30 | 56.0[cd] | 15.4[ab] | 46.6[ab] | 53.8[cd] | 18.2[a] | 52.8[b] |
| 40 | 54.1[d] | 16.3a | 48.0[a] | 51.7[d] | 19.1[a] | 55.6[a] |
| LSD ($p$<0.01) | 1.18 | 0.73 | 0.87 | 1.19 | 0.75 | 1.96 |

[1)]APL-P, apple powder; APR-P, apricot powder; L*, lightness; a*, redness; b*, yellowness.
[2)]Means followed by the different letter are significantly different using the LSD test.

**Table 5. Effects of apple and apricot powders on hardness values, overall sensory scores, and total dietary fiber (TDF) contents of the cookies**

| Addition[1)] (%) | APL-P | | | APR-P | | |
|---|---|---|---|---|---|---|
| | Hardness (N) | Overall sensory score | TDF (%) | Hardness (N) | Overall sensory score | TDF (%) |
| 0 | 49.6[e2)] | 3.8[a] | 1.9[d] | 49.6[d] | 3.8[a] | 1.9[e] |
| 10 | 54.2[d] | 3.9[ab] | 4.2[c] | 52.4[c] | 4.1[a] | 3.0[d] |
| 20 | 71.6[c] | 3.7[ab] | 7.3[b] | 60.8[b] | 3.7[ab] | 6.7[c] |
| 30 | 95.9[b] | 2.8[bc] | 10.2[a] | 60.6[b] | 2.8[bc] | 8.3[b] |
| 40 | 104.9[a] | 2.9[bc] | 11.3[a] | 63.3[a] | 2.3[c] | 10.6[a] |
| LSD ($p$<0.01) | 5.79 | 1.05 | 1.70 | 2.27 | 1.02 | 0.11 |

[1)]APL-P, apple powder; APR-P, apricot powder.
[2)]Means followed by the same letter are not significantly different using the LSD test.

APL-P and APR-P upto 20% into the cookie formulation were evaluated as acceptable in terms of the sensory properties.

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