jotaf
Journal of Tekirdag Agricultural Faculty
Tekirdağ Ziraat Fakültesi Dergisi

Mayıs/May 2026, 23(3)
Başvuru/Received: 05/12/24
Kabul/Accepted: 28/04/26
DOI: 10.33462/jotaf.1596164

http://dergipark.gov.tr/jotaf
http://jotaf.nku.edu.tr/

ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Study of the Fruit Bar Based on Apple Pomace

Elma Posasından Yapılan Meyve Barının Araştırılması

Aigul USUBALIEVA[1]*, Vildan EYIZ[2], Selman TURKER[3], Zhyldyzai OZBEKOVA[4], Aibek BODOSHOV[5], Anarseit DEIDIEV[6], Ismail TONTUL[7]

Abstract

This research aimed to incorporate apple pomace into fruit bar formulations and analyzed quality properties (chemical, physical, color and sensory parameters and biological active ingredients) of the obtained bars. For this purpose, most preferred formulation has been developed using apple pomace, raisins, peanuts, corn semolina, and honey. Then, the chemical composition, the total phenolic content, the total flavonoid content, the antioxidant activity, and the physical properties of the bar were analyzed. According to the results the optimized bar contained 18.7% moisture, 1.8% ash, 9.8% protein, 10.1% lipid, 8.7% dietary fibre, 58.5% total carbohydrate, 1.1% acidity, pH 4.4 and 364 kcal/100g energy. Furthermore, the bar contained 2.386 mg GAE (Gallic Acid Equivalent) kg^{-1} db (dry basis) of total phenolics and 850 mg CE (Catechin Equivalent) kg^{-1} db of total flavonoids. The antioxidant activity of fruit bar using by DPPH (2.2-diphenyl-1-picrylhydrazyl radical-scavenging activity), FRAP (Ferric Reducing Antioxidant Power) and CUPRAC (Cupric Reducing Antioxidant Capacity) assays were determined as 25.372 mg TEAA (Triethylammonium Acetate) kg^{-1} db, 8.701 mg TEAA kg^{-1} db, and 5.134 mg TEAA kg^{-1} db, respectively. Also, physical characteristics such as a hardness (94.2±19.1), cohesiveness (0.50±0.12), springiness (0.27±0.09), chewiness (28.2±5.20) and elasticity (0.62±0.06) were determined. Color parameters L, a* and b* were evaluated for the fruit bar. Moreover, sensory analysis revealed that the developed bar had a high level of general appreciation. Effect of storage period on moisture, pH and hardness of fruit bar was also analyzed. Therefore, incorporation of apple pomace in the bar formulation was a good way to evaluate the apple juice waste and can be used in the production of value-added product.

Keywords: Antioxidant activity, Apple pomace, Flavonoids, Phenolic content, Healthy snack

[1]***Sorumlu Yazar/Corresponding Author:** Aigul Usubalieva, Kyrgyz-Turkish Manas University, Faculty of Engineering, Department of Food Engineering, 720044, Mira av., 56, Bishkek, Kyrgyz Republic. E-mail: ausubalieva@manas.edu.kg OrcID: 0000-0001-6597-4234
[2]Vildan Eyiz, Necmettin Erbakan University, Faculty of Engineering and Architecture, Department of Food Engineering, 42090 Meram, Konya, Türkiye. E-mail: vildantop93@gmail.com OrcID: 0000-0003-1081-4166
[3]Selman Turker, Necmettin Erbakan University, Faculty of Engineering and Architecture, Department of Food Engineering, 42090 Meram, Konya, Turkey. E-mail: selmanturker@gmail.com OrcID: 0000-0003-1233-7906
[4]Zhyldyzai Ozbekova, Kyrgyz-Turkish Manas University, Faculty of Engineering, Department of Food Engineering, 720044, Mira av., 56, Bishkek, Kyrgyz Republic. E-mail: zhyldyzai.ozbekova@manas.edu.kg OrcID: 0000-0002-2471-5006
[5]Aibek Bodoshov, Kyrgyz-Turkish Manas University, Faculty of Engineering, Department of Food Engineering, 720044, Mira av., 56, Bishkek, Kyrgyz Republic. E-mail: aybek.bodoshev@manas.edu.kg OrcID: 0000-0002-7644-7074
[6]Anarseit Deidiev, Kyrgyz-Turkish Manas University, Faculty of Engineering, Department of Food Engineering, 720044, Mira av., 56, Bishkek, Kyrgyz Republic. E-mail: anarseit.deydiev@manas.edu.kg OrcID: 0000-0001-7738-8873
[7]Ismail Tontul, Necmettin Erbakan University, Faculty of Engineering and Architecture, Department of Food Engineering, 42090 Meram, Konya, Türkiye. E-mail: itontul@erbakan.edu.tr OrcID: 0000-0002-8995-1886
Atıf: Usubalieva, A., Eyiz, V., Turker, S., Ozbekova, Z., Bodoshov, A., Deidiev, A., Tontul I. (2026). Elma posasından yapılan meyve barının araştırılması. *Tekirdağ Ziraat Fakültesi Dergisi,* 23(3): 790-802.
Citation: Usubalieva, A., Eyiz, V., Turker, S., Ozbekova, Z., Bodoshov, A., Deidiev, A., Tontul I. (2026). Study of the fruit bar based on apple pomace. *Journal of Tekirdag Agricultural Faculty,* 23(3): 790-802.

Öz

Bu araştırmada elma posasının meyve barı formülasyon içeriğine dahil edilmesi ve elde edilen barın kalite özellikleri (kimyasal, fiziksel, renk ve duyusal parametreler ve biyolojik aktif bileşenler) analiz edilmesi amaçlanmıştır. Bu amaca kavuşmak için ilk önce elma posası, kuru üzüm, fıstık, mısır irmiği ve bal kullanılarak daha çok tercih edilen formülasyon geliştirilmiştir. Daha sonra optimize edilmiş olan barın kimyasal bileşimi, toplam fenolik içeriği, toplam flavonoid içeriği, antioksidan aktivitesi ve fiziksel özellikleri gibi parametreleri analiz edilmiştir. Kimyasal ve fiziksel analiz sonuçlara göre optimize edilmiş bar %18.7 nem, %1.8 kül, %9.8 protein, %10.1 lipit, %8.7 diyet lifi, %58.5 karbonhidrat, %1.1 asidite, pH 4.4 ve 364 kcal/100g enerji içermektedir. Ayrıca, barda 2.386 mg GAE (Galik Asit Eşdeğeri) kg^{-1} db (kuru bazda) toplam fenolik ve 850 mg CE (Kateşin Eşdeğeri) kg^{-1} db toplam flavonoid içerdiği belirlenmiştir. Meyveli barın DPPH (2.2-difenil-1-pikrilhidrazil radikal giderici aktivite), FRAP (Demir İndirgeyici Antioksidan Gücü) ve CUPRAC (Bakır İndirgeyici Antioksidan Kapasitesi) analizleri ile antioksidan aktivitesi sırasıyla 25.372 mg TEAA (Triethylammonium Acetate) kg^{-1} db, 8.701 mg TEAA kg^{-1} db ve 5.134 mg TEAA kg^{-1} db olarak belirlenmiştir. Ayrıca sertlik (94.2±19.1), kohezyonluk (0.50±0.12), esneklik (0.27±0.09), çiğnenebilirlik (28.2±5.20) ve elastikiyet (0.62±0.06) gibi fiziksel özellikleri de belirlenmiştir. Meyveli bar için renk parametreleri olan L, a* ve b* değerlendirilmeye alınmıştır. Ayrıca duyusal analiz sonucunda geliştirilen barın genel beğeni düzeyinin yüksek olduğu ortaya çıkmıştır. Depolama süresinin geliştirilmiş olan meyve barının nemi, pH'ı ve sertliği üzerindeki etkisi de analiz edilmiştir. Bu nedenle, bar formülasyonuna elma posasının dahil edilmesi elma suyu endüstrisi atığını değerlendirmek ve kullanmak için iyi bir yoldur. Ayrıca, elma posası katma değerli ürün üretiminde kullanılabilir.

Anahtar Kelimeler: Antioksidan aktivitesi, Elma posası, Flavonoidler, Fenolik içerik, Sağlıklı atıştırmalık

1. Introduction

Apple pomace is one of the most common forms of food waste, produced at a rate of about 4 million tons per year worldwide. Due to the possibility of microbial contamination, inappropriate handling of such biorganic waste poses significant risks to the environment and public health (Golebiewska et al., 2022). Now considerably increased, with production reportedly exceeding 96 million tons in 2022 (FAO, 2022). The percentage of apples consumed remains comparatively consistent, despite the fact that apple output is still increasing globally.

According to Shashi et al. (2008) and Shalini and Gupta (2010), 70% to 75% of apples produced worldwide are used for fresh consumption, with the remaining 25% to 30% being processed into various value-added products like juice, wine, jams, and dried goods. Apple juice, which makes about 65% of all processed apples, is still the most popular apple product (Kammerer et al., 2014). During the juice manufacturing process, approximately 75% of the fresh weight of apples extracted as a juice, the remaining material (apple pomace) collected as food waste (Vendruscolo et al., 2008). Furthermore, processing of the apple pomace reduces environmental pollution and fits into the concept of sustainable agriculture (Sobczak et al., 2022).

Skin/pulp tissue makes up much of the biomass generated. It contains bound phenolic compounds as well as cell wall polysaccharides that are dietary fiber (Bhushan et al., 2008). Because apple pomace contains phenolics, it has potent antioxidant properties (Lu and Foo, 2000). It has also been demonstrated that the phenol-rich marc extract has anticarcinogenic properties (McCann et al., 2007).

Apple pomace has the potential to be utilized as a food ingredient or functional food for human consumption, according to preclinical research that demonstrated positive effects on lipid metabolism, antioxidant capacity, and the digestive system (Skinner et al., 2018). In Kyrgyz Republic, apples are processed (approximately 7,760,000 tons) more than any other fruit and the apple pomace is thrown away as waste. Therefore, one of the main aims of this study is to evaluate this waste and use it in the production of new products (AgroWay LLC, 2023).

Therefore, this study was conducted to produce a functional fruit bar by incorporating apple pomace into the formulation. The chemical composition, total phenolic content, total flavonoids, antioxidant activity, textural properties, and sensorial properties of the developed bar were analysed. Moreover, the change in moisture content, pH, and hardness of the fruit bar during storage was observed.

Nowadays, changes in people's lifestyle and eating habits have led to an increase in fast food and snack consumption, which in turn has led to an increased demand for a variety of bars. Fruit bars are one of the most popular healthy snacks and are usually made with dried fruit, nuts, honey and other ingredients.

Since people are now consuming food not just to provide nutrition but also to avoid diet-related disorders and improve their well-being, the demand for functional foods has also grown in recent years (Brouns and Vermeer, 2000). Functional ingredients provide an excellent opportunity to develop novel products.

Since all of the ingredients in the bar are potential sources of bioactive compounds with health benefits, like phenolics and carotenoids, they all contribute to increased antioxidant activity. Numerous studies have shown that raisins have a high percentage of polyphenol chemicals (Grases et al., 2015). Peanut kernels are a healthy alternative to animal products and a great source of antioxidants and phytosterols. Total tocopherols (80–140 mg/kg) and several phenolics, such as hydroxybenzoic acid, ferulic acid, coumaric acid, resveratrol, flavonoids (catechin and procyanidins), and flavonols (quercetin and kaempferol), have been found to be present in peanut kernels (Griel et al., 2004; Isanga and Zhang, 2007). Tocopherol, phenolics, carotenoids, and sterols are among the bioactive substances found in pumpkin seeds that have been linked to health benefits (Jiao et al., 2014; Nakić et al., 2006; Rezig et al., 2012; Rezig et al., 2018; Stevenson et al., 2007; Bakır, 2024). The bar's ingredient was corn semolina, which has healthy nutrients. Corn kernels include carotenoids and polyphenols (Bae et al., 2021). Corn kernels get their yellow hue from carotenoids, another source of antioxidant activity (Venado et al., 2017; Muzhingi et al., 2017; Suwarno et al., 2015). Numerous research have demonstrated the antioxidant activity of honey (Becerril-Sánchez et al., 2021; Baek et al., 2015). As a result, the chosen ingredients have advantageous qualities and influence the created bars nutritional worth.

As their high content of phenolics, antioxidant compounds and dietary fibres, fruit by-products are good and economical products for production of functional foods (Elleuch et al., 2011). Therefore, this research intended to integrate apple pomace into the recipe for fruit bars and to evaluate the quality traits of the final product, covering its chemical, physical, color, sensory attributes, and bioactive compounds.

2. Materials and Methods

2.1. Materials

Raisins, honey, peanuts, pumpkin seeds and corn semolina were purchased from the local market (Bishkek, Kyrgyz Republic). Apple pomace (Reinette Simirenko varities) was freshly taken from the Ecoproduct Asia LLC processing line. It is one of the largest producers of natural juices, nectars, and juice drinks in the Kyrgyz Republic. Freshly taken apple pomace was brought into the lab and placed in the freezer. Then, it is dried in a Freeze Dryer (Kambic LİO-5P, Slovenia) at -50ºC at a pressure of 0.026-0.067 kPa. Finally, the dried apple pomace was crushed in a blender (Waring, Torrington, USA).

For the preparation of fruit bar following ingredients were used, dried apple pomace, raisins, peanuts, pumpkin seeds, corn semolina and honey. The bar was created in five different variations, each with different ingredient proportions. Bars were prepared with dried apple extract added in proportions of 15, 20, 25, 30 and 35%. As the proportion of dried apple extract changed, the proportion of all ingredients also changed. The main criteria were organoleptic properties and bar formation. These five variants were then submitted for organoleptic analysis. Ten trained panelists evaluated sensory properties. All panelists were trained under the "Sensory Analysis" study program. Based on the results of this analysis, the most preferred variant (with 25% dried apple extract) was identified. *Figure 1* shows the process flowchart of this bar. Raisins were cut into 0.3-0.5 cm pieces with a knife. Roasted peanuts and pumpkin seeds were crushed into small pieces with the laboratory blender (Waring, Torrington, USA). Then all the ingredients were mixed by adding corn semolina and mixed thoroughly. After mixing, the mixture was placed in special moulds (1 cm×5 cm). After holding the bars in a freezer for 1 h, the bars were removed from the mould.

2.2. Methods

2.2.1 Physico-chemical analysis

The physicochemical composition of the bar was determined by the AOAC methods for moisture and total solids (AOAC method 922.10, 17th ed., 2000, AOAC International), protein (AOAC method 920.152, 17th ed., 2000, AOAC International), lipids (AOAC method 945.44, 17th ed., 2000, AOAC International), total carbohydrate (AOAC method 925.36, 17th ed., 2000, AOAC International), water activity, total dietary fiber (AOAC Method 991.43, 17th ed., 2000, AOAC International), ash (AOAC Method 940.26, 17th ed., 2000, AOAC International), titratable acidity and pH (AOAC Method 942.15, 17th ed., 2000, AOAC International). A bench-top water activity meter, the HygroLab 3 (Rotronic Instrument Corp., Huntington, NY, USA), was used to measure the water activity (aw) of the samples at 23°C (±0.1°C). A pH meter (Model 220, Denver Instrument, USA) was used to measure the pH. Energy values were calculated according to Aigster et al. (2011).

2.2.2 Antioxidant activity, total phenolic and total flavonoid analysis

The extract utilized to measure the antioxidant activity (AA), total phenolic content (TPC), and total flavonoid content (TFC) was made according to Tontul and Topuz (2017). 20 mL of aqueous ethanol (80%) was added to 2 g of a homogenized fruit bar sample and homogenized (IKA T25, Germany) at 10000 rpm for 1 min. The mixture then incubated at 40ºC for 2 h under constant stirring at 200 rpm. After extraction, a clear extract was obtained by filtration.

For determination of TPC, 0.5 mL of extract (diluted when needed) was transferred into a test tube and 2 mL of 0.2 N Folin-Ciocâlteu solution and 2 mL of Na_2CO_3 solution (7.5%) was sequentially added. The mixture was incubated at 50ºC in a water bath for 5 minutes. The absorbance of the mixture was measured at 760 nm. The TPC was calculated as mg gallic acid equivalent (GAE) kg^{-1} dry basis (db) using the calibration curve obtained with gallic acid (Eyiz et al., 2020a; Aoudeh et al., 2024; Sahin et al., 2022).

TFC determination was carried out in 4 steps. The first step involved mixing 150 µL of 5% $NaNO_2$ solution, 2.5 mL of distilled water, and 0.5 mL of extract in a test tube. The mixture was mixed with 300 µL of a 10% $AlCl_3$ solution in the second step. In the third step, 1 mL of NaOH solution (1 M) was added. In the final step, the absorbance was measured at 510 nm. Between each step, the tube content was vigorously shaken. A calibration curve prepared with catechin was used to calculate TFC which were expressed as mg catechin equivalent (CE) kg^{-1} db (Eyiz et al., 2020a).

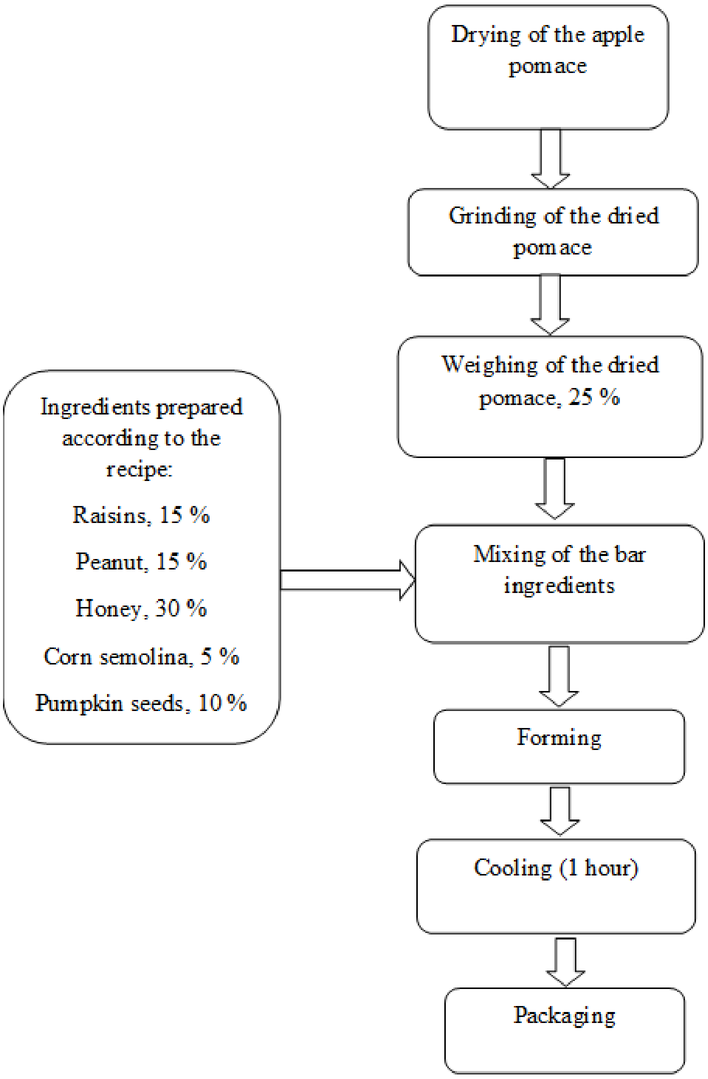

Figure 1. General flow chart of fruit bar with apple pomace

The antioxidant activity was determined using 3 different methods which were 2,2-diphenyl-1-picrylhydrazyl radical-scavenging activity (DPPH), Cupric Reducing Antioxidant Capacity (CUPRAC), and Ferric Reducing Antioxidant Power (FRAP). The details of antioxidant activity methods can be found elsewhere (Eyiz et al., 2020a). Texture analysis was done according to texture profile analysis using a TX-XT2 Plus texture analyser (Stable Microsystems, Surrey, UK). A cylindrical probe (36 mm) was used in the analysis to determine the resilience, cohesiveness, springiness, and chewiness of the samples. Analytical conditions were the same as Eyiz et al. (2020b). The color was measured using a Color Tec-PCM (HunterLab, USA), which is based on the CIELAB color system.

2.2.2 Hardness measurement

The hardness of the samples was measured with a penetrometer (Koehler K95500) (Hagenmuller and Pilloix, 2016), which is based on measuring the depth of penetration of standard needle or cone-shaped bodies into the test material. Its unit (1 penetration unit, p.u.) is equal to 0.1 mm.

2.2.2 Sensory analysis

The bars were subjected to sensory analysis on a 5-point hedonic scale. Sensory attributes (appearance, flavour, taste, chewiness, and overall acceptance) of the bars were evaluated by 10 trained panelists. The evaluation was performed in the Food Analysis laboratory (Kyrgyz-Turkish Manas University).

The mean ± standard deviations used to represent the data, and all experiment analyses performed three times.

3. Results and Discussion

3.1. Physico-chemical properties of the bar

Table 1 presents the proximate composition and energy value of the produced fruit bar. The moisture content was measured at 18.72%, while the lipid content was 10.11%. Total carbohydrate made up 58.52% of the fruit bar, with dietary fiber contributing 8.72% and ash content at 1.83%. The water activity was recorded at 0.31. The fruit bar's energy value was 364 kcal per 100g. Additionally, its acidity was determined to be 1.10%, with a pH of 4.42. A person of average weight (60 kg) will get 20% and 23% of their daily protein and lipid requirement by consuming 100 g of the produced bar, respectively. A person of average weight (60 kg) will get 20% of their daily protein requirement by consuming 100 g of the bar. It will also provide 15% of their daily energy intake.

The moisture content of the functional snack bars depends on the ingredients and processing conditions. For example, it was found that the moisture content of a bar made with the addition of apples and bananas ranged from 19.72% to 21.16% (Parimita et al., 2015). Another study found that fruit bars coated with various biopolymers had a moisture level between 13.2 and 17.14 g/100g (Eyiz et al., 2020a). In another study, the moisture content of date bars was ranged in 15.73 and 26.25% (Parn et al., 2015). The moisture content obtained in the present study (*Table 1*) showed higher than the result reported 11.24 to 13.12% in cereal bars (Marques et al., 2015). The high moisture content of the present samples (18.7%) was probably due to the presence of dried raisins which had a moisture content of 14-16% (Sharma et al., 2013). Consequently, it can be posited that the moisture level of fruit bars was barely impacted by the addition of apple pomace to their composition.

The protein content of fruit bars (which consisted of dried fruits, nuts, and honey) was 12.6 g/100 g according to Eyiz et al. (2020a). On the other hand, bars solely prepared with fruits had much less protein content (1.37-1.42%) (Parimita et al., 2015). Since nuts were also used in the formulation of the bars, the protein content of the fruit bar was determined as 9.8%. According to the literature, peanuts contain 20.7-34% of protein (Cobb and Johnson, 1973; Alhassan et al., 2017).

The lipid content of the fruit bar studied was 10.11%, which is very high compared to fruit-only bars in the literature. For example, the lipid content of the fruit bar was 0.59-0.65% (Parimita et al., 2015). However, there have also been reports in the literature of fruit bars produced with nuts and fruits having a comparable lipid content (Eyiz et al., 2020a). Therefore, the lipid content of the bars is explained by the fact that the raw materials contain lipid-containing products. Indeed, peanuts reported to contain 44-46% of lipid (Cobb and Johnson, 1973).

Table 1. Physico-chemical properties of fruit bar

Physico-chemical properties	Mean±SD*
Moisture content (%)	18.72±0.30
Total solid (%)	81.31±0.25
Protein (%)	9.82±0.40
Lipid (%)	10.11±0.30
Total carbohydrate (%)	58.52±1.20
Ash (%)	1.83±0.11
Dietary fiber (%)	8.72±0.30
Water activity	0.31±0.01
Acidity (%)	1.10±0.22
pH	4.42±0.61
Energy (kcal)	364

*SD – standard deviation

The content of dietary fibre in the fruit bar made in the research was 8.72%. Studies show that the addition of cereals to bars increases the amount of dietary fibre (Silva et al., 2013). Therefore, the addition of fibre-containing foods confirms the increase in fibre content in the bar. For bars enriched with apple by-products, the dietary fibre content was reported between 8.7 and 9.93 (Bchir et al., 2017). Consequently, the outcomes align with the findings documented in the literature.

In a previous study, the sugar content and inverted sugar content of fruit bars with papaya pulp were reported as 36.0-55.45 and 21.44-39.2, respectively (Megala and Hymavathi, 2011). The sugar content of cereal bars added with apple fibre was determined to be 74.06% (Bchir et al., 2017). As a result, the total carbohydrate content of the bars is highly dependent on the formulation.

In the present study, the ash content was 1.83%, while Marques et al. (Marques et al., 2015) reported the ash content of fruit bars as 1.33-1.45%. Depending on the composition of the bars, the ash content may vary, for example, the ash content of the bar made with grains and Amazon fruits was 1.48% (Faber and Yuyama, 2015) while it was 1.41% for apple bars (Bchir et al., 2017). The results are consistent with the literature.

The a_w of the fruit bar was 0.31, which is low enough to minimize microbial activity. In the literature, the a_w of the apple bar was 0.475 (Bchir et al., 2017), various ingredients were 0.62-0.73 (Ayad et al., 2020), and date bars was 0.5-0.6 (Munir et al., 2018). Therefore, it can be concluded that the low water activity of the bars is an indicator of creating a safe environment during their storage.

The total acidity of the fruit bar was determined as 1.10%. Similarly, the acidity of the apple bar was reported as 1.24-1.47% in the literature (Azmat et al., 2017).

The energy value fruit bar was 364 kcal/100g. The literature claims that different fruit bars have different energy values. For example, fruit bars with peanuts contain 386.96 kcal/100g (Shaheen et al., 2013), an average energy bar has a weight of 45–80 g and provides roughly 200–300 kcal. (Tiwari et al., 2017). Fruit bars coated with different biopolymers were reported between 387.3-396.6 kcal/100g (Eyiz et al., 2020a). Therefore, the results are in agreement the with literature.

3.2. Biological active ingredients of the bar

The results by content TPC, TFC, and AA of fruit bars are shown in *Table 2*. The TPC and TFC of the fruit bar containing apple pomace was 2,386 mg GAE kg^{-1} db and 850 mg CE kg^{-1} db, respectively. AA of the fruit bar was determined as 25,372 mg TEAA kg^{-1} db, 8,701 mg TEAA kg^{-1} db, and 5,134 mg TEAA kg^{-1} db according to DPPH, FRAP, and CUPRAC procedures, respectively.

The TPC of the fruit bar was 2,386 mg GAE kg^{-1} db (*Table 2*). In a previous study, the TPC of a similar fruit bar was determined to be 2,637.2 mg GAE kg^{-1} db (Eyiz et al., 2020a). Ingredients used in the production of fruit bars such as dried fruits, peanuts, and contribute to the TPC of the product.

Table 2. Total phenolic content, total flavonoids and antioxidant activity of fruit bar

Total phenolic content (mg GAE kg^{-1} db)	**Total flavonoid content (mg CE kg^{-1} db)**	**DPPH (mg TEAA kg^{-1} db)**	**FRAP (mg TEAA kg^{-1} db)**	**CUPRAC (mg TEAA kg^{-1} db)**
2,386±381*	850±12.8	25,372±2422	8,701±563	5,134±238

*SD – standard deviation

The total flavonoids of the bar were determined as 850 mg CE kg^{-1} db. The total flavonoids of sapodilla bar as 1,170.3-1,791.0 depending on the extraction solvent (Murnisyazwani and Rabeta, 2019). Given that the TFC of the fruits can fluctuate greatly, the reduced flavonoid content in this study may be due to the different raw materials (Murnisyazwani and Rabeta, 2019).

The AA of fruit bars determined by DPPH, FRAP and CUPRAC assays were determined as 25,372 mg TEAA kg^{-1} db, 8,701 mg TEAA kg^{-1} db, and 5,134 mg TEAA kg^{-1} db respectively. Eyiz et al. (2020a) reported the DPPH of fruit bars between 1,286.5-1,369.7 mg TEAA kg^{-1} db. Raisin, honey and apple pomace that include produced fruit bar influenced the increase AA content.

3.3. Physical, sensory and color parameters of the bar

The physical characteristic of the fruit bar is shown in *Table 3*. The color of the fruit bars was evaluated as L, a*, and b*.

TPA analysis showed (*Table 3*) that the hardness of fruit bars was 94.21 N, thereby it can be classified as medium hard food. The cohesiveness and springiness of the samples were determined as 0.50 and 0.27, respectively. The elasticity value of the samples was calculated as 0.62. The flexibility value of fruit bars was determined to be quite low. Its low elasticity value indicates that it is susceptible to brittleness. The chewiness value indicates the force required to reduce food to a swallowable size, and it is desirable neither too low nor too high. The chewiness value of fruit bars produced from apple pomace was determined as 28.23 N, which is in the ideal range. The current study's findings are in line with those of Eyiz et al. (2020a).

Table 3. Physical characteristic of fruit bar

Texture	Mean ± SD*
Hardness (N)	94.21±19.13
Cohesiveness	0.50±0.12
Springiness	0.27±0.09
Chewiness (N)	28.23±5.20
Elasticity	0.62±0.06
Color	
L	38.72±0.11
a*	7.01±0.52
b*	86.93±0.90

SD – standard deviation. L, a, and b* – Lightness, from green to red pigments, from blue to yellow pigments, respectively

The results of the sensory analysis are shown in *Figure 3*. The obtained data demonstrate the positive effect of adding apple pomace on the visual characteristics of fruit bars (*Figure 2*). The content of light pigments L* 38.72 is due to the presence of peanut, corn semolina and honey in the bar, indicating a clear pigment. The pigments a* from green to red were relatively low 7.01. The fact that the blue to yellow b* pigment content of the bar is 86.93 and contains raisins and dried apple pomace can be explained by the high performance of these pigments. A study by Bchir et al. (2017) found that the content of apples and apricots provided high b* values (16.7). These authors indicated than pigment indicators vary depending on the composition of the bar.

Figure 2. Fruit bar with apple pomace

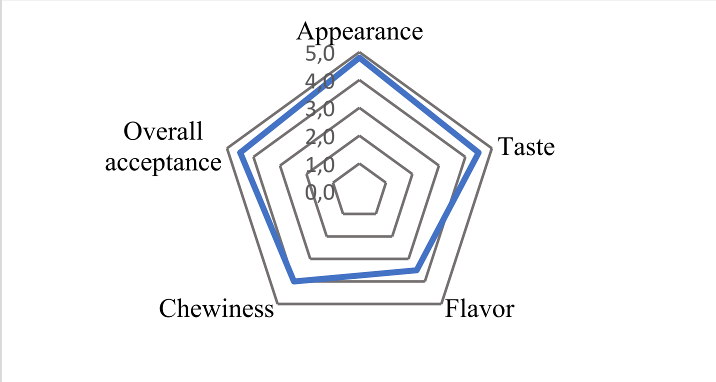

Figure 3. Sensory properties of the fruit bar

The fruit bar with 25% apple pomace addition was sensorially acceptable as the product scored above 4 for appearance, taste, chewiness and overall acceptability, with the exception of the flavour which was due to natural ingredients without the addition of odour enhancers. With the increasing of apple pomace to the bar recipe resulted in a deterioration in consistency. The panellists also noted a deterioration in chewiness. Blicharz-Kania et al. (2023) also indicated that the increase of apple residues worsened the bar's aroma.

The fruit bar was also analysed during a storage period of three months. The changes in moisture, acidity, and hardness of the fruit bar during storage are shown in Table 4.

Table 4. Effect of storage period on moisture, pH and hardness of fruit bar

Storage periods (months)	Moisture (%)	pH	Hardness (p.u.)
1	18.72±0.11	4.41±0.15	25.84±0.32
2	18.00±0.20	4.83±0.20	25.12±0.31
3	17.91±0.13	5.22±0.18	24.71±0.21

*SD – standard deviation

The storage environment is one of the most important indicators of the development of microorganisms. Previous studies showed that the acidity of the bars varies depending on the composition, but they form an acidic environment. For example, when examining the effect of adding an apple to a bar composition on shelf life, pH was determined by storage for a total of 90 days every 15 days from the date of manufacture of the bar (Akhtar et al., 2014). It was concluded that the pH range is maintained in a neutral environment with a change of 5.28-4.30. In this work it was found that the pH of the fruit bar was 4.41 and after three months of storage it changed to 5.22. The increase in pH of the bars is probably due to the addition of peanuts. Peanuts contain a significant amount of lipid and can change the acidic environment of the product during storage. During storage, the hardness of the bar changed from 25.84 to 24.71 p.u. (*Table 4*). Probably with the loss of moisture, the bar became slightly hard.

4. Conclusions

Apple pomace is the main waste of the apple juice industry. Its utilization is not only important for economic reasons but also for environmental aspects. Therefore, the present study investigated the use of apple pomace in fruit bar formulation. The study showed that apple pomace can be used in fruit bar formulation with good chemical, physical and sensory properties. A fruit bar prepared with apple pomace and other ingredients was shown to have a high TPC and AA. Raisin, honey and apple pomace that include produced fruit bar influenced the increase AA content. According to the results of the sensory study, the apple pomace-made fruit bar well received and has a lot of potential for usage in the food sector. Therefore, the use of apple pulp in fruit bar formulation is a good way to add value to this waste. Further studies will be needed to evaluate the product's quality during storage to determine its shelf life and appropriate storage temperature. Also studies on color change in fortified products stored for long periods recommended.

Acknowledgment

This work supported by the Kyrgyz-Turkish University Manas Research Project (Project No: KTMU-BAP-2019.FBE.04), Kyrgyz Republic, Necmettin Erbakan University (Turkey Republic) and Ecoproduct Asia LLC (Kyrgyz Republic).

Ethical Statement

There is no need to obtain permission from the ethics committee for this study.

Conflicts of Interest

We declare that there is no conflict of interest between us as the article authors.

Authorship Contribution Statement

Concept: Usubalieva, A., Turker, S., Tontul I.; Design: Turker, S., Bodoshov, A.; Data Collection or Processing: Eyiz, V., Ozbekova, Zh., Usubalieva, A., Bodoshov, A.; Statistical Analyses: Bodoshov, A. Deidiev, A.; Literature Search: Usubalieva, Eyiz, V., A., Deidiev, A., Ozbekova, Zh.; Writing, Review and Editing: Usubalieva, A., Tontul I., Ozbekova, Zh.

References

AgroWay LLC. (2023). Final report on the comprehensive assessment of the economic situation and competitiveness of agribusiness with the aim of building value chains and productive partnerships in Batken Region (Contract No. ARIS-IDA-RED2-CS-CQS-1), Kyrgyz Republic.

Aigster, A., Duncan, S. E., Conforti, F. D. and Barbeau, W. E. (2011). Physicochemical properties and sensory attributes of resistant starch-supplemented granola bars and cereals. *LWT-Food Science Technology*, 44(10): 2159–2165.

Akhtar, J., Bano, I., Pandey, R. K., Husain, A. and Malik, S. (2014). Effect of Different Level of Pectin and Starch on Quality and Storage Stability of Apple-Date Fruit Bar. *Journal of Food Products Development and Packaging*, 1: 31–36.

Alhassan, K., Agbenorhevi, K. J., Asibuo, J. Y. and Sampson, G. O. (2017). Proximate composition and functional properties of some new groundnut accessions. *Journal of Food Security*, 5(1): 9–12.

AOAC International (2000). Official Methods of Analysis of AOAC International. 17th ed. 481 North Frederick Avenue, Suite 500, Gaithersburg, MD 20877–2417, U. S. A.

Aoudeh, E., Şat, İ. G., Binici, H. İ. (2024). Chemical properties and antioxidant activity of different extracts from purslane (*Portulaca Oleracea L.*). *Journal of Tekirdag Agricultural Faculty*, 21(1): 81–93.

Ayad, A., Williams, L. L., Gad El-Rab, D. A., Ayivi, R., Colleran, H., Aljaloud, S. O. and Ibrahim, S. (2020). A review of the chemical composition, nutritional and health benefits of dates for their potential use in energy nutrition bars for athletes. *Cogent Food and Agriculture*, 6(1): 1–11.

Azmat, Z., Durrani, Y., Qazi, I. M., Ahmed, I. and Rasheed, S. (2017). Effect of Antioxidants on Storage Quality of Apple Sucrose Bars. *Proceedings of the Pakistan Academy of Sciences*, 54(3): 165–175.

Bae, H. H., Yi, G., Go, Y. S., Ha, J. Y., Choi, Y., Son, J. H., Shin, S., Jung, T. W. and Lee, S. (2021). Measuring antioxidant activity in yellow corn (*Zea mays* L.) inbreds from three different geographic regions. *Applied Biological Chemistry*, 64(1): 56.

Baek, Y., Kim, Y. J., Baik, M.-Y., Kim, D.-O and Lee, H. (2015). Total phenolic contents and antioxidant activities of Korean domestic honey from different floral sources. *Food Science and Biotechnology*, 24: 1453-1457.

Bakır, S. (2024). The phenolic content and antioxidant capacity of pumpkin, rosehip and pomegranate seeds. *Turkish Journal of Agriculture - Food Science and Technology*, 12(s2):2347–2354.

Bchir, B., Jean-François, T., Rabetafika, H. N. and Blecker, C. (2017). Effect of pear apple and date fibers incorporation on the physicochemical, sensory, nutritional characteristics and the acceptability of cereal bars. *Food Science and Technology International*, 24(3): 198–208.

Becerril-Sánchez, A. L., Quintero-Salazar, B., Dublán-García, O. and Escalona-Buendía, H. B. (2021). Phenolic compounds in honey and their relationship with antioxidant activity, botanical origin, and color. *Antioxidants*, 10(11): 1700.

Bhushan, S., Kalia, K., Sharma, M., Singh, B. and Ahuja, P S. (2008). Processing of apple pomace for bioactive molecules. *Critical Reviews in Biotechnology*, 28 (4): 285–296.

Blicharz-Kania, A., Vasiukov, K., Sagan, A., Andrejko, D., Fifowska, W. and Domin, M. (2023). Nutritional value, physical properties, and sensory quality of sugar-free cereal bars fortified with grape and apple pomace. *Applied Sciences*, 13(18): 10531.

Brouns, F. and Vermeer, C. (2000). Functional food ingredients for reducing the risks of osteoporosis. *Trends in Food Science and Technology*, 11(1): 22–33.

Cobb, W. Y. and Johnson B. R. (1973). Physiochemical Properties of Peanuts. In: Peanuts: Culture and Uses. Ed(s): Wilson, C.T., American Peanut Research and Education Society. Stillwater, OK, U. S. A.

Elleuch, M., Bedigian, D., Roiseux, O., Besbes, S., Blecker, C. and Attia, H. (2011). Dietary fiber and fiber-rich by-products of food processing: Characterisation, technological functionality, and commercial applications. *Food Chemistry*, 124(2): 411–421.

Eyiz, V., Tontul, İ. and Türker, S. (2020a). Effect of variety, drying methods and drying temperature on physical and chemical properties of hawthorn leather. *Journal of Food Measurement and Characterization*, 14(4): 3263–3269.

Eyiz, V., Tontul, İ. and Türker, S. (2020b). The effect of edible coatings on physical and chemical characteristics of fruit bars. *Journal of Food Measurement and Characterization*, 14 (1): 1775–1783.

Faber, M. A. and Yuyama, L. K. O. (2015). Functional Dietary Cereal Bar Based on Amazon Fruits. *Journal of Nutrition and Food Science*, 5(2): 2–6.

FAO. (2022). Food and Agriculture Organization of the United Nation. Agricultural production statistics, 2000–2022. FAOSTAT Analytical Brief 79. https://openknowledge.fao.org/

Golebiewska, E., Kalinowska, M. and Yildiz, G. (2022). Sustainable use of apple pomace (AP) in different industrial sectors. *Materials*, 15(5): 1788.

Grases, F., Prieto, R. M., Fernández-Cabot, R. A., Costa-Bauzá, A., Sánchez, A. M. and Prodanov, M. (2015). Effect of consuming a grape seed supplement with abundant phenolic compounds on the oxidative status of healthy human volunteers. *Nutrition Journal*, 14(1): 1-8.

Griel, A.E., Eissenstat, B., Juturu, V., Hsieh, G. and Kris-Etherton, P. M. (2004*). Journal of the American College of Nutrition*, 23: 660–6686.

Hagenmuller, P. and Pilloix, T. (2016). A New Method for Comparing and Matching Snow Profiles, Application for Profiles Measured by Penetrometers. *Frontiers in Earth Science*, 4:1–13.

Isanga, J. and Zhang G.N. (2007). Biologically active components and nutraceuticals in peanuts and related products. *Food Reviews International*, 23: 123–140.

Jiao, J., Li Z.G., Gai, Q.Y., Li, X.J., Wei, F.Y., Fu, Y.J. and Ma, W. (2014). Microwave assisted aqueous enzymatic extraction of oil from pumpkin seeds and evaluation of its physicochemical properties, fatty acid compositions and antioxidant activities. *Food Chemistry*, 147: 17–24.

Kammerer, D. R., Kammerer, J., Valet, R. and Carle, R. (2014). Recovery of polyphenols from the by-products of plant food processing and application as valuable food ingredients. *Food Research International*, 65: 2–12.

Lu, Y. and Foo, L. Yeap. (2000). Antioxidant and radical scavenging activities of polyphenols from apple pomace. *Food Chemistry*, 68(1): 81–85.

Marques, T. R., Corrêa, A. D., Alves, Ana Paula de C., Simão, A. A., Pinheiro, Ana Carla M. and Vinicius, de Oliveira Ramos. (2015). Cereal bars are enriched with antioxidant substances and rich in fiber, prepared with flours of acerola residues. *Journal of Food Science Technology*, 52(8): 5084–5092.

McCann, Mark J., Gill Chris, I. R., Brien, G. O′., Rao, J., McRoberts, W.C., Hughes, P., McEntee, R. and Rowland, I.R. (2007). Anti-cancer properties of phenolics from apple waste on colon carcinogenesis in vitro. *Food and Chemical Toxicology*, 45(7): 1224–1230.

Megala, P. and Hymavathi, Tv. (2011). Inulin and Fructooligosaccharides incorporated functional fruit bars. *World Academy of Science, Engineering and Technology,* 59: 393–398.

Munir, M., Nadeem, M., Qureshi, T. M., Qayyum, A., Suhaib, M., Zeb, F., Ijaz-Ul-Haq, Aneela, Q., Ashokkumar, M., Tahir, M., Qureshi, A. and Suhaib, F. (2018). Addition of oat enhanced the physico-chemical, nutritional and sensory qualities of date fruit-based snack bars. *Journal of Food and Nutrition Research*, 6(4): 271–276.

Murnisyazwani, J. and Rabeta, M. S. (2019). Antioxidant and antimicrobial activity of sapodilla (*Manilkara zapota L.*) fresh, juice and bar. *Food Research*, 3(5): 400–406.

Muzhingi, T., Palacios-Rojas, N., Miranda, A., Cabrera, M.L., Yeum, K.J. and Tang, G. (2017). Genetic variation of carotenoids, vitamin E and phenolic compounds in provitamin A biofortified maize. *Journal of the Science of Food and Agriculture*, 97: 793–801.

Nakić, S. N., Rade, D., Škevin, D., Štrucelj, D., Mokrovčak, Ž. and Bartolić, M. (2006). Chemical characteristics of oils from naked and husk seeds of Cucurbita pepo L. *European Journal of Lipid Science and Technology*, 108: 936–43.

Parimita, Er. and Puneet, Arora Er. (2015). Development of fruit bar by using apple and banana pulp supplemented with omega-3 fatty acid. *International Journal of Engineering Studies and Technical Approach*, 1:27–35.

Parn, O. J., Bhat, R., Yeoh, T. K. and Al-Hassan, A. (2015). Development of novel fruit bars by utilizing date paste. *Food Bioscience*, 9: 20–27.

Rezig, L., Chouaibi, M., Msaada, K. and Hamdi, S. (2012). Chemical composition and profile characterisation of pumpkin (*Cucurbita maxima*) seed oil. *Industrial Crops and Products*, 37: 82–87.

Rezig, L., Chouaibi, M., Ojeda-Amador, R. M., Gomez-Alonso, S., Salvador, M. D., Fregapane, G. and Hamdi, S. (2018). Cucurbita maxima pumpkin seed oil: from the chemical properties to the different extracting techniques. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 46: 663–9.

Sahin, S., Tonkaz, T. and Yarılgaç, T. (2022). Chemical composition, antioxidant capacity and total phenolic content of hazelnuts grown in different countries. *Journal of Tekirdag Agricultural Faculty*, 19(2): 262–270.

Shaheen, B., Nadeem, M., Kauser, T., Mueen-ud-Din, G. and Mahmood, S. (2013). Preparation and nutritional evaluation of date based fiber enriched fruit bars. *Pakistan Journal of Nutrition,* 12(12): 1061–1065.

Shalini, R. and Gupta, D.K. (2010). Utilization of pomace from apple processing industries: A review. *Journal of Food Science and Technology*, 47: 365–371.

Sharma, A. K., Satisha, J. and Somkuwar, G. R. (2013). Raisin Quality: The Deciding Factors. National Research Centre for Grapes. Pune, India.

Shashi, B., Kalpana, K., Madhu, S., Bikram, S. and Ahuja, P. S. (2008). Processing of Apple Pomace for Bioactive Molecules. *Critical Reviews in Biotechnology*, 28: 285–296.

Silva, de Paula N., Natal, D. I. G., Ferreira, H., Dantas, M. I. de S., Ribeiro, S. M. R. and Martino, H. (2013). Characterization of cereal bars enriched with dietary fiber and omega 3. *Revista Chilena de Nutrición*, 40(3): 269–273.

Skinner, C. R., Gigliotti, J. C., Kang-Mo, Ku.and Janet, C. Tou. (2018). A comprehensive analysis of the composition, health benefits, and safety of apple pomace. *Nutrition Reviews*, 76(12): 893–909.

Sobczak, P., Nadulski, R., Kobus, Z. and Zawiślak, K. (2022). Technology for Apple Pomace Utilization within a Sustainable Development Policy Framework. *Sustainability*, 14(9): 5470.

Stevenson, D. G., Eller, F. J., Wang, L., Jane, J. L., Wang, T. and Inglett, G. E. (2007). Oil and tocopherol content and composition of pumpkin seed oil in 12 cultivars. *Journal of Agricultural and Food Chemistry*, 55: 4005–13.

Suwarno, W. B., Pixley, K. V., Palacios-Rojas, N., Kaeppler, S. M. and Babu, R. (2015). Genome-wide association analysis reveals new targets for carotenoid biofortification in maize. *Theoretical and Applied Genetics*, 128: 851-864.

Tiwari, P., Agrahari, K., Jaiswal, M. and Singh, A. (2017). Standardization and development of different types of energy bars. *International Journal of Home Science*, 3(1): 370–372.

Tontul, I. and Topuz, A. (2017). Effects of different drying methods on the physicochemical properties of pomegranate leather (pistil). *LWT-Food Science Technology,* 80(6): 294–303.

Venado, R. E., Owens, B. F., Ortiz, D., Lawson, T., Mateos-Hernandez, M., Ferruzzi, M. G. and Rocheford, T. R. (2017). Genetic analysis of provitamin A carotenoid b-cryptoxanthin concentration and relationship with other carotenoids in maize grain (*Zea mays L.*). *Molecular Breeding*, 37: 127.

Vendruscolo, F., Albuquerque, P. M., Streit, F., Esposito, E. and Ninow, J. L. (2008). Apple pomace: A versatile substrate for biotechnological applications. *Critical Reviews in Biotechnology*, 28: 1–12.