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Comparative Analysis of Raw and Roasted Peanut Skins: General Composition, Fatty Acids, and Minerals

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Abstract

Peanut (*Arachis hypogaea* L.) is widely cultivated in Türkiye, particularly in the Osmaniye region, and its processing generates a substantial amount of peanut skin as a by-product. Although commonly discarded, peanut skins contain valuable nutritional components. This study aimed to determine the general composition, fatty acid profile, and mineral content of peanut skins as well as to evaluate the effect of roasting on these parameters. The moisture, ash, fat, and protein contents of raw peanut skins were determined as 11.42%, 3.62%, 19.64%, and 16.89%, respectively. For roasted peanut skins, these values were 9.86% (moisture), 3.79% (ash), 15.91% (fat), and 14.94% (protein). The results showed that raw peanut skin had higher moisture, fat, and protein levels compared to the roasted samples, while the ash content was slightly higher in the roasted sample. Oleic and linoleic acids were identified as the predominant fatty acids in peanut skins, accounting for over 70% of the total fatty acid composition, with slightly lower levels in the roasted samples. Mineral analysis revealed that potassium, calcium, magnesium, and phosphorus were the major elements in peanut skins. While the levels of potassium and magnesium increased after roasting, other minerals such as calcium, phosphorus, iron, manganese, copper, and zinc showed a decreasing trend. These findings highlight the underutilized nutritional potential of peanut skins and offer valuable insights into the compositional differences between raw and roasted forms.

Keywords: Agro-industrial by-product, Fatty acid composition, Mineral content, Valorisation, Peanut skin

1..INTRODUCTION

Peanut (*Arachis hypogaea* L.) is a globally favored and significant industrial crop, highly valued for its rich nutritional content, diverse health benefits, and distinctive aroma. Globally, approximately 70% of peanut production originates from China, India, Nigeria, Sudan, and the United States. Türkiye contributes a 0.4% share of the world's peanut production, ranking 25th globally (FAO, 2021). Domestically, 83% of Türkiye's total in-shell peanut production is concentrated in the provinces of Adana and Osmaniye (TUİK, 2021). While Adana traditionally holds a leading position in peanut cultivation, Osmaniye province is the center for roasted peanut production, supported by a geographical indication certificate for its qualified peanuts. A substantial portion of the cultivated peanuts in Türkiye is consumed as snacks, with smaller quantities utilized in the production of peanut butter, confectionery, pastries, and oil extraction.

Peanut pods typically consist of an outer shell enclosing kernels. Each kernel is enveloped by a thin, paper-like, pinkish-red layer known as

"peanut skin." Peanut skin constitutes approximately 3% of the total kernel weight. In the production of most peanut-based products, such as snacks, butter, and confectionery, peanut skin is removed. This process, commercially termed "blanching" or "skinning," is performed using specially designed machinery. Typically, after a brief, moderate heat treatment, kernels enter a blanching machine where peanut skin is separated with mechanical friction or pressurized air. Despite its high volume as a byproduct in the peanut industry, peanut skin holds very low commercial value. Although a portion is used in animal feed, its utilization remains limited to 5–8% due to its high phenolic content. These compounds may inhibit protein digestion and absorption, reducing animal performance. Its low caloric value also contributes to this limited use (Christman et al., 2018; Constanza et al., 2012; Lorenzo, 2018). Undervalued peanut skins are often treated as waste, either by incineration or removal from processing facilities (Sorita et al., 2020).

In recent years, peanut skin has gained significant attention due to its rich phenolic composition. While variations in peanut varieties and extraction methods have led to diverse phenolic compositions across studies, previous research consistently indicates that proanthocyanidins are the dominant phenolic compounds present in peanut skin. (Bodoira et al., 2022; Larrauri et al., 2016; Ma et al., 2014; Sarnoski et al., 2012). Numerous beneficial effects of procyanidins on human health have been reported, including antioxidant (Saito et al., 2009), anticancer (Rossi et al., 2013), antiatherosclerotic (Zhang et al., 2013) and hypoglycemic properties (Kim et al., 2020). However, despite the extensive focus on the antioxidant properties of peanut skins, comprehensive studies detailing their other nutritional characteristics, such as proximate composition, fatty acid and mineral content, are relatively limited in the existing literature. Only, Muñoz-Arrieta et al. (2021) have investigated the general chemical composition of peanut skins. This study has mainly focused on the peanut skin from the varieties of Spanish, Valencia and Virginia market types. However, the impact of roasting on the specific chemical composition of peanut skins is not yet fully understood or adequately documented in the literature. To our knowledge, no studies have investigated the chemical composition of peanut skins derived from peanuts cultivated in Osmaniye province, Türkiye, which holds the largest share of peanut production in the country.

This study primarily aimed to characterize the proximate composition, mineral profiles, and fatty acid content of peanut skins obtained from Virginia market-type peanuts cultivated in Osmaniye, Türkiye, and subsequently to investigate how roasting affects these specific parameters. The findings of the study may contribute to optimizing the utilization of raw and roasted peanut skin as a functional food component.

2. MATERIAL AND METHOD

2.1 Peanut Skin

Peanut skins (PSs) were obtained in May 2023 from the Yılmazer Peanut Factory located in Osmaniye, Türkiye. These skins were sourced from Virginia market-type peanuts harvested during the 2022 crop year. Roasted peanut skins were obtained from peanuts roasted at 110°C for 17 minutes. Upon receipt, the peanut skins were immediately vacuum-sealed into 500-gram nylon bags and stored at -20°C to preserve their quality until they were ready for analysis.

2.2 General Composition

Proximate composition, including moisture, oil, and ash content, were determined according to the methodologies described by Eker et al. (2022). Moisture content (%) was quantified by drying samples in a drying oven (Jeio Tech, ON-O2G, Korea) at 105±1 °C until a constant mass was achieved. Oil content (%) was determined using a Soxhlet apparatus (Behr, E4, Germany)

with *n*-hexane as the extraction solvent. For ash content, approximately 1 g of the homogenized sample was combusted in a high-temperature oven (SNOL, 8,2/1100, Lithuania) at 550–600 °C for 5–6 hours until gray ash remained.

2.3 Fatty Acid Analysis

The fatty acid composition of the oils was determined by preparing fatty acid methyl esters (FAMEs) as described previously (Bozdogan et al., 2019). The oil was obtained through Soxhlet extraction using *n*-hexane as solvent. In brief, 100 mg of oil was combined with 2 mL of *n*-hexane and 0.2 mL of 0.2 N KOH in methanol. The mixture was then centrifuged at 500 rpm for 10 minutes. The resulting supernatant was injected into a gas chromatograph (YL6500 GC, YL Instruments, South Korea). The gas chromatograph was equipped with a flame ionization detector (FID) and a split/splitless injector. Separations were achieved using a fused-silica capillary column (30 m, 0.32 mm i.d., 0.25 µm BP20 film thickness, SGE Analytical Sciences, USA). The injector and detector temperatures were maintained at 220 °C and 280 °C, respectively. The oven temperature program commenced at 140 °C for 5 minutes, then increased to 200 °C at a rate of 4 °C/min, and finally reached 220 °C at a rate of 1 °C/min. An injection volume of 1 µL was used, with a split ratio of 100. Individual peaks were identified by comparing their retention times with those of a FAME mix solution (Restek, ABD). Results are presented as percentages.

2.4 Mineral Analysis

To determine the mineral content of the peanut skin samples (200 mg), they were first diluted with 2N HCl to facilitate the release of bound minerals. Subsequently, the concentrations of minerals were quantitatively determined using an Atomic Absorption Spectrophotometer (Agilent, 240FS AA, Australia). All mineral analysis results for the peanut skins are reported on a dry-weight basis (Kacar & İnal, 2008).

2.5 Statistical Analysis

All quantitative data exception of fatty acid profiles were expressed as means ± standard deviation. To determine statistically significant differences between the mean values of the raw and roasted samples, an independent samples T-test was performed. Statistical significance was evaluated at probability levels of $p<0.05$, $p<0.01$, and $p<0.001$. All statistical analyses were carried out using SPSS Statistics software.

3. RESULTS AND DISCUSSION

3.1 General composition

The proximate composition of raw and roasted peanut skins is summarized in Table 1. As expected, the moisture content significantly decreased from 11.42% to 9.86% by roasting. This reduction is typical of thermal processing due to the evaporation of water. This factor can contribute to enhanced shelf-life stability of peanut skins. Ash content showed a slight statistically insignificant increase from 3.62 g/100 g dry matter (DM) in raw skins to 3.79 g/100 g DM in roasted skins.

Table 1. Proximate composition of raw and roasted peanut skins

Properties	Raw	Roasted	Significance
Moisture (%)	11.42 ± 0.36	9.86 ± 0.10	**
Ash (g/100 g DW)	3.62 ± 0.17	3.79 ± 0.07	ns
Fat (g/100 g DW)	19.64 ± 1.92	15.91 ± 2.65	ns
Protein (g/100 g DW)	16.89 ± 0.50	14.94 ± 0.05	**

DW: Dry weight; Statistical significance is indicated as follows: *p<0.05; **p<0.01; ***p<0.00; ns: Not statistically significant (p≥0.05).

When considering the characteristics of other commonly consumed nut skins, such as those of almonds, hazelnuts, and pistachios, it becomes evident that these agricultural by-products consistently emerge as a source of nutritional compounds (Alalwan et al., 2022). Our analysis of peanut skin's proximate composition reveals several interesting

comparisons with existing literature. Specifically, the moisture content of both raw and roasted peanut skin falls within the range reported by Muñoz-Arrieta et al. (2021). Furthermore, the ash content in both our raw and roasted peanut skin samples consistently exceeded the values reported for hazelnut skin (1.7%) (Özdemir et al., 2014), cashew nut skin powder (2.2%) (Nguyen et al., 2024), and the peanut skin varieties studied by Muñoz-Arrieta et al. (2021) (2.07-2.13%). Regarding fat content, our raw peanut skin (19.64 g/100g DM) showed higher levels compared to the ranges reported by Muñoz-Arrieta et al. (2021) (9.59-10.2%) and hazelnut skin (14.5%) (Özdemir et al., 2014), while our roasted peanut skin fat content (15.91 g/100g DM) aligns closely with that of cashew nut skin powder (16.8%). Finally, the protein content in both our raw and roasted peanut skin samples was consistently higher than all cited literature values, including hazelnut skin (8.2%), cashew nut skin powder (10.3%), and the peanut skin varieties (8.88-12.7%) (Muñoz-Arrieta et al., 2021).

Roasting is the most usual method of peanut processing in Türkiye. Our findings revealed a reduction in total lipid content in peanut skin following roasting, which aligns with some previous studies on other oilseeds. For instance, Rodrigues et al. (2011) observed that the total lipid content in peanuts showed either a ignificant decrease or no change following roasting at 200 °C for 50 minutes. This contrasts with studies on sesame seeds (Yoshida & Takagi, 1997) and Turkish hazelnut varieties (Alasalvar et al., 2010), where increased oil yields were observed with roasting. Another work on almond kernels also showed an increase in oil yields when roasted at 150 or 180 °C for various durations, although at 200 °C, yields were lower but still increased with duration (Lin et al., 2016). These discrepancies highlight that the impact of roasting on lipid content is highly dependent on the specific matrix, the initial composition of the material, and the precise roasting conditions (temperature and duration).

3.2 Fatty Acid Analysis

The fatty acid composition of raw and roasted peanut skins is detailed in Table 2. The fatty acid profiles of both raw and roasted peanut skins were dominated by three major fatty acids: palmitic acid (C16:0), oleic acid (C18:1Δ^{9}), and linoleic acid (C18:2$\Delta^{9,12}$). These findings are consistent with typical peanut kernel lipid profiles (Eker et al., 2022). The major saturated fatty acid was palmitic acid (C16:0), the major monounsaturated fatty acid (MUFA) was oleic acid (C18:1Δ^{9}), and the major polyunsaturated fatty acid (PUFA) was linoleic acid (C18:2$\Delta^{9,12}$) for the peanut skins. These results indicate that the fatty acid composition of Virginia market-type peanut skins was similar to other market types such as Spanish and Valencia as reported by Muñoz-Arrieta et al. (2021). An examination of the fatty acid composition of hazelnut skin indicated a remarkable richness in monounsaturated fatty acids, comprising 73.1% of its total fatty acids (Caimari et al., 2015). The monounsaturated fatty acid percentage of the current study is lower than the hazelnut skin.

Table 2. Fatty acid composition (%) of raw and roasted peanut skins

Fatty Acids	Raw	Roasted
Myristic Acid (C14:0)	0.10	0.05
Palmitic Acid (C16:0)	11.71	10.35
Palmitoleic Acid (C16:1Δ^{9})	0.79	0.25
Margaric Acid (C17:0)	0.31	0.13
Stearic Acid (C18:0)	3.11	3.15
Oleic Acid (C18:1Δ^{9})	57.97	54.37
Linoleic Acid (C18:2 $\Delta^{9,12}$)	19.50	18.23
Arachidic Acid (C20:0)	1.17	1.50
Eicosenoic acid; (C20:1 Δ^{11})	1.21	1.31

Behenic Acid (C22:0)	2.13	2.54

The oleic/linoleic acid (O/L) ratio was determined to be 2.97 and 2.98 for raw and roasted peanut skins, respectively. These calculated values exceeded the O/L ratios of 1.5–2 previously reported for traditional peanut varieties by Davis and Dean (2016). The O/L ratio serves as a crucial quality indicator for peanuts, particularly regarding their storability. A higher O/L ratio positively influences the shelf life of peanut seeds, as documented by Guo et al. (2010), due to oleic acid's greater oxidative stability compared to linoleic acid. For instance, high oleic peanuts (with an average oleic/linoleic (O/L) ratio of 27.3) stored at 25°C and 40% relative humidity were projected to reach a peroxide value (PV) of 10 meq/kg in roughly 360 days, whereas normal oleic peanuts (average O/L ratio = 2.2) reached this threshold in only 32 days (Braddock et al., 1995).

Roasting generally led to a decrease in the percentages of most individual fatty acids, particularly myristic acid, palmitic acid, palmitoleic acid, margaric acid, oleic acid, and linoleic acid. Conversely, arachidic acid, eicosenoic acid, and behenic acid showed a slight increase after roasting. Variations in fatty acid profiles, including the observed decrease in oleic and linoleic acids, are consistent with previous reports attributing such changes to thermal degradation or structural transformation during heat processing (Aljuhaimi & Özcan, 2018). This is further supported by a study indicating that microwave heating can affect specific fatty acids like palmitic acid by increasing its content (Megahed, 2001).

3.3 Mineral Analysis

The mineral composition of raw and roasted peanut skins is presented in Table 3. The findings reveal that potassium, calcium, magnesium, and phosphorus were the most abundant minerals detected in both raw and roasted samples. Following these major elements, iron, copper, zinc, and manganese were present as trace minerals. Roasting had an impact on the concentrations of these elements, exhibiting both increases and decreases depending on the specific mineral.

Table 3. Mineral composition of raw and roasted peanut skins (mg/kg DW)

Minerals	**Raw**	**Roasted**	**Significance**
K	4640.1 ± 34.6	5965.1 ± 34.1	***
Ca	2870.6 ± 176.6	2242.2 ± 70.4	***
Mg	2041.4 ± 13.0	2253.8 ± 13.1	ns
P	2222.2 ± 65.5	1905.2 ± 71.9	***
Cu	98.0 ± 2.9	90.2 ± 2.9	***
Mn	26.2 ± 1.1	17.0 ± 1.3	***
Fe	1205.1 ± 123.2	428.6 ± 25.7	***
Zn	91.6 ± 2.0	55.6 ± 1.4	***

DW: Dry weight; K: Potassium; Ca: Calcium; Mg: Magnesium; P: Phosphorus; Cu: Copper; Mn: Manganese; Fe: Iron; Zn: Zinc. Statistical significance is indicated as follows: *p<0.05; **p<0.01; ***p<0.00; ns: Not statistically significant (p≥0.05).

Potassium showed a significant increase from 4640.1 mg/kg DW in raw skins to 5965.1 mg/kg DW in roasted skins. Similarly, magnesium, another important major mineral, increased slightly from 2041.4 mg/kg DW to 2253.8 mg/kg DW after roasting. But this increase is found statistically insignificant. Magnesium concentrations in our samples were comparable to those reported for the Valencia and Virginia types (2220–2440 mg/kg), indicating consistency across different peanut varieties and processing methods (Muñoz-Arrieta et al., 2021). Conversely, calcium exhibited a statistically significant decrease from 2870.6 mg/kg DW in raw samples to 2242.2 mg/kg DW in roasted samples. Phosphorus levels in the current study (2222.2 mg/kg for raw and 1905.2 mg/kg for roasted) were considerably higher than those found in Spanish- and Virginia-type skins (1120–1710 mg/kg), potentially due to differences in agricultural practices or variations in analytical methodologies (Muñoz-Arrieta et al., 2021). Among the trace minerals, iron exhibited the most substantial reduction, decreasing from 1205.1 mg/kg DW to 428.6 mg/kg DW. Similarly, Al Juhami et al. (2025) had shown that roasting significantly influences the mineral content of purslane seeds, with variations observed in macronutrients like nitrogen, calcium, phosphorus, and potassium, as well as micronutrients such as iron and zinc, depending on roasting conditions.

When compared with mineral levels of peanut kernel reported by Abdelrahim et al. (2012) and Arya et al. (2015), peanut skins reveal a generally similar distribution of essential elements, including potassium, calcium, magnesium, phosphorus, copper, manganese, zinc, and iron. However, while the presence of these elements is common, their quantitative concentrations demonstrate notable variation across studies and between the kernel and skin components. For instance, raw peanut skins in the current study consistently exhibited significantly higher levels of iron when compared to reported whole kernel values, which ranged from 45.8 mg/kg (Arya et al., 2015) to 262 mg/kg (Abdelrahim et al., 2012). Similarly, calcium and magnesium are generally enriched in the skins compared to the mineral values of the kernel (Abdelrahim et al., 2012; Arya et al., 2015). This suggests that while the overall spectrum of minerals is common, the proportional contribution of certain minerals is distinctly higher in the peanut skin, making it a particularly concentrated source of these specific micronutrients. These findings provide valuable insights into the nutritional implications of utilizing roasted peanut skins in various food applications.

4. CONCLUSION

This study provided an evaluation of the proximate composition, fatty acid profiles, and mineral content of raw and roasted peanut skins from Virginia market-type peanuts cultivated in Osmaniye, Türkiye. Roasting influenced the chemical composition of peanut skins, notably reducing moisture, lipid, and protein contents while slightly increasing ash levels. Oleic and linoleic acids were the dominant fatty acids, and the favorable oleic/linoleic ratio indicated good oxidative stability and potential for longer shelf life. Roasting resulted in a decrease in several fatty acids, consistent with thermal degradation patterns observed in similar studies. Mineral analysis revealed peanut skins as rich sources of essential nutrients such as potassium, magnesium, calcium, and iron, although roasting led to changes in mineral concentrations, with significant reductions in calcium and iron.

In industrial processes, roasted peanut skin tends to generate more waste compared to raw peanut skin, due to its easy detachment after thermal treatment and its complete removal from the final product. Overall, study provide valuable insights into the nutritional implications of utilizing roasted peanut skins in various food applications.

DECLARATION OF CONFLICTING INTERESTS

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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