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A Scientific Investigation on Antioxidant Activities, Total Phenolic and Flavonoid Contents of Honeys Enriched with Different Spices

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Abstract

This study aimed to develop alternative products with high added value by combining honey with various traditionally used spices to make their consumption easier and preferable. The levels of 1,1-Diphenyl-2-picrylhydrazyl (DPPH), total phenolics and total flavonoids were analyzed in five samples of five different spicy honey mixtures. According to the data obtained, DPPH values varied among the different mixtures. Sumac honey had the highest DPPH value (98.82±0.29 mg/mL), while the other mixtures had lower values. Sumac Honey also had the highest total phenolic content (311.5 ± 3.28 mg GAE/100 g), followed by Turmeric Honey and Ginger Black Pepper Honey. In terms of total flavonoid content, Sumac Honey had the highest value (164.05 ± 45.92 QE/100 g), while Ginger Honey had the lowest total flavonoid content. The results show that Sumac Honey is superior in terms of antioxidant capacity, total phenolic content and total flavonoid content. However, significant variation also exists among the other honeys, emphasizing that honeys offer a wide spectrum in terms of health potential and nutritional value. The study addresses the potential to provide health professionals and chefs with new alternatives as well as the opportunity to explore different tastes and flavors.

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Farklı Baharatlarla Zenginleştirilen Balların Antioksidan Aktiviteleri, Toplam Fenolik ve Flavonoid İçerikleri Üzerine Bilimsel Bir İnceleme

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Özet

Bu çalışma, bal ile katma değeri yüksek alternatif ürünler geliştirme amacı taşırken, geleneksel olarak kullanılan çeşitli baharatların bal ile birleştirilmesi ile tüketiminin daha kolay ve tercih edilebilir hale getirilmesini hedeflemiştir. Beş farklı baharatlı ballı karışımın beş numunesinde 1,1-Difenil-2-pikrilhidrazil (DPPH), toplam fenolik madde ve toplam flavonoid düzeyleri incelenmiştir. Elde edilen verilere göre, DPPH değerleri farklı karışımlar arasında değişiklik göstermektedir. Sumak Bal, (98,82±0,29 mg/mL) ile en yüksek DPPH değerine sahipken, diğer karışımlar daha düşük değerlere sahiptir. Sumaklı Bal aynı zamanda toplam fenolik madde içeriği açısından da en yüksektir, (311,5 ± 3,28 mg GAE/100 g) onu Zerdeçal Bal ve Zencefil Karabiber Bal izlemektedir. Toplam flavonoid içeriği açısından ise yine Sumak Bal en yüksek değere sahipken, (164,05 ± 45,92 QE/100 g) Zencefil Bal ise en düşük toplam flavonoid içeriğine sahiptir. Sonuçlar, Sumak Bal'ın antioksidan kapasitesinin, toplam fenolik madde içeriği ve toplam flavonoid içeriği bakımından üstün olduğunu göstermektedir. Ancak, diğer ballar arasında da önemli varyasyonlar mevcuttur, bu da balların sağlık potansiyeli ve besin değeri açısından geniş bir yelpaze sunduğunu vurgulamaktadır. Çalışma, sağlık profesyonellerine ve şeflere yeni alternatifler sunmanın yanı sıra farklı tatları ve lezzetleri keşfetme fırsatı sağlayan bir potansiyeli ele almaktadır.

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Introduction

Spices have played an important role in both human nutrition and trade throughout history. More recently, however, the growing understanding of the relationship between nutrition and health has made the privileged place of spices in our daily diet more apparent. What makes spices particularly noteworthy are the bioactive compounds they contain, which have significant therapeutic potential to address a wide range of health issues. These spices not only provide essential nutrients but also offer a variety of physiological benefits and often fall into the category of functional foods that can prevent chronic conditions [1]. Many people's food habits are changing in search of alternatives that are both tasty and healthy. The health potential of natural foods and traditional dishes has long been of interest to researchers. In this context, the health benefits of honey and spices are of increasing interest both in scientific studies and in culinary practice. This article will specifically examine the possible health effects of honey and spice mixtures and their role in the field of gastronomy. Spices and seasonings are commonly used to add a range of properties to foods, such as taste, smell, acidity, or ease of digestion, while also offering nutritional value. These natural ingredients are widely preferred to enhance the flavor of dishes, as well as to enrich their aroma and sometimes add a slight sour touch. Furthermore, some spices and seasonings can positively affect gastrointestinal health by promoting digestion. Therefore, spices and seasonings play an important role in the food industry and home kitchens, both in terms of flavor and nutritional value [2]. These spices and condiments are considered excellent sources of polyphenols. Polyphenols are compounds noted for their potent antioxidant properties and other important health benefits. Therefore, the antioxidant capacity and potential health benefits of polyphenols have been widely investigated. These natural components can reduce oxidative stress caused by free radicals and play an important role in preventing or improving various health conditions. Thus, the fact that spices and condiments are rich in polyphenols is of great nutritional and health importance [3]. Beyond being a natural food source, honey is enriched with antioxidants and acts as a source of energy for the body. Furthermore, research on the potential prebiotic effects of honey and its ability to support intestinal health suggests that honey can make positive contributions to the digestive system. The use of honey is not only for nutritional but also for medicinal purposes. The composition of honey is highly diverse and depends on the flowers from which the honey comes, seasonal conditions, environmental factors, and processing processes. This review focuses on how the components of honey are taken up by the human body, how they are metabolized, and what positive biological effects they have. Honey forms a saturated sugar solution - fructose (38%) and glucose (31%) - and also contains several different components such as minerals, proteins, free amino acids, enzymes, vitamins, and polyphenols. In particular, flavonoids, which are among the polyphenols, are compounds that are closely associated with the health benefits of honey. Therefore, the positive effects of honey on the body occur as a result of these various components. Potential uses of honey include antioxidant activity, stimulation of anti-inflammatory and immunomodulatory effects, delaying cancer and cardiovascular diseases, inhibiting bacterial pathogens, controlling viral infections, and improving gut health as a prebiotic agent [4].

The high correlation between the antioxidant activity of honey and its total phenolic content suggests that the antioxidant properties of honey are largely due to its phenolic components. This suggests that a large part of the positive health effects of honey is due to its antioxidant abilities. In particular, it is suggested that the therapeutic properties of honey may be closely related to this antioxidant activity. Furthermore, the capacity of honey to remove reactive hydroxyl radicals may also control its antibacterial effects. Honey contains a variety of antioxidants, including water-soluble and fat-soluble antioxidants. The coexistence of these different antioxidant components supports the recognition of honey as a natural antioxidant that can act at different cellular sites [5]. Today's medical research recognizes several plants and compounds that stand out for their powerful antioxidant capacity and play a vital function in disease prevention. These plants and compounds are characterized by their ability to reduce free radical damage, control inflammation, boost the immune system, and support cellular health. Therefore, medicinal plants and their constituents are of increasing importance in health and disease prevention strategies. Ginger (Zingiber officinale rhizome) is a plant species belonging to the Zingiberaceae family that has been used as an indispensable source of flavor in kitchens for thousands of years and is also used in traditional medicine. The uses of this plant are not limited to the kitchen; it is also used effectively in the pharmaceutical, nutraceutical, and cosmetic industries. Ginger contains a unique and recognizable aroma, the main components of which are volatile and non-volatile oils. In addition, ginger rhizomes have a blend of mixed aroma oils containing phenolic compounds

such as gingerol, shogaol, zingerone, and paradol. However, ginger also contains starch, saccharides, proteins, and trace amounts of minerals that enhance the spice components. Ginger has a range of pharmacological activities, which are associated with cardioprotective, anti-inflammatory, antimicrobial, antioxidant, cell proliferation-controlling, neuro-protective, and liver-protective effects. For this reason, many researchers have shown great interest in developing ginger as a less toxic and effective treatment option. However, the efficacy of ginger in treating specific diseases is not yet fully proven, especially in areas such as respiratory infections, cancer, and tumor treatments. This situation encourages further exploration of the potential health benefits of ginger, while it remains one of the focal points of future research [6]. Ginger is a powerful antioxidant that stands out for its impressive ability to reduce oxidative stress levels. In particular, its capacity to effectively reduce free hydroxyl radical production offers the potential to protect the body at a cellular level. These properties suggest that ginger makes an important contribution to good health and may help prevent several diseases associated with oxidative stress [7].

Turmeric (*Curcuma longa* L.) is a popular herb with a very wide range of uses in traditional medicine. In particular, the root of the plant is the most common part used for medicinal purposes and contains different types of phytochemicals and minerals. Curcumin stands out as the main active ingredient of turmeric and is generally considered the main component of ground turmeric rhizome. Turmeric has a range of biological activities, making it a plant with important properties such as anti-inflammatory, antioxidant, anticancer, antimutagenic, antimicrobial, antiobesity, hypolipidemic, cardioprotective, and neuroprotective effects. These reported pharmacological activities suggest that turmeric is an important candidate that should be evaluated with further research in the future [8]. Among the bioactive components found in the essential oil of turmeric is a compound called tumerone, which is known for its ability to prevent carcinogenesis. Previous studies have demonstrated that turmeric has remarkable antioxidant potential. This is an important finding that highlights the health importance of turmeric and the potential of this herb to offer an effective defense mechanism against carcinogenic effects [9]. Moreover, turmeric extract showed potent antioxidant activity, as indicated by the results of ABTS and DPPH assays. The remarkable antioxidant potential of turmeric was specifically associated with the reduction in prostaglandin E2 levels, which serves as an indicator of oxidative stress in HepG2 cells. These findings underscore the capacity of turmeric to effectively reduce oxidative stress and promote cellular health [10]. Recently, turmeric has attracted a great deal of attention due to its special ability to stimulate antioxidant responses, particularly through direct scavenging of oxygen radicals and activation of nuclear factor erythroid 2-related factor 2 (Nrf2). This property has resulted in favorable outcomes, particularly in improving endothelial function and reducing tissue and plasma inflammation, and is potentially useful in the treatment of diabetic microangiopathy. This is an important case highlighting the health importance of turmeric's antioxidant properties [11]. Curcumin, the active component of turmeric, has similar effects to BHA, a potent antioxidant. In addition, the aqueous extract of turmeric was also found to be an effective inhibitor. Liposomes obtained by adding the aqueous extract showed a high inhibition rate of 70% at a concentration of 300 ng/µ1. This result indicates that turmeric contains antioxidants other than lipophilic curcumin. Furthermore, the aqueous extract was found to provide 80% protection against peroxidative damage to DNA. This component of turmeric has been identified and investigated as having antioxidant and anticlastogenic properties and also working as an anti-promoter [12].

Black pepper (*Piper Nigrum* L.) is often referred to as the "King of Spices" and occupies an important and respected position among various spices due to its versatility and importance. Its exceptional flavor, captivating aroma, and wide range of applications in both nutrition and medicine make it extremely valuable and a critical commodity. Black pepper serves as a natural spice, possesses aromatic qualities, and offers carminative properties. It also acts as a powerful natural antioxidant and is known for its anti-inflammatory, anti-cancer, antiperiodic, and antipyretic properties. Black pepper contributes to lowering cholesterol levels in the human body and has a nutritional profile that includes essential vitamins such as A, C, E, K, niacin, and β-carotene, and minerals such as iron, calcium, and phosphorus. The amino acids found in black pepper play a role in increasing the bioavailability of nutrients and may have antimicrobial and antibacterial functions. The combination of these valuable properties positions black pepper as a promising natural health promoter and nutrient-rich product [13]. Black pepper, which has the active ingredient piperine, also has a rich profile of chemical compounds including essential oils, oleoresins, and other phytochemicals [1]. Black pepper is known in medicine as an herb used to treat health problems such as epilepsy, headaches, and diabetes. The positive health effects of this herb have been specifically linked to a nitrogen alkaloid called piperidine. Piperidine is a chemical compound found in black pepper that is responsible for the medicinal benefits of this plant. This alkaloid in particular is thought to be able to help manage the health problems in question. The medicinal use of black pepper is closely linked to the effects of this particular compound

and many researchers have explained the health benefits of black pepper through this compound [14]. Piperine showed a strong effect in terms of free radical scavenging abilities, effectively removing DPPH radicals, and this was confirmed by DCFH-DA and Griess assays [15].

Rhus coriaria Linn. commonly known as sumac, grows in non-agricultural areas and several species can be used for medicinal purposes. This plant grows mainly in Iran, Afghanistan, and countries bordering the Mediterranean Sea. It has been used in folk medicine to treat stroke, diarrhea-dysentery, hemorrhoids, leukorrhea, sore throat, eye problems, wound healing, pain, and chronic symptoms of liver diseases. Sumac also shows a protective effect on some risk factors of atherosclerosis and oxidative stress. Research has shown that sumac can serve as a source of hydrolyzable tannins and natural antimicrobial agents and is a useful natural preservative, antioxidant, and antimicrobial ingredient in the food industry. These biological properties are attributed to the presence of individual phytochemicals, mainly phenolic compounds [16]. Sumac (*Rhus coriaria*) is a plant with a wide range of uses and growing in popularity, especially as a spice. The fruits of this plant contain several positive properties that are important for health. Thanks to its antioxidant properties, it can reduce cellular stress by fighting free radicals harmful to the body. It can also control inflammatory processes thanks to its anti-inflammatory effects, thus playing a protective role against various inflammatory diseases. Furthermore, its antimicrobial properties can help fight germs, reducing the risk of infection. All these properties make sumac not only a delicious spice but also a valuable health ingredient [17].

Honey and spices are natural sources of nutrients and important ingredients, each with their unique health benefits. Honey has historically been recognized as a valuable food for its antioxidant properties and sweetening effect. Spices (e.g. turmeric, ginger, black pepper, sumac), on the other hand, are often favored for their anti-inflammatory properties and high nutritional value. Combining these two food groups offers a very attractive combination from a health perspective. In particular, when spices are combined with honey, these blends combine both their antioxidant properties and their ability to provide energy. For example, turmeric honey combines the antioxidant effects of the curcumin in turmeric with the energizing properties of honey. This results in a very positive outcome, both in terms of health and in terms of meeting energy requirements. Furthermore, honey and spice blends are thought to have the potential to reduce the risk of many diseases thanks to their antioxidants and anti-inflammatory components. These blends can be an attractive alternative for health-conscious individuals and can add flavor to many traditional recipes while also contributing to health. In conclusion, combining honey and spices has the potential to offer new and healthier alternatives in the world of nutrition, while offering the opportunity to discover new tastes and flavors in the culinary. Such blends can offer an experience in terms of both health and flavor. Therefore, further exploring this unique relationship between honey and spices is designed to inspire health professionals as well as chefs and food enthusiasts.

Materials and Methods

Production of mixtures

Honey harvested in 2023 was used to produce the blends. Honey Turmeric product contains 97.57% honey and 2.43% turmeric. Honey Ginger product contains 96.97% honey and 3.03% ginger. The Honey with Sumac product contains 88.89% honey and 11.11% ginger. Ginger+Black Pepper+Honey mixture contains 95.23% honey, 2.38% ginger and 2.38% black pepper. In the Ginger+Turmeric+Honey mixture, 95.91% honey, 2.04% ginger and 2.04% turmeric were used and prepared in a mixing vessel under room conditions.

Antioxidant (DPPH) Analysis

To determine the antioxidant capacity of honey samples, 2 grams of honey was taken and mixed with 10 mL of methanol in a vortex. Then, 100 µL, 200 µL, and 300 µL were taken into test tubes, and 2.9-2.8-2.7 solvent (Methanol) was added and the final volume was adjusted to 4 mL. Then, 1 mL of DPPH radical was added to each tube and mixed in a vortex. The analysis was repeated three times. The prepared samples were kept at room temperature for 30 minutes in a light-free environment. Comparison was done as % inhibition. Afterward, the samples were read at a wavelength of 517 nm using a spectrophotometer of the SHIMADZU brand UV-1280 UV-VIS model. Total antioxidant capacity was analyzed according to Brand Williams et al. [18].

Total Phenolic Analysis

It was analyzed spectrophotometrically using the Folin-Ciocalteau method. In this analysis, samples (5 g) were weighed and supplemented with 50 mL of distilled water. Then, the samples were placed in a shaking water bath (24±1°C) for 20 min. After extraction, the samples were centrifuged at 4100 rpm for 10 min to obtain the supernatant [19,20]. To determine the total phenolic content, Folin & Ciocalteau reagent was diluted 1:9 with distilled water and a 7.5% Na_2CO_3 solution was prepared. To the test tubes, 400 µl of sample for analysis and 2 mL of Folin solution were added and mixed with vortex. Then 1.6 mL Na_2CO_3 was added to the tubes. The mixture was kept in the dark for 1 hour at room temperature. After 1 hour, the absorbance was measured at 760 nm wavelength on a SHIMADZU UV-1280 UV-VIS model spectrophotometer. The analysis was performed in 3 replicates. From the absorbance values obtained as a result of the analysis, the total amount of phenolic substances was calculated as equivalent to gallic acid (mg GAE/g) [21].

Flavonoid Analysis

To determine the flavonoid content of honey samples, a special solution was prepared to be used with 5% NaNO2 solution, 10% $AlCl_3$ solution, and 1 M NaOH solution. In test tubes, 1 mL of honey sample was added and 4 mL of distilled water was added and dissolved by vortexing. Then, 0.3 mL of 5% $NaNO_2$ solution and 0.3 mL of 10% $AlCl_3$ solution were added, mixed, and allowed to stand for 5 minutes. After the waiting period, 2 mL of 1 M NaOH solution was added to the samples and kept for 6 minutes, then the solvent was added to make a final volume of 10 mL. The absorbance of the samples was measured at a wavelength of 510 nm on a SHIMADZU UV-1280 UV-VIS spectrophotometer. The analysis was performed according to the method of Zhinsen et al. [22].

Statistical Analysis

IBM SPSS Statistical Software (Version 27, USA) was used to determine the differences between the mixtures. Data were statistically analyzed using One-Way ANOVA followed by Bonferroni test. The significance level chosen to determine statistical significance was $P < 0.005$.

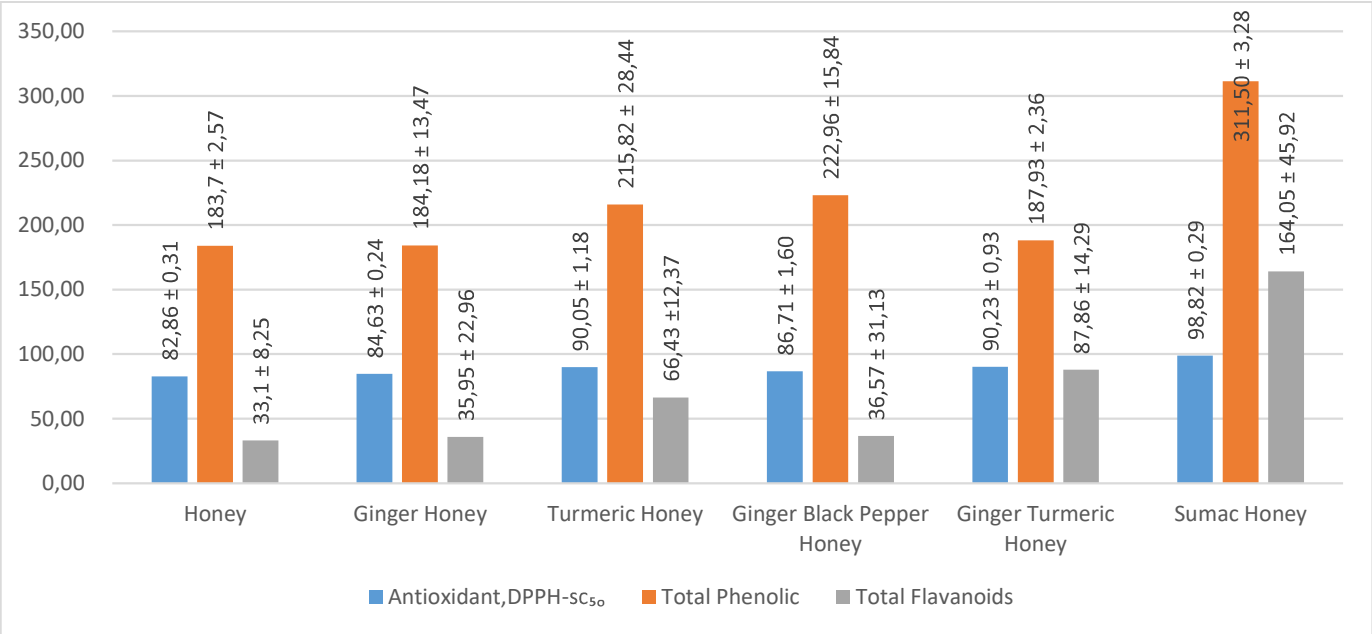
Results and Discussion

The average values of total phenolic matter, flavonoid level, and antioxidant activity in spice and honey mixtures are given in the table below (Table 1, Figure 1).

Table 1. Means and standard errors of total phenolics (mg GAE/100 g), flavonoids (QE/100 g), and antioxidants (mg/mL) in honey samples produced with different spices.

ANALYSIS	**Honey**	**Ginger Honey**	**Turmeric Honey**	**Ginger Black Pepper Honey**	**Ginger Turmeric Honey**	**Sumac Honey**
Antioxidant, DPPH-sc_{50}	82,86 ± 0,31	84,63 ± 0,24	90,05 ± 1,18	86,7 ± 1,16	90,23 ± 0,93	98,82 ± 0,29
Total Phenolic	183,7 ± 2,57	184,18 ± 13,47	215,82 ± 28,44	222,96 ± 15,84	187,93 ± 2,36	311,5 ± 3,28
Total Flavanoids	33,1 ± 8,25	35,95 ± 22,96	66,43 ± 12,37	36,57 ± 31,13	87,86 ± 14,29	164,05 ± 45,92

Figure 1: Means and standard deviations of total phenolic, flavonoid and antioxidant analysis results of spice honey mixture samples.



DPPH analysis included comparisons between various honey types. While there was no significant difference between the other groups except for Sumac Honey, there was a significant difference between turmeric honey and honey ($p<0.005$). Similarly, there was a significant difference between turmeric honey and sumac honey ($p<0.005$). On the other hand, the difference between ginger honey and sumac honey was not significant. This analysis suggests that there are significant differences between honey types in terms of apparent nutritional or quality characteristics. In particular, Sumac honey was found to have a significant difference compared to all other honey types.

According to the total phenolic matter analysis, there were significant differences between Sumac Honey and all other groups ($p<0.005$), indicating that Sumac Honey was different from the other groups in terms of total phenolic matter. The findings suggest that there is diversity in bioactive components among different honey species and that the differences identified by this analysis are notable among the prominent species.

According to the results of total flavonoid analysis, no significant difference was found between Turmeric Honey and Ginger Black Pepper Honey and other groups. There was also no significant difference between Ginger Turmeric Honey and other groups. However, significant differences were found between Sumac Honey and other groups ($p<0.005$). These findings show that especially sumac is rich in flavonoid content [24].

In this study, DPPH, total phenolic matter, and total flavonoid levels were analyzed in 5 samples of 5 different spiced honey blends produced by using sensory test methods to develop alternative products with high added value and to make the consumption of traditionally used different spices easier and preferable by adding them to honey. The results obtained show that honey enriched with spices has great potential in terms of health and nutritional value. Various applications of antioxidants are increasing due to their important role in reducing the damage caused by oxidative stress to the body. In this context, 1,1-Diphenyl-2-picrylhydrazyl radical (DPPH) is a widely used assay method to evaluate the antioxidant activity of different compounds in a rapid, simple, and economical way [25]. The DPPH radical is one of the highly stable free radicals found in plants and foods that have been widely used to assess their free radical scavenging properties. This method is used to determine the activity of antioxidants and the DPPH radical itself is known as an unstable free radical. Antioxidants interact with the DPPH radical and convert it to 1,1-diphenyl-2-picrylhydrazine, which can be observed through a color change. This simple and effective test is used to quickly assess the antioxidant capacity of a compound or extract and helps us understand its potential health benefits [26].

The DPPH free radical scavenging method offers a basic approach to assess the antioxidant capacity of a compound or a biological source; it is a simple assay in which a potential antioxidant reacts with a DPPH radical

solution and then its absorbance is measured over a certain period [27]. This method of analysis was also thought to be useful for evaluating the antioxidant capacity of honey enriched with spices. DPPH assay was used as an indicator of antioxidant capacity and the results were quite impressive. The DPPH values determined in the samples show variability among different kinds of honey and spiced honey. Sumac Honey had the highest DPPH value (98.82 ± 0.29 mg/mL), indicating that it has a stronger free radical scavenging (antioxidant) capacity than the other mixtures. Among the other honeys, Turmeric Honey (90.05 ± 1.18 mg/mL) and Ginger Turmeric Honey (90.23 ± 0.93 mg/mL) had the highest DPPH values. The lowest DPPH value was found in Ginger Honey (84.63 ± 0.24 mg/mL), while honey had the lowest DPPH value (82.86 ± 0.31 mg/mL). These results indicate that spiced honey also has significant antioxidant activity and may contribute positively to health. Since the DPPH value reflects the ability of a compound to neutralize free radicals, these results indicate that these honey can effectively scavenge free radicals. Phenolic compounds are natural components originating from secondary metabolites of plants. They often act to protect plants from insects and other harmful organisms. Phenolic compounds are classified into two main groups: phenolic acids and flavonoids. The structures of these compounds are so diverse that thousands of different phenolic compounds are found in plants and plant-derived products. Phenolic compounds contribute to the taste and aroma of many plant foods and can sometimes be the source of bitterness and astringency in foods. Beyond this, phenolic compounds are potentially powerful antioxidants found in nature. They can effectively inhibit harmful free radical reactions in the body, reducing the development of serious health problems such as cancer, heart disease, and lung diseases. Therefore, including foods rich in phenolic compounds in our diet is an important way to support overall health and prevent disease [28].

According to the results of Total Phenolic Content Analysis, Sumac Honey had the highest phenolic content (311.5 ± 3.28 mg GAE/g), followed by Turmeric Honey (215.82 ± 28.44 mg GAE/g) and Ginger Black Pepper Honey (222.96 ± 15.84 mg GAE/g), while honey in the "Honey" category (183.7 ± 2.57 mg GAE/g honey) had a lower phenolic content than the other honey. Phenolic compounds not only contribute to antioxidant activity but also support various health benefits [29]. This high phenolic content suggests that spiced honey may offer positive health benefits. The high total phenolic content of Sumac Honey differs significantly from other honey. Honey in the "Honey" category, on the other hand, has a lower phenolic substance content. These nuances clearly show that honey enriched with spices can be a valuable alternative not only in terms of taste but also in terms of health. For consumers with a healthier dietary approach, the addition of this honey to their daily diet could enhance their health benefits. However, more research and clinical trials need to be conducted in this area. Key findings and results suggest that dietary flavonoids are important molecules with positive effects on human health. These compounds have bioavailable properties such as antioxidant, cardioprotective, antibacterial, antiviral, and anticancer activities. Furthermore, the metabolization process of these compounds can produce other compounds with these positive effects in our bodies. Therefore, consuming foods containing flavonoids is very important for our health [30].

In particular, the research emphasizes that flavonoid compounds have effective antioxidant activities and can be used as anticancer agents with these properties [31]. Total flavonoid content analysis presents another important finding of this study. As a result of this analysis, Sumac Honey was found to have the highest total flavonoid content (164.05 ± 45.92 QE/100 g). This high flavonoid content of Sumac Honey indicates that it has health potential for the body by increasing its antioxidant properties. Ginger Turmeric Honey followed Sumac Honey in this respect with (87.86 ± 14.29 QE/100 g). Among other spiced honeys, Turmeric Honey (66.43 ± 12.37 QE/100 g), Ginger Black Pepper Honey (36.57 ± 31.13 QE/100 g), and Ginger Honey (35.95 ± 22.96 QE/100 g) have different levels of total flavonoid content. These differences indicate that the nutritional value of honey enriched with spices may vary. "Honey" had the lowest total flavonoid content compared to the others (33.1 ± 8.25 QE/100 g). These results highlight the potential health benefits and nutritional value of honey enriched with spices. In particular, the high flavonoid content means that these products may have anti-inflammatory effects and effectively neutralize free radicals. According to these data, Sumac honey has a higher antioxidant capacity, and total phenolic and total flavonoid content than other honey. However, significant differences are also observed among other honeys.

Conclusion

Honey is known for its antioxidant properties and sweetening effect, while spices (e.g. turmeric, ginger, black pepper, sumac) often have anti-inflammatory properties and high nutritional value. Therefore, the combination of these two food groups offers an important innovation in terms of health and gastronomy. This study shows that Sumac Honey is superior to other honey in terms of antioxidant capacity, total phenolic content, and total flavonoid content. However, there are also significant differences between other honey, emphasizing that spice-blended honey offers a rich spectrum of health potential and nutritional value. The strong positive correlation between antioxidant activity and total phenolic and flavonoid contents may also suggest that these compounds play an important role as primary antioxidants contributing to the observed effects. Honey and spice blends have the potential to offer a creative experience in both the health and gastronomic industry. For health professionals and chefs, this study may also contribute to the discovery of healthy and tasty alternatives. This study shows that spice-enriched honey is an exciting and innovative approach in the world of health and gastronomy and that further research is needed. Future studies and clinical trials are important to further increase the marketability and consumer acceptance of these products.

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References

[1] Butt MS, Pasha I, Sultan MT, Randhawa MA, Saeed F, et al. (2013) Black Pepper and Health Claims: A Comprehensive Treatise. Black Pepper and Health Claims: A Comprehensive Treatise. vol. 53.

[2] Prakash UNS, Srinivasan K (2012) Fat digestion and absorption in spice-pretreated rats. J Sci Food Agric 92:503–10.

[3] Lindberg Madsen H, Bertelsen G (1995) Spices as antioxidants. Trends Food Sci Technol 6:271–7.

[4] Miguel MG, Antunes MD, Faleiro ML (2017) Honey as a Complementary Medicine. Https://DoiOrg/101177/1178633717702869 12:1–15.

[5] Aljadi AM, Kamaruddin MY (2004) Evaluation of the phenolic contents and antioxidant capacities of two Malaysian floral honeys. Food Chem 85:513–8.

[6] Pratap SR, V. GH, K. M (2017) Ginger: A Potential Neutraceutical, An Updated Review. Int J Pharmacogn Phytochem Res 9:1227–38.

[7] Satya Prasad N, Raghavendra R, Lokesh BR, Akhilender Naidu K (2004) Spice phenolics inhibit human PMNL 5-lipoxygenase. Prostaglandins Leukot Essent Fat Acids 70:521–8.

[8] Ahmad RS, Hussain MB, Sultan MT, Arshad MS, et al. (2020) Biochemistry, Safety, Pharmacological Activities, and Clinical Applications of Turmeric: A Mechanistic Review. Evidence-Based Complement Altern Med 2020.

[9] Chinedum E, Kate E, Sonia C, Ironkwe A, Andrew I Polyphenolic Composition and Antioxidant Activities of 6 New Turmeric (*Curcuma Longa* L.) Accessions. n.d.

[10] Menghini L, Genovese S, Epifano F, Tirillini B, Ferrante C, et al. (2010) Antiproliferative, Protective and Antioxidant Effects of Artichoke, Dandelion, Turmeric and Rosemary Extracts and Their Formulation. Http://DxDoiOrg/101177/039463201002300222 23:601–10.

[11] Mazzarino L, Silva LFC, Curta JC, Licínio MA, Costa A, et al. (2011) Curcumin-Loaded Lipid and Polymeric Nanocapsules Stabilized by Nonionic Surfactants: An InVitro and In Vivo Antitumor Activity on B16-F10 Melanoma and Macrophage Uptake Comparative Study. J Biomed Nanotechnol 7:406–14.

[12] Shalini VK, Srinivas L (1987) Lipid peroxide induced DNA damage: protection by turmeric (Curcuma longa). Mol Cell Biochem 77:3–10.

[13] Meghwal M (2012) Nutritional Constituent of Black Pepper as Medicinal Molecules: A Review. J Food Process Technol 01:1–7.

[14] Fernández-Lázaro D, Mielgo-Ayuso J, Martínez AC, Seco-Calvo J (2020) Iron and Physical Activity: Bioavailability Enhancers, Properties of Black Pepper (Bioperine®) and Potential Applications. Nutr 2020, Vol 12, Page 1886 12:1886.

[15] Jaisin Y, Ratanachamnong P, Wongsawatkul O, Watthammawut A, Malaniyom K, et al. (2020) Antioxidant and anti-inflammatory effects of piperine on UV-B-irradiated human HaCaT keratinocyte cells. Life Sci 263:118607.

[16] Rad AH, Khaleghi M (2020) Sumac in Food Industry: A Changing Outlook for Consumer and Producer. J Food Technol Nutr Sci 2:1–3.

[17] Nagip M (2017) Hypolipidemic Effect of Sumac (Rhus Coriaria L) Fruit Powder and Extract on Rats Fed High Cholesterol Diet. Bull Natl Nutr Inst Arab Repub Egypt 50:119–43.

[18] Brand-Williams W, Cuvelier ME, Berset C (1995) Use of a free radical method to evaluate antioxidant activity. LWT - Food Sci Technol 28:25–30.

[19] Gao L, Wang SD, Oomah BDD, Mazza G (2002) Wheat quality: Antioxidant activity of wheat millstreams. Wheat Qual Elucidation 219–31.

[20] Beta T, Nam S, Dexter JE, Sapirstein HD (2005) Phenolic Content and Antioxidant Activity of Pearled Wheat and Roller-Milled Fractions. Cereal Chem 82:390–3.

[21] Slinkard K, Singleton VL (1977) Total Phenol Analysis: Automation and Comparison with Manual Methods. Am J Enol Vitic 28:49–55.

[22] Zhishen J, Mengcheng T, Jianming W (1999) The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. Food Chem 64:555–9.

[23] Khalafi R, Goli SAH, Behjatian M (2016) Characterization and Classification of Several Monofloral Iranian Honeys Based on Physicochemical Properties and Antioxidant Activity. Int J Food Prop 19:1065–79.

[24] Assefa AD, Keum YS, Saini RK (2018) A comprehensive study of polyphenols contents and antioxidant potential of 39 widely used spices and food condiments. J Food Meas Charact 12:1548–55.

[25] Seyhan SA (2019) DPPH Antioksidan Analizinin Yeniden Değerlendirilmesi Re- Evaluating of The DPPH • Antioxidant Assay. 9:125–35.

[26] Sassi A, Normah H, Khattak MMAK, Hanapi MJ (2022) Analysis of phenolic profile, total phenolic content and antioxidant activity in Anacardium occidentale leaves. Food Res 6:20–6.

[27] Kedare SB, Singh RP (2011) Genesis and development of DPPH method of antioxidant assay. J Food Sci Technol 48:412.

[28] NizamLıoğlu NM, Nas S (2010) Meyve ve sebzelerde bulunan fenolik bileşikler ; yapıları ve önemLeri. Gıda Teknol Elektron Derg 2010:20–35.

[29] Laganà P, Anastasi G, Marano F, Piccione S, Singla RK, et al. (2019) Phenolic Substances in Foods: Health Effects as Anti-Inflammatory and Antimicrobial Agents. J AOAC Int 102:1378–87.

[30] Barreca D, Trombetta D, Smeriglio A, Mandalari G, Romeo O, et al. (2021) Food flavonols: Nutraceuticals with complex health benefits and functionalities. Trends Food Sci Technol 117:194–204.

[31] Rengarajan S, Melanathuru V, Govindasamy C, Chinnadurai V, Elsadek MF (2020) Antioxidant activity of flavonoid compounds isolated from the petals of Hibiscus rosa sinensis. J King Saud Univ - Sci 32:2236–42.