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Analysis of the Composition and Contaminants in Packaged Mixed Herbal Tea Blends from Aydın Province

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Abstract
Medicinal plants and herbal infusions have been used for centuries in healing and disease prevention, maintaining their importance in traditional medicinal practices worldwide. Due to their perceived natural origin, botanical medicines and herbal tea blends are generally expected to be safe for consumers and free from contaminants. This cross-sectional descriptive study aimed to analyze the composition of eleven different labelled and unlabelled packaged mixed herbal teas. These tea blends were obtained from fifteen registered herbalists and spice shops under the Aydın Provincial Directorate of Food, Agriculture, and Livestock. Each blend underwent individual analysis, and the labels on the packages were documented. The plants in the blends were identified through morphological analysis, and the presence of foreign substances or contaminants was recorded. The morphological analyses revealed that all of the packaged products contained plant materials from foreign species that were not listed on the labels, making them unsuitable for inclusion in the blends. Additionally, several tea samples were found to contain animal matter, including insect larvae, insect eggs, and bird feathers, with some packages even containing live insects. Furthermore, significant fungal contamination was observed in certain tea blends. These findings indicate that mixed herbal teas sold by herbalists may be of poor quality, containing undeclared and potentially harmful substances. The study highlights a serious concern that warrants increased public awareness and stricter regulation of these products.

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1. Introduction

Medicinal plants have been utilized since ancient times as humanity's oldest method for addressing diseases. Traditional herbal medicines, derived from around 21.000 plant taxa, continue to serve as the primary treatment for health issues affecting approximately 80% of developing nations and around 87.5% of the global population (Parveen et al., 2015). From 2014 to 2023, the World Health Organization (WHO) focused on promoting the integration of medicinal plants into the health systems of member countries, emphasizing the importance of traditional medicine in treatment (WHO, 2023). The public's use of plants for therapeutic purposes is influenced by various factors, including the distance to modern healthcare facilities, the perception that herbal remedies are safer and more effective, the common belief in the safety of natural products despite the potential for severe adverse drug reactions, the lower cost of herbal medicines compared to synthetic alternatives, and the limitations of modern medicine in treating certain conditions. Additionally, both written and visual media play a crucial role in advocating for the therapeutic use of plants (Çelik et al., 2019). Individuals in both rural and urban areas often turn to herbs purchased from herbalists or spice shops to manage their health issues, relying heavily on information sourced from newspapers and television (Akçakaya, 2015).

The term "herbal tea" refers to a beverage made from medicinal plants, herbs, and spices, which can be sold in the form of tea bags or in a loose, unpackaged format. Herbal tea is produced by brewing parts of various plant species-such as leaves, flowers, fruits, roots, stems, and seeds-that do not include *Camellia sinensis* (L.). Kuntze. It is important to note that this definition excludes beverages that incorporate parts of the tea plant. Unlike caffeinated beverages like coffee and traditional tea, herbal tea is naturally caffeine-free. Its medicinal and therapeutic properties have contributed to the widespread consumption of herbal tea globally (Alakali et al., 2016). According to the European Pharmacopoeia, herbal tea is defined as "aqueous preparations obtained by infusion, decoction, or maceration of one or more herbal substances just prior to consumption for oral intake" (Anonymous, 2005). Herbal teas are a popular drink in Türkiye and around the world, with an estimated 50 to 60 varieties of herbs consumed in tea form (Sezik, 2004). These teas are typically sold as tea bags, ground or crushed products, or dried whole plants. Additionally, they can be consumed as mixtures and sometimes marketed as single products. Mixed herbal teas are characterized by the use of multiple plant species combined together. These teas, marketed under names such as "mixed herbal teas," "atom tea," "detox tea," and "relaxing tea," consist of a blend of plants with specific biological activities. For instance, the term "mixed herbal teas" in Turkish generally refers to tea consumed in colder weather. Mixed herbal teas are usually served hot, often enhanced with ingredients like cloves, walnuts, and cinnamon to provide warmth during cold seasons (Karagoz et al., 2023). Consumers are drawn to herbal teas due to their therapeutic benefits, affordability, and the belief that they have minimal or no toxic side effects when consumed in larger quantities compared to other beverages. Tea is made by brewing (infusing), boiling (decocting), or steeping herbs, spices, or other plant materials (such as dried fruits, flowers, seeds, roots, etc.) in hot water for a specified duration (Naithani and Kakkar, 2005; Tayel and El-Tras, 2009).

The effectiveness of herbal teas can depend on various botanical factors, including the specific parts of the plants used, such as seeds, flowers, leaves, stems, and roots. Other influencing factors include geographical location, harvest time, drying methods, and storage conditions (Kökdil, 2002; Chen and Mujumdar, 2006). Commonly consumed plants used in herbal teas include thyme (*Thymus* sp.), black cumin (*Nigella sativa* L.), chamomile (*Matricaria chamomilla* L.), nettle (*Urtica* sp.), senna (*Cassia angustifolia* Vahl.), rosemary (*Rosmarinus officinalis* L.), linden (*Tilia* sp.), ginger (*Zingiber officinale* Roscoe), mint (*Mentha piperita* L.), carob (*Ceratonia*

siliqua L.), hawthorn (*Crataegus monogyna* Jacq.), and sage (*Salvia officinalis* L.). Other popular herbs include yarrow (*Achillea millefolium* L.), hollyhock (*Hibiscus* sp.), St. John's wort (*Hypericum perforatum* L.), chaste tree (*Vitex agnus-castus* L.), and echinacea (*Echinacea purpurea* (L.) Moench) (Tulukcu and Sağdıç, 2011). Sales of certain herbs, such as sage (*Salvia* sp.), ginger (*Zingiber officinale* Roscoe), marshmallow (*Althaea officinalis* L.), cinnamon (*Cinnamomum* sp.), hibiscus (*Hibiscus sabdariffa* L.), rosehip (*Rosa canina* L.), and nettle (*Urtica* sp.), tend to increase with seasonal changes, particularly influenced by media coverage.

Although consumers often perceive herbal teas as 'natural', 'harmless', and/or 'beneficial to health', studies have shown that these teas, typically consumed for their medicinal properties, can become contaminated with a variety of physical, chemical, and biological hazards. These contaminants include microorganisms, mycotoxins, pesticides, heavy metals, animal droppings, stones, and feathers (Scolari et al., 2001; Chan, 2003; Tripathy et al., 2015). Microorganisms are a significant source of contamination in herbal teas and can infiltrate these products at various stages of production, including harvesting, drying, grading, grinding, processing, packaging, and storage. The biological contamination in herbal teas can stem from polluted air, both from the ground and processing facilities, as well as microorganisms of human origin. Santos et al. (2013) noted that molds are a major contributor to this contamination. Molds can be found in the natural flora of herbal teas and in contaminated air and soil (Araújo and Bauab, 2012). Additionally, microbial metabolites, including toxic and low molecular weight compounds from molds, can serve as chemical pollutants, further contributing to contamination (Kosalec et al., 2009; Can and Duraklı Velioğlu, 2018). Research has indicated that these products, especially those marketed as tea, can harbor various microorganisms, including pathogenic species and molds that produce mycotoxins (Scolari et al., 2001; Stevic et al., 2012). The presence of mycotoxigenic molds among the microorganisms typically found in herbal teas highlights the potential risks associated with mycotoxins in these products. Molds that proliferate in raw materials that have not been processed under proper conditions can generate mycotoxins harmful to human health and lead to spoilage in improperly processed raw materials (Sabuncuoğlu et al., 2008; Erginkaya and Kabak, 2010; Can and Duraklı Velioğlu, 2018).

One of the primary challenges faced in the sale of medicinal plants by herbalists is the issue of standardization (Kartal, 2008). Another significant concern is misidentification, which can occur when plants are incorrectly identified. This confusion may lead to toxic events that could result in serious harm, including death or disability. Additionally, the adulteration of herbal products during their production or sale constitutes a significant issue. It encompasses the production of substandard or low-quality items, as well as the contamination of products with substances such as animal excreta (e.g., from rodents), stone fragments, and undesirable plant residues (WHO, 2007; Kayıran and Kırıcı, 2019).

The aim of this study was two fold: first, to conduct a morphological identification of medicinal plants in both labeled and unlabeled mixed herbal teas sold in herbalists and spice shops registered with the Aydın Provincial Directorate of Food, Agriculture and Livestock; and second, to assess the presence of undesirable physical and biological impurities in the packaging content of these herbal tea mixtures.

2. Material and Methods

This study was conducted between November 2017 and January 2018 and focused on analyzing packaged mixed herbal teas obtained from commercial herbalists and spice shops in the specified locations. We purchased eleven distinctly labeled herbal mixtures marketed as "mixed herbal teas" from fifteen

different herbalist and spice shops. After purchasing, the samples were stored at room temperature in a laboratory until the study commenced. In the laboratory, each mixed herbal tea was examined individually. The label information on the packages was recorded, and the plants contained in the mixtures were identified morphologically. The Flora of Turkey (Flora of Turkey and the East Aegean Islands) and the Checklist of Turkey Plants (Vascular Plants) provide an outline of indigenous and non-native species used for medicinal purposes or cultivated in Türkiye. This information is based on the scientific works of Davis (1965-1985), Davis et al. (1988), Güner et al. (2000), and Güner et al. (2012). In this instance, morphological diagnosis was employed to ascertain the contents of the teas. The morphological identification was generally successful for the mixed herbal tea samples due to the presence of sufficient plant parts. The identification process utilized a stereomicroscope, loupes, and diagnostic tools, including needles, forceps, and a ruler.

For mixed herbal tea samples lacking label information, the designation "no label information" was noted and assessed separately. Insects discovered in the tea sample packages were identified through morphological observation. This identification method was applied to plants not specified in the tea ingredients, as well as to species contaminated with foreign substances and those infected with fungi. Additionally, each sample was assigned a unique identification number, and photographs were taken using a Canon EOS 650D camera (see Figure 1).

Figure 1. Herbal shop and mixed herbal teas samples. a. Herbal shop, b. Unlabeled mixed herbal teas, c. Labeled mixed herbal teas, d. Plant uses in mixed herbal teas

3. Results

The findings from the investigation of eleven mixed herbal tea blends, which were randomly purchased from commercial herbalists in the Aydın Provincial Center, are presented in Table 1 and Table 2. The study identified the most prevalent herbs in the analyzed "Mixed Herbal Teas" packages, which included *Alcea rosea, Cinnamomum verum, Zingiber officinale, Alpinia officinarum, Rosa canina, Matricaria chamomilla, Hibiscus* sp., *Curcuma longa,* and *Salvia* sp. Out of the eleven "Mixed Herbal Teas" blends obtained from herbalists, only five samples had labels, while six samples were unlabeled (Table 1). Consequently, the identification of plants in the unlabeled packets was not feasible; this task was successfully conducted only on the labeled samples (Tables 1 and 2).

Table 1. Analysis results of mixed herbal tea blends sold in herbal shops in the city center of Aydın

Mixed herbal tea samples	Plants listed on the label	Identified plants	Unlabeled plants	Unwanted foreign substances / contamination
1	Hibiscus Turmeric Echinacea Cinnamon Ginger Galangal Hibiscus Daisy Rosehip Hollyhock	*Hibiscus* sp. *Matricaria chamomilla* *Alcea rosea*	*Sideritis* sp. *Bromus hordeaceus* *B. tectorum* *Avena barbata* *Crepis foetida* *Verbascum* sp.	Contamination of *Sideritis* sp. with fungus Maggot residues in *Matricaria chamomilla* specimens
2	Galangal Daisy Hibiscus Cinnamon Sage Rosehip Hollyhock Ginger Linden	*Cinnamomum verum* *Zingiber officinale* *Tilia* sp. *Salvia fruticosa* *Rosa canina* *Hibiscus* sp. *Alcea rosea* *Matricaria chamomilla* *Alpinia officinarum*	*B. tectorum*	Insect parts were found in the package *Hibiscus* sp. feathers were mixed with the samples
3	Ginger Cinnamon Chinese Rose Galangal Dried Apple Orange Peel Lemon Peel Linden Sage Medicinal Sage Rosehip Marshmallow Flower Eucalyptus Carnation Turmeric Daisy Bilya Thyme	*Sideritis* sp. *Citrus sinensis* *Rosa canina* *Malus sylvestris* *Zingiber officinale* *Alcea rosea.* *Eucalyptus* sp. *Curcuma longa* *Hibiscus* sp. *Matricaria chamomilla*	*Verbascum* sp. *Bromus tectorum* *Lavandula stoechas* *Helichrysum* sp. *Avena* sp. *Myrtus communis*	The package contains unwanted branch and debris content A total of 4 insects were counted in the package *Malus sylvestris* plant contaminated with the fungus

4	Hibiscus Ginger Turmeric Galangal Linden Allspice Cinnamon Hollyhock Rosehip Taurus Mint Fennel Apple Cactus Sage Lemon Peel Goldenrod Orange Peel May Daisy Zahter Thyme	*Tilia* sp. *Alcea rosea* *Helichrysum* sp. *Sideritis* sp. *Hibiscus* sp. *Rosa canina* *Curcuma longa* *Citrus sinensis* *Cinnamomum verum* *Malus sylvestris* *Pimenta racemosa* *Zingiber officinale* *Citrus limon* *Alpinia officinarum* *Mentha* sp. *Thymbra* sp. *Foeniculum vulgare*	No unlabeled plants were detected	The package contains unwanted branch and debris content Insect eggs were detected on the leaves of *Alcea rosea* *Rosa canina* fruits are spoiled and contaminated with fungi
5	Ginger Hibiscus Cinnamon Bark Hollyhock Dried Apple Orange Peel Turmeric Daisy Sage Rosehip Galangal Lemon Peel Primrose	*Rosa canina* *Alcea rosea* *Matricaria chamomilla* *Hibiscus* sp. *Cinnamomum verum* *Citrus sinensis* *Citrus limon* *Malus sylvestris* *Zingiber officinale* *Alpinia officinarum* *Salvia* sp. *Curcuma longa* *Primula* sp.	*Verbascum* sp.	Insect eggs were detected on the leaves of *Alcea rosea* Fungal contamination was detected in *Malus sylvestris*
6	Galangal Turmeric Ginger Hollyhock Cinnamon Calendula Rosehip Eucalyptus Hawthorn fruit Echinacea Myrtle Leaf Hibiscus	*Alcea rosea* *Cinnamomum verum* *Calendula officinalis* *Hibiscus* sp. *Eucalyptus* sp. *Alpinia officinarum* *Curcuma longa* *Zingiber officinale* *Crataegus monogyna* *Rosa canina*	*Malus sylvestris* *Bromus tectorum* *Lavandula stoechas* *Helichrysum* sp. *Matricaria chamomilla* *Salvia* sp. *Verbascum* sp.	Unwanted branch garbage content was detected in the package Plastic rope was detected in the package.
7	There were no labels on the product package	*Cinnamomum verum* *Hibiscus* sp. *Salvia* sp. *Alcea rosea* *Rosa canina*	The product could not be evaluated due to the absence of a label on the package	*Salvia* sp. was found to be contaminated with fungus Insect larvae were detected in the product The product was found to contain mouldy dry branches

8	There were no labels on the product package	*Hibiscus* sp. *Helichrysum* sp. *Calendula officinalis* *Rosa canina* *Citrus sinensis* *Hypericum perforatum* *Thymus* sp. *Malus sylvestris* *Matricaria chamomilla* *Alcea rosea* *Myrtus communis* *Verbascum* sp. *Quercus* sp. *Rosa* sp.	The product could not be evaluated due to the absence of a label on the package	*Myrtus communis* leaves were found to be contaminated with fungus Fungal contamination was detected in *Malus sylvestris*
9	There were no labels on the product package	*Tilia* sp. *Alcea rosea* *Hibiscus* *Rosa canina* *Sideritis* sp. *Helichrysum* sp. *Alpinia officinarum* *Malus sylvestris* *Lavandula stoechas* *Verbascum* sp. *Matricaria* sp. *Bromus tectorum* *Armeniaca vulgaris* *Citrus sinensis* *Zingiber officinale*	The product could not be evaluated due to the absence of a label on the package	*Tilia* sp. leaves were found to be contaminated with fungi *Armeniaca vulgaris* samples were found to be infested with insects, and the plant was deteriorated A total of 27 insects were counted in the package
10	There were no labels on the product package	*Cinnamomum verum* *Zingiber officinale* *Curcuma longa* *Alpinia officinarum* *Hibiscus* sp. *Bromus tectorum* *Rosa canina* *Lolium* sp. *Alcea* sp. *Matricaria chamomilla* *Malus sylvestris*	The product could not be evaluated due to the absence of a label on the package	Stone fragments were detected in the dried flowers of *Malus sylvestris*. Cobwebs were detected in the flowers of *Hibiscus* sp.
11	There were no labels on the product package	*Cinnamomum verum* *Zingiber officinale* *Curcuma longa* *Alpinia officinarum* *Hibiscus* sp. *Rosa canina*	The product could not be evaluated due to the absence of a label on the package	Unwanted branch and debris content was detected in the package.

Table 2. Results of the analysis of the herbal content of mixed herbal tea blends

Mixed herbal tea samples	The number of plants on the label	Plants identified in the package	Plants identified as off-label
1	10	3	6
2	9	9	1
3	17	10	6
4	17	17	0
5	13	13	1
6	12	10	7
7	No labels on the product package	5	-
8	No labels on the product package	14	-
9	No labels on the product package	15	-
10	No labels on the product package	11	-
11	No labels on the product package	6	-

The mixed herbal teas analyzed in this study were also examined for foreign materials and contamination within the package contents. A comprehensive evaluation of the eleven herbal tea blends revealed that all packaged products contained plant components from foreign plants deemed unsuitable for tea mixtures. Additionally, certain samples were found to have insect larvae, insect eggs, and animal remnants, such as bird feathers, while some packages contained live organisms, particularly insects (Table 1). Morphological observations indicated that the plants included in the mixed herbal teas were affected by fungal contamination. The most heavily contaminated plants were identified as *Malus sylvestris* flowers, *Alcea rosea* leaves, and *Hibiscu*s sp. flowers.

Consumers often perceive medicinal plants as "natural," "harmless," and/or "beneficial to health." Research has shown that these plants exhibit antioxidant, anticarcinogenic (Çelik et al., 2022), and antimicrobial properties (Feitosa et al., 2019; Dash et al., 2020). The number of active constituents in herbal medicines can vary based on several factors, including the geographical location of the source, the plant's developmental stage at harvest, post-harvest handling, drying methods, stability requirements, and standardization practices (Gezmen-Karadağ et al., 2013).

Despite the numerous documented health benefits of herbal teas, they pose a significant risk to human health when contaminated due to improper use, excessive consumption, or uncontrolled production. The environments in which these plants grow can be contaminated with harmful substances from various sources. To ensure the safety and efficacy of herbal therapies, it is crucial to implement standardization and quality control measures, which include selecting and processing raw materials, assessing the safety, efficacy, and stability of finished products, providing clear product information to consumers, and promoting the products effectively (WHO, 2004). Achieving this requires a close examination of quality indices, including macro- and microscopic assessments, moisture content analysis, qualitative chemical evaluations, and toxicological studies of herbal products and any derived herbal-based medicines.

Studies have indicated that commercially available herbal teas, often used for medicinal purposes, may contain microorganisms, pesticides, mycotoxins, heavy metals, and certain harmful chemicals, such as polycyclic aromatic hydrocarbons and pyrrolizidine alkaloids (Scolari et al., 2001; Chan, 2003; Tripathy et al., 2015; Akduman and Korkmaz, 2020). Herbal products can become contaminated and undergo changes in their composition, color, odor, taste, and

concentration if stored improperly—such as near doors, in uncovered glass containers, in unsealed bags on shelves, or in open sacks—leading to biological contamination (Schilter et al., 2003; Kayıran and Kırıcı, 2019). The presence of mycotoxigenic molds among the microorganisms found in herbal teas highlights the potential hazards posed by mycotoxins in these products. Contamination of plant materials used in tea production with microorganisms can occur prior to harvesting due to factors such as soil, water, fertilizers, sewage, animal waste, and residues. This contamination can also arise during various production stages, including harvesting, drying, grading, grinding, processing, packaging, and storage (Özyaral et al., 1994; Heperkan, 2006). While there is insufficient data to compare biological contamination levels between wild and cultivated plant materials, it is hypothesized that cultivated plants are more prone to contamination during post-harvest processing (Kosalec et al., 2009).

The growth of molds in unprocessed raw materials under unsuitable conditions can produce mycotoxins that negatively impact human health and lead to product spoilage. Herbal infusions left in suboptimal environments for prolonged periods without adequate temperature or humidity control are particularly susceptible to mold growth and mycotoxin production (Sabuncuoğlu et al., 2008; Erginkaya and Kabak, 2010).

A study investigating the growth of pathogens in intentionally contaminated brewed teas in a laboratory setting revealed that certain herbal teas used in clinical environments could pose a risk for nosocomial infections in patients during their care (Araújo and Bauab, 2012). Our research findings indicated that the plants in the mixed herbal tea blends were infected with fungi, with the highest levels of fungal contamination found in *Tilia* sp., *Myrtus communis*, *Malus sylvestris*, *Alcea rosea*, and *Hibiscus* sp. (Table 1).

In line with this rationale, our objective was to perform ethnobotanical and content analyses of packaged mixed herbal tea mixtures obtained from commercial herbalists and spice shops in the city center of Aydın. The present study specifically focused on analyzing the non-native components found in the packages of mixed herbal teas (Tables 1 and 2). A thorough examination of the eleven different mixed herbal tea blends revealed that each packaged product contained plant components from foreign plants that were not suitable for inclusion in tea blends. Additionally, several samples were found to contain insect larvae, insect eggs, and animal matter, including bird feathers. Some packages even harbored live organisms, particularly insects (Table 1 and Table 2). Previous studies have reported similar findings, noting the presence of insects and their larvae in samples collected from herbalists in Adana Province (Baldemir and Güvenç, 2007).

Herbal products available for sale must include promotional labels that specify the route of administration, dosage, composition, and method of use. However, only six out of the eleven mixed herbal tea packages purchased from herbalists had labels, while five packages were unlabeled. Of the products with labels, only two contained the herbs that were listed; the remaining four packages contained unlabeled herbs instead. The labels on these packaged products were primarily in Turkish and lacked essential information, such as production expiration dates and place of origin. These findings align with those of a similar study conducted with herbalists in Adana, which revealed comparable results (Kayıran and Kırıcı, 2019). If the product label does not provide this essential information, it poses a potential risk to consumer health, especially for those looking to benefit from these products. The lack of details regarding the herbs, dosage, contraindications, and important health warnings may contribute to the misconception that natural products are completely safe.

4. Conclusion

Fifteen mixed herbal tea blends obtained from herbalists were examined, revealing significant issues with labeling and contamination. The packages lacked essential

information, such as production and expiration dates, and did not accurately reflect the ingredients. Some packages contained foreign plant samples, while others included foreign animal substances, such as insect larvae, insect eggs, bird feathers, and even live insects. Additionally, several plant species in the samples showed signs of fungal contamination. These findings underscore the problems of mislabeling, ingredient substitution, and contamination, which complicate the accurate identification and safety of herbal teas. The presence of both plant and animal contaminants further highlights the need for stricter quality control and proper labeling in herbal tea packaging.

To address these issues, it is essential that herbal tea blends adhere to proper labeling standards, ensuring the inclusion of production and expiration dates, as well as a clear list of ingredients, both in local and scientific terms. Good Manufacturing Practices (GMP) should be strictly followed in the processing and packaging of herbal teas, including protocols for cleanliness and quality assurance. Furthermore, measures should be implemented to prevent contamination from foreign substances, such as insects, molds, and animal residues, by ensuring proper storage conditions, including temperature and humidity control, before and after the sale of the products. These steps are crucial to ensuring the safety and quality of herbal teas and providing consumers with reliable and safe products.

Declaration of Author Contributions

The authors declare that they have contributed equally to the article. All authors confirm that they have seen, read, and approved the final version of the article, which is ready for publication.

Declaration of Conflicts of Interest

All authors declare that there are no conflicts of interest related to this article.

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