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Storage of Medicinal and Aromatic Plants in Licensed Warehouses and Their Trading Potential in the Turkish Mercantile Exchange (TMEX)*

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Abstract

Medicinal and aromatic plants are those used as medicines to prevent diseases, maintain health, or treat illnesses. This study aims to evaluate the storability of medicinal and aromatic plants under appropriate conditions in Licensed Warehouses (LW) in Türkiye and to analyze their potential for trading on the Turkish Mercantile Exchange (TMEX). The increasing use of these plants in phytotherapy, cosmetics, and food industries has made their integration into sustainable agricultural systems strategically important for generating high added value in the economy. Employing a qualitative research design, the study analyzed the storability of these plants by considering their physical, chemical, and microbiological characteristics. Furthermore, the level of knowledge regarding current legal regulations and operational practices was examined through semi-structured interviews with 12 LW experts, based on an interview form developed after a literature review. The findings indicate that the current infrastructure, legislation, and storage standards are insufficient for these products. However, with proper drying, packaging, and infrastructural improvements, these products could be traded within the Electronic Warehouse Receipt (EWR) system on TMEX. The study provides guiding insights for policymakers by highlighting the potential to diversify the LW system and create new financing opportunities for producers.

Keywords
Licensed Warehousing, Turkish Mercantile Exchange, Electronic Warehouse Receipt, Medicinal and Aromatic Plants

JEL Classification
Q13, Q14, G10

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Tıbbi ve Aromatik Bitkilerin Lisanslı Depolarda Depolanması ve Türkiye Ticaret Borsası'nda (TMEX) Ticaret Potansiyeli

Öz

Tıbbi ve aromatik bitkiler, hastalıkları önlemek, sağlığı korumak veya tedavi etmek için ilaç olarak kullanılan bitkilerdir. Bu çalışma, Türkiye'deki Lisanslı Depolarda (LW) uygun koşullar altında tıbbi ve aromatik bitkilerin depolanabilirliğini değerlendirmeyi ve Türkiye Ticaret Borsası'nda (TMEX) işlem görme potansiyellerini analiz etmeyi amaçlamaktadır. Bu bitkilerin fitoterapi, kozmetik ve gıda endüstrilerinde artan kullanımı, ekonomiye yüksek katma değer sağlamak için sürdürülebilir tarım sistemlerine entegrasyonunu stratejik olarak önemli hale getirmiştir. Nitel bir araştırma tasarımı kullanan çalışmada, bu bitkilerin fiziksel, kimyasal ve mikrobiyolojik özellikleri dikkate alınarak depolanabilirlikleri analiz edilmiştir. Ayrıca, literatür taraması sonrasında geliştirilen bir görüşme formuna dayanarak, 12 LW uzmanıyla yarı yapılandırılmış görüşmeler yoluyla mevcut yasal düzenlemeler ve operasyonel uygulamalar hakkındaki bilgi düzeyi incelenmiştir. Bulgular, mevcut altyapı, mevzuat ve depolama standartlarının bu ürünler için yetersiz olduğunu göstermektedir. Ancak, uygun kurutma, paketleme ve altyapı iyileştirmeleriyle bu ürünler, TMEX'teki Elektronik Depo Fişi (EWR) sistemi kapsamında işlem görebilir. Çalışma, LW sistemini çeşitlendirme ve üreticiler için yeni finansman fırsatları yaratma potansiyelini vurgulayarak politika yapıcılara yol gösterici bilgiler sunmaktadır.

Anahtar Kelimeler
Lisanslı Depoculuk, Türkiye Ticaret Borsası, Elektronik Depo Fişi, Tıbbi ve Aromatik Bitkiler

JEL Classification
Q13, Q14, G10

1. Introduction

Technological transformations are leading to the emergence of new applications in almost every aspect of life. While the effects of this transformation produce positive outcomes in some areas, they also cause negative consequences in others. The impact of this change is particularly evident in sectors such as health, cosmetics, and food. In these fields, where practices based on natural plants were once widespread, the use of chemically formulated products has gradually increased over time. Although chemicals have the potential to provide the desired effects more quickly and effectively, they have also brought about considerable side effects and environmental risks.

At this point, especially in the field of health, there has been a renewed interest in traditional herbal products. Medicinal and aromatic plants are considered alternatives to their chemical counterparts not only in the treatment of diseases but also in areas such as cosmetics and functional foods. However, one of the main challenges in the use of these plants is the risk of losing their effectiveness quite rapidly after harvest. Therefore, the ability to store medicinal and aromatic plants for long periods without loss of quality is of great importance. On the other hand, since plant-

based products do not provide direct economic benefits to producers during the storage period, this situation constitutes a significant financial problem, particularly for small-scale producers.

In this context, the licensed warehousing system established in Türkiye for the preservation of durable agricultural products such as wheat, barley, and hazelnuts stands out. Within this system, products are stored under insurance, and Electronic Warehouse Receipts (EWRs) issued on behalf of the producer enable integration into financial markets. These receipts allow producers to both obtain credit from banks and convert their products into cash through the Turkish Mercantile Exchange (TMEX). Thus, the producer is protected from storage-related risks while also being supported in terms of cash flow. However, whether this structure can be applied to medicinal and aromatic plants constitutes the main problem of this study. Based on this premise, the study aims to examine the storability of medicinal and aromatic plants in licensed warehouses and to investigate their integration into the EWR and TMEX systems. Solution-oriented recommendations are developed in line with the findings obtained.

2. Conceptual Framework

2.1. Medicinal and Aromatic Plants

Although it is not possible to define medicinal and aromatic plants precisely, the terms “medicinal” and “aromatic” are often used together. Medicinal and aromatic plants are those used as medicines to prevent diseases, maintain health, or treat illnesses. Medicinal plants are utilized in areas such as nutrition, cosmetics, body care, incense, or religious ceremonies, while aromatic plants are primarily used for their scent and flavor (Faydaoğlu & Sürücüoğlu, 2011).

Some of these plants are collected from nature, while others are cultivated under controlled agricultural production. The most notable and widely studied characteristic of these plants is their therapeutic use. A significant portion of plants used for medicinal purposes is obtained from natural sources.

2.2. Collection of Medicinal and Aromatic Plants

The collection process must be carried out with great care. The person performing the collection should have at least some knowledge about the plant to be gathered. In other words, they should know whether the area where the plant is collected is suitable, whether the plant is poisonous, whether the season is appropriate, and which part of the plant should be collected.

Otherwise, careless collection may harm both nature and the sustainability of the plant species. To ensure that the plant community continues to exist in the following season, it should not be entirely harvested; only the required amount should be collected. Trees whose flowers, leaves, or fruits are harvested should not be damaged. It should be remembered that careless harvesting of plants whose roots are used may negatively affect the ecosystem and lead to the extinction of plant species (Kurt, 2019-2020).

Although collection is generally performed manually, in countries where medicinal and aromatic plant cultivation is practiced, agricultural machinery is often used for harvesting. The timing and method of collection are extremely important to ensure that the plant drug contains a sufficient amount of bioactive compounds. As in the case of drug quality, great attention must be paid to the collection times of leaves, flowers, fruits, and seeds. The collected parts of the plants, except for the underground portions, should not be washed with water. Plants should not be collected near lakes or streams contaminated with chemical waste, in areas with heavy traffic pollution, or in fields treated with pesticides. In line with the principle of sustainable nature conservation, plants should not be harvested in quantities exceeding actual needs (Geven, 2025).

2.3. Preservation of Medicinal and Aromatic Plants

There are certain methods and several stages involved in the preservation of medicinal and aromatic plants. The first stage is pre-cooling immediately after harvest. This is followed by the drying phase, during which the plants are made suitable for storage. The final stage is the storage process itself. Information on these stages is provided below.

2.3.1. Pre-Cooling

The temperature difference between a freshly harvested product and the optimum storage temperature indicates the field temperature. Rapidly lowering this temperature to a level close to the ideal storage temperature is known as pre-cooling or the removal of field heat. Typically, up to 88% of the temperature difference is eliminated during this process. Pre-cooling is limited by the time and energy required to reduce the product temperature to its optimal storage level. The field temperature of freshly harvested products is usually high and should be removed as much as possible before transportation, processing, and storage. Pre-cooling is generally a separate procedure that requires specialized equipment and rooms designed to maximize the product's shelf life (Arafa & Dewidar, 2014).

2.3.2. Drying of Medicinal and Aromatic Plants

Fresh plant material can deteriorate very quickly; therefore, the drying process should be performed as soon as possible after harvest. Temperature and humidity must be carefully controlled to prevent damage to the active chemical components of the plant material. The drying method and temperature used have a significant effect on the quality of the resulting medicinal plant material. For instance, shade drying is preferred to preserve or minimize the loss of color in leaves and flowers, while lower temperatures should be used for medicinal plants containing volatile compounds (Tamil Nadu Agricultural University, 2025).

In this context, the drying of plants can be classified into two main categories: traditional and modern methods. Traditional methods include techniques such as sun drying, shade drying, and natural drying at room temperature. Modern methods, on the other hand, involve more advanced technological applications such as microwave drying, vacuum drying, infrared drying, freeze-drying, and fluidized-bed drying. Although each method has its own advantages and limitations, modern drying techniques generally yield superior results, especially in preserving volatile oils and biologically active compounds (Günaydın et al., 2022).

2.3.2.1. Traditional drying methods

In traditional drying methods, considering that the temperature range where enzymes are most active during drying is between 35°C and 50°C, it is crucial to ensure that the plant material remains within this temperature range for only a short period. The drying process should be carried out without exceeding or falling below this range, and drying should preferably be performed outdoors in shaded areas. Through drying, the moisture content of the plant is reduced by removing water from its tissues (fresh fruits contain 85–95% moisture, herbs and roots 70–85%, stems and woody parts 40–60%, and seeds and dried fruits 10–15%) to a level of 8–12% (Geven, 2025). In this context, some of the traditional drying methods used for plants are presented below (Günaydın et al., 2022).

Shade Drying: This method involves drying the green parts of the plant in covered structures with open sides, such as sheds, hangars, or wire-mesh rooms. In this technique, the material is not exposed to direct sunlight but is dried in open air.

Glasshouse Drying: This method is used in areas where the ambient temperature is not sufficiently high. The plant materials are dried either in bundles or spread in very thin layers on racks inside glass structures.

Hot-Air Drying: Depending on the type and quantity of the plant material, this method uses one of several systems such as drying cabinets, drying rooms, or drying tunnels, where hot air is circulated to remove moisture efficiently.

2.3.2.2.Modern drying methods

Modern drying methods, which aim to prevent microbial spoilage by removing water from products in a controlled manner, have emerged as traditional methods have become insufficient over time. These methods are particularly effective in enhancing the quality and extending the shelf life of products containing volatile oils and biologically active compounds.

Freeze Drying (Lyophilization): Freeze drying, also known as lyophilization, is a method used for heat-sensitive products, in which the material is first frozen at very low temperatures (−40°C or below), and then the ice is sublimated directly under reduced pressure. This technique preserves the product's shape, taste, color, and nutritional value, allowing long-term storage without significant quality loss (Ray & May, 2010; Tang & Pikal, 2004).

Vacuum Drying: This method operates under reduced pressure and is used to remove moisture from heat-sensitive products. With this technique, the moisture within the product evaporates faster and at lower temperatures, helping preserve the product's nutritional value, aroma, and color. It also consumes less energy and minimizes product deformation (Nindo & Tang, 2007; Zielinska & Markowski, 2012).

Microwave Drying: A fast and efficient drying method that heats the product from the inside out, allowing moisture to evaporate rapidly.

Infrared (IR) Drying: A method in which heat energy is transmitted directly to the surface of the product through electromagnetic waves. The IR rays used in this process are rapidly absorbed by water molecules, leading to quick evaporation of internal moisture.

Fluidized Bed Drying: An effective technique in which a stream of gas passes upward through solid particles, creating a fluid-like state that enhances uniform drying.

Spray Drying: A particle-processing technique in which liquid material is atomized into fine droplets that are dried in a stream of hot gas, resulting in separate dry particles.

Vacuum Microwave Drying: An advanced drying technique combining the low-temperature advantage of vacuum drying with the speed of microwave drying. In this method, the ambient pressure is reduced to lower the boiling point of water, enabling drying at low temperatures (Krakowska-Sieprawska et al., 2022; Mujumdar, 2006).

Table 1

Characteristics of Modern Drying Methods

Method	Temperature	Duration	Quality Preservation	Cost	Suitability
Freeze Drying	Very Low	Long	Excellent	Very High	Products containing volatile oils and pharmaceutical materials
Vacuum Drying	Low	Moderate	High	Moderate	All heat-sensitive products
Microwave Drying	Medium	Very Short	Medium–High	Moderate	Plants with dense leaves
Infrared Drying	Medium	Short	Medium	Moderate	Surface drying
Fluidized Bed Drying	Medium	Short	High	High	Powdered or fragmented plant materials
Spray Drying	High	Very Short	Medium	High	Extracts and liquid-based products
Vacuum Microwave Drying	Low	Very Short	High	High	Delicate and high-value products

Sources. Given, 2008; Günaydın et al. 2022; Krakowska-Sieprawska et al., 2022; Mujumdar, 2006; Palinkas et al., 2015; Ratti, 2001.

2.4. Storage

The storage and preservation of medicinal and aromatic plants aim to maintain their quality by optimizing temperature and relative humidity conditions, preventing deterioration caused by microorganisms, fungi, and insects during storage, and preserving both qualitative and quantitative characteristics after drying. During storage, metabolic activity should be minimized to make the plants less susceptible to spoilage. This can be achieved by reducing the product's moisture content to appropriate levels, cooling, or applying a modified atmosphere in the storage system. The standard storage period for medicinal plants is one year; however, a longer shelf life may be accepted if the producer provides a stability test proving that the product characteristics are preserved within the recommended period (Masand et al., 2014; Silva et al., 2013).

2.5. Licensed Warehouses and the Turkish Mercantile Exchange (TMEX)

Licensed warehouses are defined as "storage facilities established as joint-stock companies, operating under state-regulated procedures, which ensure that agricultural products are stored under healthy conditions in return for a rental fee."

The Turkish Mercantile Exchange (TMEX) was established on June 8, 2018, pursuant to the Council of Ministers Decision No. 2017/9986, published in the Official Gazette dated April 6, 2017 (No. 30030), upon the proposal of the Ministry of Trade of the Republic of Türkiye and the Capital Markets Board, in accordance with Article 53 of the Union of Chambers and Commodity Exchanges of Türkiye Law No. 5174 and the Turkish Commercial Code No. 6102 (TÜRİB, 2025).

Farmers who store their products in licensed warehouses receive Electronic Warehouse Receipts (EWRs) in return for their goods. They can either sell these receipts on TMEX or use them as collateral when applying for credit. Through this investment support mechanism, which operates under government assurance, a secure environment has been created for the buying and selling and exchange of goods. For farmers, this system not only provides an alternative financing model that enhances the sustainability of agriculture but also contributes to the development of the national economy.

3. Methodology

3.1. Research Purpose and Scope

The aim of this study is to promote the wider market participation of medicinal and aromatic plants (MAPs), to increase their market value, and to introduce the use of Electronic Warehouse Receipts (EWRs) as an alternative financial resource for producers of these plants.

In line with this purpose, the scope of the research includes an examination of the financial and economic aspects of integrating medicinal and aromatic plants into the value chain of licensed warehousing and the Turkish Mercantile Exchange (TMEX) system. The research analyzes storage processes, legal frameworks, market mechanisms, and financial opportunities available to producers.

3.2. Research Method, Sample, and Technique

In accordance with the aim and scope of the research, interviews were conducted only with warehouse managers and specialists directly involved in the processes of storing medicinal and

aromatic plants in licensed warehouses and trading them on the Turkish Mercantile Exchange (TMEX).

At this stage, purposeful sampling was initially chosen to identify relevant participants, followed by snowball sampling to expand the sample size.

Data were collected from 12 licensed warehouses across Türkiye. In this context, semi-structured, in-depth interviews were conducted with expert personnel working in these warehouses. The ethical approval for the interview form used in the study was granted by the Artvin Çoruh University Scientific Research and Publication Ethics Committee with the decision dated 22.02.2024 and numbered E-18457941-050.99-129358.

The licensed warehouses included in the study are concentrated in the provinces of Ankara, Giresun, Konya, Gaziantep, Şanlıurfa, Mardin, and Diyarbakır. Accordingly, the research focuses exclusively on individuals who are directly involved in the storage and trading of medicinal and aromatic plants within the licensed warehouse and TMEX systems.

The main objective of the research is to analyze the existing structure, identify its development potential, determine the economic and structural barriers, and propose policy recommendations accordingly. For this purpose, a multi-layered qualitative analysis strategy was adopted. The analysis process consists of the following stages:

Thematic Coding (Deductive Thematic Analysis): Data are coded according to predefined themes developed based on the literature, research questions, and interview guide. The coded data are then categorized under relevant sub-themes.

Content Analysis: The codes within each theme are analyzed in detail to identify recurring expressions, key concepts, and verbal patterns. Participant statements are supported with representative quotations.

Interpretive Connections and Policy Implications: The findings are contextualized within the conceptual framework, and for each theme, structural and economic barriers as well as proposed solutions are presented. In this way, both academic contributions and policy-level recommendations are developed.

3.3. Findings

In line with the purpose of the research, the data are first evaluated using the thematic analysis method.

3.3.1. Thematic Coding (Deductive Thematic Analysis)

Based on the literature and expert opinions, a total of four main themes were predetermined according to the semi-structured interview form developed for the study. These themes are presented below.

Table 2

Relationship Between Main and Sub-Themes

Main Theme Code	Main Theme Title	Sub-Themes
A	Participant Profile and Institutional Structure	A1. Geographical Distribution and Representation A2. Type of Institution and Organizational Structure A3. Professional Positions A4. Educational Level A5. Gender Representation A6. Duration of Experience and Institutional Memory
B	Plant Awareness, Knowledge Level, and Storability	B1. Knowledge of Medicinal and Aromatic Plants B2. Sources of Information and Awareness Gaps B3. Perception of Storability B4. Technical/Spatial Conditions (odor, humidity, form) B5. Drying, Packaging, Shelf Life B6. Technical Standards and Regulatory Knowledge B7. Experience-Based Suitability Criteria
C	Warehouse Infrastructure and Operational Conditions	C1. Physical Infrastructure (humidity, ventilation, temperature) C2. Insulation and Odor Management C3. Packaging–Palletizing Practices C4. Product Inflow–Outflow Process C5. Personnel Competence and Operational Experience C6. Digital Systems and Traceability
D	TMEX and EWR Process	D1. Institutional Awareness and Definition of TMEX D2. Market Conditions and Legal Compliance D3. Knowledge Level on the EWR System D4. Product Suitability and Regulatory Limitations D5. Transaction Duration and Validity D6. Market Potential and Demand Uncertainty D7. Economic Contribution and Risk Perception D8. Obligation and Usage Patterns of EWR D9. Integration Between EWR and TMEX

Main Theme A: Participant Profile and Institutional Structure:

Examining the structural characteristics of the institutions where participants work reveals that most are organized as private-sector entities, either as joint-stock companies or family-owned businesses. Regarding professional positions, participants hold various roles such as expert, accounting officer, purchasing manager, company owner, and authorized classifier. In terms of educational background, the majority hold undergraduate or graduate degrees, mainly in disciplines

such as economics, business administration, and food engineering. The fact that all participants are male indicates that the sector has limited gender representation in terms of equality. Lastly, most participants possess five or more years of institutional experience, suggesting that the interview data are grounded in long-term observations and organizational memory.

Main Theme B: Plant Awareness, Knowledge Level, and Storability:

The majority of participants openly stated that they have limited knowledge about products categorized as "medicinal and aromatic plants." During interviews, expressions such as "I have no knowledge," "I don't know much," or "our system is mostly grain-based" were frequently mentioned. This demonstrates that while sector representatives have a general awareness of plant-based alternative products, their technical knowledge remains insufficient. However, some warehouse representatives—particularly company owners or technical managers—stated that certain species, such as lavender and thyme, could be stored in dried form.

Main Theme C: Warehouse Infrastructure and Operational Conditions:

The interviews emphasized the importance of elements such as dried form, low humidity, sealed packaging, and odor isolation. However, there is no systematic knowledge or standardized approach regarding how these elements should be implemented operationally. Some participants stated that their current warehouse systems lack specialized sections, shelving, or isolated compartments for such products, expressing the need for physical segregation with remarks such as "if it's dry, we may store it, but it needs a separate space so the smell doesn't mix." This suggests that storing aromatic products together with other goods poses a risk of quality degradation. Moreover, the number of participants who provided direct, species-based assessments of storability was quite limited.

Main Theme D: TMEX and EWR Process:

The results of the interviews indicate that while most participants are generally familiar with the TMEX and EWR systems, they possess significant knowledge gaps regarding their implementation details. The TMEX system is often defined as "a structure where products are traded on the exchange," while the EWR is conceptualized as "a document representing the stored product." However, there is no clear awareness of how medicinal and aromatic plants could be traded within these systems or what technical and legal conditions must be met. This shows that participants' understanding of the system is mostly theoretical, with limited practical experience.

They also highlighted the uncertainty of product-based trading criteria. Questions such as which characteristics medicinal and aromatic plants should possess to be traded on TMEX, which laboratory processes they must undergo, and which documents are required could not be clearly answered. Additionally, knowledge regarding fundamental elements such as validity period, valuation methods, and transaction procedures was found to be quite limited.

3.3.2. Content Analysis

Main Theme A: Participant Profile and Institutional Structure:

In terms of geographical distribution, the participants operate in various provinces such as Ankara, Diyarbakır, Giresun, Konya, Gaziantep, Şanlıurfa, and Mardin, representing diverse regions and enhancing representativeness.

Regarding professional positions, participants hold a wide range of roles, including Human Resources Specialist, Authorized Classifier, Food Engineer, Accountant, Procurement and Licensed Warehousing Specialist, Company Owner, Board Member, and Appraiser. This diversity ensures representation from administrative, technical, and managerial roles, allowing perspectives from multiple institutional levels.

In terms of gender distribution, all participants were male, highlighting the weak gender representation in the sector.

Examining educational and professional backgrounds shows that most participants hold bachelor's or master's degrees in fields such as economics, food engineering, and business administration. Accordingly, while the participants have strong technical and managerial knowledge, diversity at the fieldworker level remains limited.

Regarding institutional experience, most participants have over five years of experience, indicating strong institutional memory and process awareness.

Main Theme B: Plant Awareness, Knowledge Level, and Storability:

The content analysis results under Main Theme B are presented below:

1.Knowledge Level on Medicinal and Aromatic Plants:

The majority of participants stated that they possess only a basic level of knowledge about this product group and lack detailed information or experience. Direct quotations on this issue include:

"I don't have much knowledge about medicinal and aromatic plants." (Gaziantep)

"Our system mainly works with grains. These plants are not part of our field." (Konya)

"We don't have knowledge on this; we haven't received or processed such products." (Giresun)

These statements indicate that knowledge-based capacity in the sector regarding this product group is low, and practical application remains very limited.

2.Specific Plant Knowledge and Product-Based Awareness:

Responses to questions on specific plant knowledge and product-based awareness revealed that some participants are familiar with certain plant species (e.g., lavender, thyme). However, this awareness is mostly interpretive rather than experiential. Direct quotations include:

"It could be thyme or lavender, but if left exposed, their scents mix, and the quality drops." (Diyarbakır)

"Products like lavender and thyme may be suitable in the future, but we haven't experienced it." (Tokat)

"We haven't received any plant products, and there has been no guidance on this." (Giresun)

Accordingly, it can be inferred that species-based awareness is limited, but the system has the potential to expand if proper guidance is provided.

3.Storability Criteria:

Participants appear to base their decisions on storability largely on observational criteria. The key criteria emphasized include:

Dried form: "We accept it if moisture is below 10%, but this limit isn't the same for all plants."

Packaging condition: "Loose products cause problems; they must be packaged."

Odor profile and isolation: "Aromatic products like thyme and lavender leave their scent on other goods."

Technical uncertainty: "Some products would require laboratory testing."

These responses indicate that storability criteria are not based on systematic standards but rather evolve according to operational habits and individual experiences.

4.References to Legislation and Standards:

Only a few participants indirectly referred to legal or technical regulations. Example quotations include:

"There is a system under the Ministry of Trade, but I haven't seen specific guidance for these products."

"I don't think these plants are defined in the warehouse legislation."

Overall, the content analysis of Theme B suggests that the sector's knowledge level regarding medicinal and aromatic plants is low and awareness of practical implementation is limited; however, there is potential for development in certain product categories if proper institutional guidance is provided.

Main Theme C: Warehouse Infrastructure and Operational Conditions: The results of the content analysis under Main Theme C are presented below:

1. Current State of Warehouse Infrastructure and Traditional Structure: The majority of participants stated that licensed warehouse systems are primarily designed for traditional products such as grains and oilseeds. Direct quotations include:

"Our system is entirely built for products like wheat, barley, and corn." (Tokat)

"We have never received different products so far; our infrastructure isn't suited for them." (Konya)

"We only have licensed products; we haven't accepted any medicinal plants." (Gaziantep)

These findings indicate that the existing infrastructure lacks the flexibility to support product diversification.

2. Physical Conditions for Medicinal and Aromatic Plants: Participants emphasized that specific physical conditions must be met for the acceptance of these products. The most frequently mentioned elements were humidity control, odor isolation, and the requirement for packaged products. Direct quotations include:

"We accept it if moisture is below 10%, but this limit isn't the same for every plant."

"If aromatic products mix their scent with others, quality drops; they need a separate section."

"We don't accept open products; packaging is mandatory."

"We might store it if it's dry, but it would need a separate place to avoid odor transfer." (Diyarbakır)

These responses reveal that medicinal and aromatic products require specialized storage areas, shelving systems, and isolated conditions to maintain their quality.

3. Operational Uncertainty and Lack of Experience: None of the participants reported any practical experience regarding the acceptance or handling of medicinal and aromatic plants. Direct quotations include:

"We haven't received them, so we don't know how to store them."

"I don't know how the process works; we haven't been trained."

"The rules are unclear; no one provides guidance."

These statements indicate that, in addition to infrastructural limitations, there is also a serious lack of operational knowledge and experience.

4. Alternative Storage Needs and Future Perspectives: Some participants noted that due to their small volume, high value, and sensitive nature, medicinal and aromatic plants may require different storage systems. Representative statements include:

"Shelf-type storage might be more suitable."

"Temperature- and humidity-monitored areas may be needed."

"The inflow–outflow tracking process would differ from regular products."

These insights suggest that the system needs updating not only in terms of physical infrastructure but also in technological capacity.

Overall, the analysis of this theme shows that licensed warehouse infrastructures are structured for traditional product groups and are currently unsuitable for medicinal and aromatic plants. Insufficient physical conditions, lack of specialized areas, and limited experience emerge as key obstacles to integrating this product group. However, with technical guidance and infrastructure adaptation, certain products could have feasible storage potential.

Main Theme D: TMEX and EWR Process:

The content analysis results for Main Theme D are presented below: General Knowledge

1. Level About TMEX and EWR: Most participants had limited knowledge about the TMEX and EWR systems. While they were familiar with the basic concepts, they lacked practical understanding of the procedures. This is reflected in the following statements:

"To trade on TMEX, you need to meet certain conditions, but we've never sent a product in this category."

"EWR is only used for hazelnuts in our system; we've never tried it for other products."

"There's information about which products can be traded, but nothing specific for medicinal plants."

"Only traditional products are included in the EWR system; I don't know how it works for others."

Thus, while theoretical awareness exists, there are no product-based practical applications.

2. Uncertainty in Trading Criteria: Participants lacked clear knowledge about the technical, legal, and analytical requirements for medicinal and aromatic plants to be traded on TMEX. Statements include:

"Even if we store the plant, we're not sure if it can be traded."

"It's unclear what criteria determine trading eligibility."

"We issued an EWR, but couldn't find a platform for trading."

"We don't know if analysis or certification is required."

These comments highlight the absence of defined standards for product suitability, analytical requirements, and classification criteria.

3. Perception of Economic Benefit and Risk: Some participants acknowledged that the EWR system could potentially enhance financial access; however, they also pointed out limitations related to price stability, buyer interest, and valuation challenges.

"If EWRs are issued, they could serve as collateral, but valuation would be problematic for aromatic plants."

"I'm not sure if banks would accept the product's value."

"It could work if there's demand abroad, but who determines the price in Türkiye?"

These statements demonstrate that, despite its financial potential, the system does not yet function effectively for medicinal and aromatic plants.

4. Legal Uncertainty and Lack of Guidance: Participants expressed uncertainty about issues such as whether issuing an EWR is mandatory, which laboratory to apply to, and which documents are required. Example statements include:

"We don't know who grants the necessary permissions."

"We know the procedure for hazelnuts, but no one provides guidance for products like thyme."

"I don't know how long an EWR remains valid or how it expires."

These findings suggest that legal processes must be clarified to expand the system.

In general, the findings reveal that although most participants possess theoretical knowledge of the TMEX and EWR systems, there are significant gaps and practical deficiencies concerning the integration of medicinal and aromatic plants into these frameworks. The lack of clear product-based trading criteria limits system usability. Furthermore, despite the potential economic benefits, challenges related to valuation, market acceptance, and regulatory guidance hinder the system's overall functionality.

3.3.3. Interpretive Connections and Policy Implications

3.3.3.1. Main theme a – interpretive evaluation and policy recommendations

The findings show that participants in the licensed warehousing sector exhibit significant geographical and institutional diversity, which makes standardization in practices difficult. Although the predominance of private-sector organizations provides flexibility in decision-making processes, it also leads to variations in regulatory interpretation. The diversity of participants' professional roles provides a multi-dimensional perspective to the sector but also creates imbalances in technical knowledge levels. Furthermore, the fact that all participants are male reveals the limited level of gender representation in the sector, while the presence of experienced personnel indicates that institutional memory is strong but not yet effectively transferred to innovative practices.

In light of these findings, it is recommended to:

- Develop region-sensitive guidance models that consider local differences,
- Prepare flexible regulatory manuals tailored to different types of institutions,
- Establish role-based training and certification programs,
- Promote female employment,
- Encourage the inclusion of experienced personnel in innovation-oriented initiatives,
- Adopt a representation-based approach in policy development processes.

3.3.3.2. Main theme b – interpretive evaluation and policy recommendations

The results indicate that participants' knowledge level regarding medicinal and aromatic plants is generally limited and that a systematic knowledge infrastructure has not yet been established in the sector. A lack of technical detail is evident, although some company owners and technical staff have developed awareness and limited experience with specific plants such as lavender and thyme. Storability assessments appear to be based largely on personal observation and experience, rather than on legal or scientific criteria. This suggests that instinctive decision-making dominates, and access to legal and pharmacopoeial standards remains weak.

Nevertheless, the existing potential and partial accumulation of experience indicate that knowledge and awareness levels in the sector could be improved through appropriate guidance, technical training, and product-based regulatory compliance programs.

Accordingly, it is recommended to:

- Implement training and awareness programs to increase sector-wide knowledge and capacity,
- Prepare product-specific technical manuals,
- Establish scientifically grounded evaluation systems,
- Create communication platforms to facilitate information sharing,
- Support mentorship roles for experienced actors, and
- Simplify access to national legislation and pharmacopoeia standards through clear, user-friendly guidelines.

3.3.3.3.Main theme c – interpretive evaluation and policy recommendations

The findings reveal that existing licensed warehouse systems are primarily designed for grains and oilseeds, and therefore lack adequate physical and operational infrastructure for storing medicinal and aromatic plants. Participants emphasized the need for special conditions concerning odor isolation, humidity control, and packaging, but noted that shelf-type storage systems, isolation units, and environmental monitoring technologies are not yet available. The lack of practical experience demonstrates that the sector has not yet achieved familiarity with these products at an operational level.

However, positive opinions about the potential acceptance of certain products such as lavender and thyme under specific conditions indicate that the system possesses a degree of flexibility and adaptability. Despite infrastructure limitations, the presence of guidance and pilot implementation opportunities suggests a developmental capacity that could be expanded with proper direction.

Based on these findings, the following are recommended:

- Establish technical storage standards specific to medicinal and aromatic plants,

- Encourage modular and shelf-type infrastructures,
- Expand pilot projects to test feasibility,
- Develop technical training programs for warehouse personnel,
- Prepare flexible operational guidelines for product acceptance, and
- Create support mechanisms for odor and humidity monitoring technologies,
- Disseminate implementation manuals across the sector.

3.3.3.4.Main theme d – interpretive evaluation and policy recommendations

The findings indicate that licensed warehouse representatives have limited knowledge of the Turkish Mercantile Exchange (TMEX) and the Electronic Warehouse Receipt (EWR) systems, and that practical awareness regarding their operation is weak. While participants can conceptually define these systems, they lack information on how medicinal and aromatic plants could be integrated, analyzed, and classified within them. Uncertainties regarding product valuation, price stability, and collateral acceptance by financial institutions are key barriers preventing system expansion. These challenges reveal not only technical but also regulatory and informational gaps, which create a significant institutional void.

In general, while the potential of TMEX and EWR systems is acknowledged, the integration of medicinal and aromatic plants into these market mechanisms requires clear regulations, practical guidelines, and directive policy frameworks.

Based on the findings, it is recommended to:

- Develop plant-specific legislation for integrating medicinal and aromatic plants into TMEX and EWR systems,
- Prepare simplified implementation manuals,
- Establish transparent valuation and pricing mechanisms,
- Launch pilot projects to create model warehouse processes,
- Strengthen collaborations with financial institutions for collateral recognition, and
- Expand awareness programs to promote system understanding among stakeholders.

3.3.3.5.Summary of policy recommendations by theme

Based on the information above, a summary table of policy recommendations developed for each theme is presented below.

Table 3

Policy Recommendations Related to the Themes

Main Theme	Policy Recommendations
A. Participant Profile and Institutional Structure	Targeted awareness and capacity-building programs should be implemented for enterprises with different organizational structures, taking regional diversity into account.
B. Plant Awareness, Knowledge Level, and Storability	Plant-based technical training sessions should be organized, regulatory guideline documents should be prepared, and awareness-raising programs should be developed for warehouse representatives with limited knowledge.
C. Warehouse Infrastructure and Operational Conditions	Technical criteria and investment incentive mechanisms should be established to make warehouse infrastructures suitable for plant acceptance. Odor isolation and shelf-type storage systems should be supported.
D. TMEX and EWR Process	Product-based legislative regulations should be developed to integrate medicinal and aromatic plants into the TMEX and EWR systems, and criteria such as validity period, valuation method, and trading requirements should be clarified.

As shown in the table, there are significant deficiencies in areas such as capacity, infrastructure, legislation, knowledge, standards, and integration.

4. Conclusions and Recommendations

This research was conducted to examine the storability of medicinal and aromatic plants (MAPs) under suitable conditions in licensed warehouses and their potential to be traded on the Turkish Mercantile Exchange (TMEX). Within this scope, a multi-layered qualitative data analysis was carried out through literature-based review, document analysis, and semi-structured in-depth interviews.

The analysis and findings indicate that licensed warehouses currently lack sufficient technical infrastructure for the storage of medicinal and aromatic plants. Parameters such as light, humidity, and temperature cannot be controlled according to product-specific standards, and several challenges exist regarding the integration of these products into current storage regimes.

On the other hand, it was observed that the Electronic Warehouse Receipt (EWR) system, which provides financial flexibility in agricultural products, could potentially increase producer motivation if applied to medicinal and aromatic plants as well. Some licensed warehouse

representatives expressed a positive attitude toward expanding this system but stated that the lack of clear regulations causes hesitation in its implementation.

The TMEX system and licensed warehousing practices are largely focused on grain and nut-based products, while the integration of medicinal and aromatic plants into these systems has not yet been institutionally addressed. Based on the results of this study, several policy recommendations have been developed:

- *Regulatory Adaptations*: Amendments should be made within the framework of Law No. 5300 to allow the inclusion of medicinal and aromatic plants in the licensed warehousing system. Product definitions for these plants should be established under TMEX to enable their inclusion in the EWR system.
- *Infrastructure Standardization*: Minimum criteria for light, humidity, and temperature control should be determined in warehouses. A classification system with compliance certificates for medicinal and aromatic plants should be introduced.
- *Product-Based Shelf Life and Quality Classification*: In collaboration with universities and public institutions, product-specific storage protocols should be developed based on characteristics such as shelf life and volatile oil loss.
- *Financial Incentive Mechanisms*: Credit systems backed by plant-based EWRs should be supported through Ziraat Bank and Agricultural Credit Cooperatives, providing low-interest loan opportunities for small producers.
- *Pilot Applications for TMEX Integration*: Pilot trading definitions should be established for selected plants (e.g., thyme, sage, lavender), and trial trading operations should be implemented on the exchange.
- *Training and Awareness Activities*: Training programs on the EWR and TMEX systems should be developed for licensed warehouse operators, producers, and cooperatives, along with widespread dissemination activities.
- *Digital Tracking and Traceability*: To enhance the reliability of EWRs, digital labeling and QR code systems should be integrated for tracking plant-based products.

The findings of this study provide valuable insights for the Ministry of Agriculture and Forestry, TMEX, Commodity Exchanges, producer cooperatives, and private-sector licensed

warehouse operators. In particular, the improvement of storage infrastructure, expansion of regulations, and widespread use of the EWR system will strengthen both producer security and the agricultural value chain. Furthermore, improving the system's functionality will contribute to the local, regional, and national economy, beginning with farmers.

This study revealed the potential for integrating medicinal and aromatic plants into the licensed warehousing and TMEX systems, offering policy-relevant findings on infrastructure, regulation, and financial mechanisms in the sector. The research concludes that incorporating these products into the economic value chain will enhance producer security and promote regional development.

For future research, it is recommended to conduct mixed-method (hybrid) studies supported by quantitative data analysis, monitor product-based pilot applications in different geographical regions, and model the relationship between TMEX trading volume, price fluctuations, and the medicinal plant market. Additionally, experimental analyses on shelf life and quality preservation criteria for different plant species are suggested, as well as the development of a "suitability index" for plants to be integrated into the licensed warehousing system.

The limitations of this study include the sample being restricted to licensed warehouses in specific geographic regions, the inability to generalize findings due to the use of qualitative methods, and the interviews being limited to managerial-level participants. Moreover, since the study does not include quantitative modeling, its predictive capacity regarding market impacts and financial outcomes remains limited.

In conclusion, this study provides a multidimensional analysis of medicinal and aromatic plants, emphasizing their evaluation not only as biological entities but also as economic and strategic assets. In doing so, it contributes directly to policy development processes in addition to generating scientific knowledge.

Declaration of Research and Publication Ethics

In order to apply the survey method in this study, permission was obtained from the Artvin Çoruh University Scientific Research and Publication Ethics Board with letter number 129358 dated 12.02.2024, and this study complied with research and publication ethics.

Researcher's Contribution Rate Statement

The authors contributed equally to the article.

Declaration of Researcher's Conflict of Interest

There are no potential conflicts of interest in this study.

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