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Assessment of Medicinal and Aromatic Plants' Contribution to the Country's Economy by Hybrid Multi-Criteria Decision-Making Approach: The Case of Turkey

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ABSTRACT
Medicinal and aromatic plants contribute to both the national economy and the well- being of forest villagers. In addition, these plants are generally used in a variety of industries such as medicine, food, paint, and perfumery. It is gaining popularity, and individuals are turning to herbal therapy as an alternative medical treatment. These medicinal plants can be popularised and utilised to boost the economies of medicinal-growing countries and provide livelihoods for local stakeholders. Furthermore, overexploitation of these therapeutic plants should be restricted, important species with high marketing potential should be protected, and cultivation of these plants should be encouraged for future use. Against this background, this study employs a hybrid multi-criteria decision-making technique to identify the medicinal and aromatic plants that contribute the most to the Turkish economy. The medicinal and aromatic plants that contributed the most to the country's economy were found to be poppy seed, thyme, and laurel leaves. Moreover, the seed (sesame seed, flax seed, safflower seed) plants are determined as the least contributing medicinal and aromatic plants to the country's economy. Cumin, anise, and salvia have also potential in terms of economics. Hence, these findings can help the farmers and decision-makers to determine which plants are more economically beneficial. Thus, plants with high economic value can be cultivated and exported to the rest of the world.

Keywords: TOPSIS, Entropy, Medicinal and aromatic plants

1. Introduction

Non-wood forest products are defined as all kinds of herbal or animal products other than wood raw materials obtained from forests. Medicinal and aromatic plants account for the majority of non-wood forest products worldwide, including in Turkey (Kurt et al. 2016).

Mostly medicinal and aromatic plants are used to preserve human health or to cure and prevent disease. They are also utilised in nutritional supplements, herbal tea, flavour, spice, skin care, fragrance, and cosmetics (Anonymous 2005; Faydaoğlu & Sürücüoğlu 2011).

The history of medicinal and aromatic plants is as old as human history itself. The oldest book of medicinal and aromatic plants was written by Chinese Emperor Shen Nung in 3700 BC. More than 200 plants are mentioned in the book (Temel et al. 2018). For instance, the Sumerian clay medications engraved with cuneiform including agricultural and medicinal knowledge, which are roughly 5000 years old, are among the oldest recorded writings concerning the usage of plants. It comprised 12 recipes for drug preparation using variety of over 250 plants (Petrovska 2012). The Ebers papyrus, which is supposed to have been written in 1500 B.C., is the oldest and most important written resources about the medicinal and aromatic plants, including over 870 prescriptions and formulae and 700 medicinal herbs (Okigbo et al. 2009). In addition, Hippocrates, the founder of Greek medicine, and Aristotle, his student, used medicinal plants to treat diseases (Jamshidi-Kia et al. 2018).

The oldest information about these plants in Turkey can be traced to; the 11th century when IbniSina mentioned various medical substances in the second volume of his book titled ' Canon of Medicine ' (Nasser et al. 2009). Ibn al-Baytar (1197-1248) authored a work titled 'Compendium of Simple Drugs and Food'. In this study, more than 1400 medical drugs were defined (Abu-Rabia 2005).

Today, the use of plants for therapeutic purposes varies according to the development level of the countries. While 80% of the population in developing countries uses herbal products therapeutically, the rate of its use for this purpose is lower in developed countries. In some countries in Asia, Africa, Latin America and the Middle East, the rate of herbal product use is above 85%. In addition, currently, it is estimated that over half of pharmaceutical drugs are derived from medicinal plants (Acıbuca & Budak 2018; Jamshidi-Kia et al. 2018). According to FAO, about 30% of all drugs sold worldwide contain compounds derived from plant material (FAO 2005).

There are a total number of 422000 plant species in the world. 72000 of these are medicinal and aromatic plant species and the highest number of these are in China with 4941, followed by India, USA, Vietnam, Thailand, Pakistan and Malaysia (Schippman et al. 2006). In Europe, over 2000 medicinal and aromatic plants are employed for different purposes. Albania, Bulgaria, Poland, Hungary and Turkey are leading suppliers of medicinal and aromatic plants to European nations (Güney 2019). Today, medicinal plants are estimated to have an annual market value of approximately $60 billion (Faydaoğlu & Sürücüoğlu 2011).

Turkey is very abundant in flora, with approximately 12000 plant species. Over 25% of these are aromatic plants and about 8% of plant species are used in medicine purpose (Baser 2002). Approximately 400 of these plant species in Turkey are exported (Karık & Tunçtürk 2019).

Examining the foreign trade performance of medicinal and aromatic plants in the world reveals that the medicinal and aromatic plants reached a volume of 70.7 billion dollars worldwide in 2019. Turkey increased its export of medicinal and aromatic plants, which was approximately 106 million dollars in 2001, to approximately 371 million dollars in 2019 by increasing 3.5 times. Import of medicinal and aromatic plants in world trade was 71.9 billion dollars in 2019. In recent years, Turkey's medicinal and aromatic plant imports have increased and reached an import value of 656.5 million dollars in 2019 (General Directorate of Agricultural Research and Policies-TAGEM 2021).

There are several studies on the production, consumption, trade, use, market, history, ethnobotanics, and chemical and biological structure of medicinal and aromatic plants (Jamshidi-Kia et al. 2018; Göktaş & Gıdık 2019; Karık & Tunçtürk 2019; Ravi & Bharadvaja 2019; Tohidi et al. 2019; Zougagh et al. 2019; Sprea et al. 2020; Yücel & Yücel 2020). There is a limited study that attempts to identify those which contribute the most to the national economy among medicinal and aromatic plants using the Multiple Criteria Decision Making Methods in medicinal aromatic plants.

The Multi-Criteria decision making (MCDM) methods assist decision makers in making decisions in cases where there is more than one conflicting criterion. The MCDM methods divide the problems into smaller pieces, allowing handling complex problems. There are various MCDM methods used in the literature such as Analytical Hierarchy Process, Entropy, ELECTRE, TOPSIS, VIKOR (Mardani et al. 2015). In some studies, the MCDM methods have been used alone (Halicka 2020) or in combination with other methods (Singh et al. 2020). In this research, a hybrid MDCM was used, which was created by combining the Entropy and TOPSIS methods.

Among to the decision-making methods, the TOPSIS method was chosen to rank alternatives in this study because its process is simpler, it is easier to understand, it is one of the popular method, it provides good performance in different areas, it allows direct application on the obtained data, it needs less subjective input, and it has intuitive and clear logic that represents the rationale of human preference by considering both the best and worst attributes of the alternatives simultaneously (Roszkowska 2011; Vafai et al. 2018; Bahadır 2020; Emovon & Albuecefe 2020; Ersen et al. 2022). The basic principle of the TOPSIS method is based on ranking the alternatives according to the ideal solution. Starting from the alternative that is relatively close to the ideal solution, a ranking is carried out and then the relative closeness of the other alternatives is determined, respectively (Cheng-Min 2001).

One of the most important stages for MCDM methods is the determination of the criterion weights because each criterion has a different meaning and importance in a MCDM problem (Alp et al. 2015; Çatı et al. 2017). The weighting process, which shows the importance level of the criteria, is generally done in two ways: subjective weighting and objective weighting (Shemshadi et al. 2011). In subjective weighting methods, like Analytic Hierarchy Process (AHP) and Delphi, decision makers evaluate the criteria (Lofi & Fallahnejad 2010). Objective weighting methods, like entropy and CRITIC, are completely based on the characteristics of the available data (Ecer, 2020). Entropy method was chosen in this study because it is a well-known and widely used objective weighting method in decision making problems and it can prevent subjective preference assessment in the decision making process (Alp et al. 2015; Yuan et al. 2019). Entropy is a tool used to evaluate criteria in a decision matrix that contains alternative information (Nijkamp 1977).

There are many studies in which two methods were used together in the field of agriculture. Pakpour et al. (2013) attempted to identify the best of ten DNA extraction methods for agricultural soil using seven criteria. They used the entropy method for weighting the criteria and the TOPSIS method for ranking the DNA extraction methods. Wang & Hao (2016) examined the supply chain risk assessment of fresh agricultural products. They used the improved TOPSIS method, which is a combination of the improved entropy and the TOPSIS. Li et al. (2018) evaluated to the suitability of groundwater for domestic and agricultural purposes using entropy-weighted TOPSIS. Li et al. (2019) evaluated the agricultural water resources allocation plans with the entropy-based TOPSIS method. Wang et al. (2021) analyzed the impact of agricultural extension service on sustainable agricultural development using entropy and TOPSIS methods. Chen et al. (2021) focused on the agricultural investment environment and its influencing factors in the countries around the Black Sea. Criterion weights were determined by the Entropy method and the TOPSIS method was used to rank the countries. Lu et al. (2022) is designed a model on the selection of agricultural machinery with the help of the method formed by the combination of CRITIC, entropy, and GRA-TOPSIS and agricultural machines are ranked with this model. The financial performances of ten agricultural companies are examined with the help of the Entropy-TOPSIS method by Zheng & Wu (2022). Wang et al. (2022) aimed to evaluate the sustainable development level of agriculture with data obtained from 13 cities in China from 2016 to 2019 and applied the entropy and TOPSIS models. In recent years, Entropy-TOPSIS has been also successfully applied to various areas, such as transportation (Huang et al. 2018), product design (Tiwari 2019), competitiveness (Liang et al. 2019), innovation (Chen et al. 2020), construction (Dehdasht et al. 2020), energy (Sun & Yun 2021), safety (Omidi et al. 2022), optimization (Wang et al. 2022), education (Wang et al. 2022) and financial (Yen et al. 2023).

In the paper, the medicinal and aromatic plants that contribute to Turkey's economy more greatly have been attempted to be determined using a hybrid multi-criteria decision-making method. The weight values (importance levels) of the criteria were determined using the Entropy method. The ranking of alternatives was made via the TOPSIS method. Thanks to this paper, medicinal and aromatic plants that contribute the most to the economy of the country have been identified and will aid in taking the necessary measures for those products in practice.

2. Material and Methods

2.1. Material

The data were collected from the Turkey Statistical Institute and Turkey General Directorate of Forestry, and the research covers the past decade (2012-2021). The data obtained from the General Directorate of Forestry are the amount of production of laurel leaf, rosemary and linden. Another data used in the study are obtained from the Turkey Statistics Institute (TSI 2022).

2.2. Method

2.3. The Entropy method

The Entropy method was proposed by Shannon & Weaver (1949). This method is defined as the measure of uncertainty in information formulated using probability theory (Shemshadi et al. 2011; Yuan et al. 2019). The entropy method consists of 4 steps (Li et al. 2011).

Step 1: Creating the decision matrix

There are alternatives in the lines section of the decision matrix and evaluation criteria in the columns section. The decision matrix is given below:

$$X = \begin{vmatrix} x_{11} & x_{12} & \dots & x_{1j} & \dots & x_{1m} \\ x_{21} & x_{22} & \dots & x_{2j} & \dots & x_{2m} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ x_{i1} & x_{i2} & \dots & x_{ij} & \dots & x_{im} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ x_{n1} & x_{n2} & \dots & x_{nj} & \dots & x_{nm} \end{vmatrix}$$

Step 2: Normalization of the decision matrix

The data were subjected to normalization using the equations below.

$$a_{ij} = x_{ij} / max_{ij} (i=1,\dots,n;\ j=1,\dots,m) \tag{1}$$

$a_{11} = 26490 / 39935 = 0.66333$

$$a_{ij} = min_{ij} / x_{ij} (i=1,\dots,n;\ j=1,\dots,m) \tag{2}$$

$a_{13} = 5 / 1021 = 0.00490$

$$P_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \tag{3}$$

$$P_{11} = \frac{0.663328}{(0.663328 + 0.395893 + 0.253512 + 0.420508 + 0.001427 + 0.058771 + \cdots + 0.499186 + 1)} = 0.14238$$

Where: i is alternative; j is criteria;P_{ij} is normalized value, and a_{ij} is benefit value.

Step 3: Calculating the entropy (e_j) value

The entropy value of each criterion is calculated by using the equation (4). The k value in the equation represents the entropy coefficient. The e_j value takes a value between 0 and 1.

$$e_j = -k \sum_{i=1}^{n} P_{ij}\, InP_{ij} \tag{4}$$

$$e_j = -0.345976 * [(0.14238 * ln0.14238) + (0.08497 * ln0.08497) + (0.05441 * ln0.05441 + (0.09026 * ln0.09026) ... + (0.21464 * ln0.21464)] = 0.7844$$

$$k = (\ln n)^{-1}$$

$$k = (\ln 18)^{-1} = 0.345976$$

Step 4: Calculation of weight (w_{ij}) value

The formula of w_{ij} is given in the equation (5). The sum of the weight values calculated for each criterion should be 1.

$$w_{ij} = \frac{1-e_{ij}}{\sum_{j=1}^{m}(1-e_{ij})} \tag{5}$$

$$w_{11} = \frac{0.2156}{(0.2156 + 0.3086 + 0.5985 + 0.3299 + 0.3589)} = 0.1190$$

2.3. The TOPSIS method

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method was first proposed by Hwang & Yoon (1981), and later developed by Yoon (1987) and Hwang et al. (1993). This method starts with the creation of the decision matrix and consists of 6 steps. The stage of forming the decision matrix was described in the steps of the Entropy method, and the other steps were listed as follows (Tsaur 2011).

Step 2: Normalization

Normalization of the data was calculated with the help of the equation (6).

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \tag{6}$$

$$r_{11} = \frac{26490}{\sqrt{26490^2+15810^2+10124^2+16793^2+57^2+2347+17649^2+1829^2+\cdots+19935^2+39935^2}} = 0.41026$$

Step 3: Creating a weighted and normalized decision matrix

Following normalization, weight value (w_j) is determined for each criterion. Then, the weight values are multiplied by the normalized process data ($V_{ij} = r_{ij} * w_j \rightarrow V_{11} = 0.4126 * 0.1190$), and the V matrix are obtained.

$$V = \begin{bmatrix} r_{11}w_1 & \dots & r_{1n}w_n \\ \dots & \dots & \dots \\ r_{1n}w_1 & \dots & r_{mn}w_n \end{bmatrix}$$

Step 4: Determination of positive (v+) and negative (v-) ideal solution values

Weighted-normalized data are used to determine positive ideal solution and negative ideal solution values. Positive ideal values are determined using the equation (7), and negative ideal values are determined using the equation (8).

$$v^+ = \left\{\left(\sum_i^{max} v_{ij}/j \in J\right), \left(\sum_i^{min} v_{ij}/j \in J'\right)/i = 1,2, \dots . n\right\} \tag{7}$$

$$v^{+} = (0.0736007, \quad 0.0990801, \quad 0.0000099, \quad 0.1139570, \quad 0.0000431)$$

$v^{-} = \{(\sum_i^{min} v_{ij} / j \in J), (\sum_i^{max} v_{ij} / j \in J') / i = 1,2, \dots . n\}$
(8)$v^{-} = (0.0000018, \ 0.0000117, 0.2912629, \ 0.0000833, \ 01954206)$

Step 5: Calculation of positive (s_i^+) and negative (s_i^-) ideal solution distances

Positive and negative ideal solution distance values are calculated using Equations 9 and 10. Euclidean distances are used in the calculation.

$$s_i^{+} = \left\{\sqrt{\sum \left(v_{ij} - v_j^{+}\right)^2}\right\} \tag{9}$$

$$s_1^{+} = \sqrt{\begin{array}{c}(0.0488214 - 0.0736007)^2 + (0.0783154 - 0.0736007)^2 \\ +(0.0020275 - 0.0736007)^2 + \\ (0.0766841 - 0.0736007)^2 + (0.0012634 - 0.0736007)^2\end{array}} = 0.0494$$

$$s_i^{-} = \left\{\sqrt{\sum \left(v_{ij} - v_j^{-}\right)^2}\right\} \tag{10}$$

$$s_1^{-} = \sqrt{\begin{array}{c}(0.0488214 - 0.0000018)^2 + (0.0783154 - 0.0000018)^2 \\ +(0.0020275 - 0.0000018)^2 + \\ (0.0766841 - 0.0000018)^2 + (0.0012634 - 0.0000018)^2\end{array}} = 0.3684$$

Step 6: Calculation of the relative degree of approximation (c*) to the ideal solution and ranking

The relative degree of approximation to the ideal solution for each alternative is calculated using the equation (11). C* takes a value between 0 and 1. Alternatives are ranked according to their c* value. The alternative with the highest value is ranked first.

$$c_i^{*} = \frac{s_i^{-}}{s_i^{-} + s_i^{+}} \tag{11}$$

$$c_1^{*} = \frac{0.3684}{0.0494 + 0.3684} = 0.8818$$

3. Results and Discussion

The decision matrix consists of alternatives and evaluation criteria. There are 18 alternatives and 5 criteria in this research. The alternatives are: laurel leaves, thyme, anise, cumin, coriander, black cumin, sesame seed, hop, salvia, lavender, mint, rosemary, linden, fenugreek, poppy seed, flax seed, carobs, and safflower seed. Although there are many definitions of medicinal and aromatic plants in the literature, the products included in the scope of medicinal and aromatic plants are not clearly specified. In this research, the products (alternatives) used in many studies and the data of which are available were taken into consideration. The criteria in the study also were constructed by referring to the studies on forest products (Bayram 2020) and fishery and aquaculture products (Akmermer & Çelik 2021). The criteria are: production, export quantity, import quantity, export value, and import value. One of the main objectives of countries is economic growth. The role of foreign trade is very important in the economic growth process of countries. Because it activates internal dynamics. Today, economic development cannot be achieved without foreign trade. Foreign trade consists of exports and imports (Şerefli 2016). In addition, the increase in production, in the agricultural sector and manufacturing industry, positively affects all elements of sustainable development (economic, social, environmental and institutional) and therefore, increases economic growth (Behun et al. 2018). The arithmetic mean of the production, export and import quantities of each alternative in the decision matrix were determined, along with the weighted mean of the export and import values of each alternative. The decision matrix is given in Table 1. The institution that is responsible for the management of non-wood forest products in Turkey is The General Directorate of Forestry (GDF) which is affiliated with the Ministry of Agriculture and Forestry. In Turkey, non-wood forest products are generally grown in the forest and 99% of forests are owned by the state (Ok & Tengiz 2018).

Table 1- Decision matrix (TSI 2022; GDF 2022)

Alternatives	*Production (tonnes)*	*Export Quantity (tonnes)*	*Import Quantity (tonnes)*	*Export value (000$)*	*Import value (000$)*
Laurel leaves	26490	13389	1021	37730	1467
Thyme	15810	16939	1794	56069	4640
Anise	10124	2613	1743	9706	3941
Cumin	16793	5105	1753	15272	3945
Coriander	57	157	895	276	468
Black cumin seed	2347	380	3122	1066	2811
Sesame seed	17649	10373	146673	22078	226912
Hop	1829	5	167	41	2107
Salvia	586	1954	986	7451	2432
Lavender	1463	2	5	68	242
Mint	16658	471	85	1598	131
Rosemary	193	679	620	1939	844
Linden	64	95	63	1093	251
Carobs	15489	1489	3394	3214	10002
Fenugreek	633	89	253	174	184
Flax seed	1	321	62624	161	31321
Poppy seed	19935	15274	14	50698	50
Safflower seed	39935	1300	47055	686	16322

Following the decision matrix created, the data were normalized using Equations 1, 2 and 3 (P_{ij} values were obtained).

$$P_{ij} = \begin{vmatrix} 0.14238 & 0.18955 & 0.00310 & 0.18025 & 0.01440 \\ 0.08497 & 0.23981 & 0.00176 & 0.26786 & 0.00455 \\ 0.05441 & 0.03699 & 0.00182 & 0.04637 & 0.00536 \\ 0.09026 & 0.07227 & 0.00180 & 0.07296 & 0.00535 \\ 0.00031 & 0.00222 & 0.00353 & 0.00132 & 0.04513 \\ 0.01261 & 0.00538 & 0.00101 & 0.00509 & 0.00751 \\ 0.09486 & 0.14685 & 0.00002 & 0.10547 & 0.00009 \\ 0.00983 & 0.00007 & 0.01894 & 0.00020 & 0.01002 \\ 0.00315 & 0.02766 & 0.00321 & 0.03560 & 0.00868 \\ 0.00786 & 0.00003 & 0.63273 & 0.00032 & 0.08727 \\ 0.08953 & 0.00667 & 0.03722 & 0.00763 & 0.16122 \\ 0.00104 & 0.00961 & 0.00510 & 0.00926 & 0.02502 \\ 0.00034 & 0.00134 & 0.05022 & 0.00522 & 0.08414 \\ 0.08325 & 0.02108 & 0.00093 & 0.01535 & 0.00211 \\ 0.00340 & 0.00126 & 0.01250 & 0.00083 & 0.11478 \\ 0.00001 & 0.00454 & 0.00005 & 0.00077 & 0.00067 \\ 0.10715 & 0.21624 & 0.22597 & 0.24220 & 0.42239 \\ 0.21464 & 0.01840 & 0.00007 & 0.00328 & 0.00129 \end{vmatrix}$$

Using the Equations (4) and (5), the entropy value and the weight value of each criterion were determined. The entropy and weight values are given in Table 2.

Table 2-Entropy and weight values

Entropy and weight	*Production (tonnes)*	*Exportquantity (tonnes)*	*Import Quantity (tonnes)*	*Export value (000$)*	*Import value (000$)*
$\mathbf{e_j}$	0.7844	0.6914	0.4015	0.6701	0.6411
w_j	0.1190	0.1704	0.3304	0.1821	0.1981

The weight values of the criteria determined by the Entropy method were found as import quantity (0.3304), import value (0.1981), export value (0.1821), export quantity (0.1704), and production quantity (0.1190). This result represented that the import quantity is of greater significance to the ranking of the economic value of medicinal and aromatic plants in Turkey. In the study of the contribution of forest products to the national economy by Bayram (2020), the entropy weight value of the import quantity criterion was found to be the highest. Although exports are vital for a country's development and growth, the balance of imports and exports should also be observed. Imports in particular, play an important role for emerging economies such as Turkey. In the Turkish economy, imports have a larger share than exports (Çoşkun 2019). Necessary steps should be taken to reduce the dependence on imports and to increase exports (Yurdakul & Uçar 2015). In Turkey, various steps are taken to increase exports, such as creating regional export associations, and providing incentives to businesses engaged among others (Çoşkun 2019).

After determining the significance levels of the criteria using the Entropy method, the alternatives were ranked using the TOPSIS method. In the TOPSIS method, the decision matrix (Table 1) used in determining the weights of the criteria was employed. Firstly, the normalization of the data in the decision matrix was performed. Equation (6) was used for normalization. Then, the V_{ij} matrix was obtained. To get this matrix, the normalized data were multiplied by the weight values of the criteria. The V_{ij} matrix was given below.

$$V_{ij} = \begin{vmatrix} 0.0488214 & 0.0783154 & 0.0020275 & 0.0766841 & 0.0012634 \\ 0.0291380 & 0.0990801 & 0.0035625 & 0.1139570 & 0.0039961 \\ 0.0186587 & 0.0152840 & 0.0034612 & 0.0197269 & 0.0033941 \\ 0.0309497 & 0.0298603 & 0.0034811 & 0.0310395 & 0.0033975 \\ 0.0001051 & 0.0009183 & 0.0017773 & 0.0005610 & 0.0004030 \\ 0.0043256 & 0.0022227 & 0.0061997 & 0.0021666 & 0.0024209 \\ 0.0325273 & 0.0606741 & 0.2912629 & 0.0448723 & 0.1954206 \\ 0.0033709 & 0.0000292 & 0.0003316 & 0.0000833 & 0.0018146 \\ 0.0010800 & 0.0114294 & 0.0019580 & 0.0151437 & 0.0020945 \\ 0.0026963 & 0.0000117 & 0.0000099 & 0.0001382 & 0.0002084 \\ 0.0307009 & 0.0027550 & 0.0001688 & 0.0032478 & 0.0001128 \\ 0.0003557 & 0.0039716 & 0.0012312 & 0.0039409 & 0.0007269 \\ 0.0001180 & 0.0005557 & 0.0001251 & 0.0022215 & 0.0002162 \\ 0.0285464 & 0.0087095 & 0.0067398 & 0.0065323 & 0.0086139 \\ 0.0011666 & 0.0005206 & 0.0005024 & 0.0003536 & 0.0001585 \\ 0.0000018 & 0.0018776 & 0.1243586 & 0.0003272 & 0.0269742 \\ 0.0367405 & 0.0893412 & 0.0000278 & 0.1030408 & 0.0000431 \\ 0.0736007 & 0.0076040 & 0.0934417 & 0.0013943 & 0.0140568 \end{vmatrix}$$

Ideal positive (v^+) and negative solution (v^-) values were obtained with the help of the V_{ij} matrix. v^+ values were determined by choosing the highest value from each criterion (column) value, and v^- values were determined by choosing the lowest value.The positive and negative ideal solution values are given in Table 3. The assessed criteria play a decisive role in determining the positive ideal solution and the negative ideal solution. Among the criteria selected in this study, import quantity and import value are negative criteria, the smaller of which is the better, whereas the amount of production, export quantity and export value are the positive criteria, the larger of which is the better. Finally, S^+, S^-, C^* values were calculated using equations (9, 10, and 11), respectively, and the alternatives were ranked based on C^* values.

Table 3-Positive and negative ideal solution values

Ideal solution distance	*Production (tonnes)*	*Export quantity (tonnes)*	*Import Quantity (tonnes)*	*Export value (000$)*	*Import value (000$)*
v^+	0.0736007	0.0990801	0.0000099	0.1139571	0.0000431
v^-	0.0000018	0.0000117	0.2912629	0.0000833	0.1954206

When Table 4 was examined, the importance levels of medicinal and aromatic plants in terms of contribution to the country's economy were ranked as follows: poppy seed, thyme, laurel leaves, cumin, anise, salvia, carobs, mint, rosemary, linden, black cumin seed, lavender, hop, fenugreek, coriander, safflower, flax seed and sesame seed.

The reason for the poppy seed’s first-place position in the ranking is that its amount of production, export quantity and export value are quite high. It is noteworthy that Turkey's poppy seed import is quite low. In terms of poppy seed trade, Turkey is among the leading countries in the world (Acıbuca & Budak 2018). Other medicinal and aromatic plants, which are significant for the Turkish economy, were found to be thyme and laurel leaves. Like poppy seeds, the production quantity and export quantities and values of thyme and laurel leaves are high. The export quantities and values of these three products are considerably higher than the others. Turkey is the leading exporter of thyme in the world (Bağdat 2006). In addition, approximately 90% of the total world market share belongs to Turkey for laurel leaves (Semerci & Çelik 2017).

Being the lowest among the products that contribute to the country's economy, it is a remarkable finding that the amount and value of sesame seed imports are high. While the production of sesame seeds may be high, the export amount and value are quite low. Flax seed production in Turkey is at a very low level, and Turkey meets its flax seed needs through imports. Another remarkable result is that although safflower seed production and import is high, its contribution to the country's economy is low. Turkey is a net importer of the seed trade (Ceylan et al. 2018). Although the production of sesame and safflower seeds is high, measures should be taken to reduce dependence on foreign markets and increase exports.

Table 4-S^+, S^-, C values and ranking

Alternatives	S^+	S^-	*C*	***Rank***
Laurel leaves	0.0494	0.3684	0.8818	3
Thyme	0.0448	0.3782	0.8941	2
Anise	0.1376	0.3474	0.7162	5
Cumin	0.1162	0.3500	0.7507	4
Coriander	0.1670	0.3490	0.6763	15
Black cumin seed	0.1635	0.3443	0.6781	11
Sesame seed	0.3619	0.0821	0.1850	18
Hop	0.1665	0.3495	0.6773	13
Salvia	0.1507	0.3485	0.6981	6
Lavender	0.1667	0.3506	0.6777	12
Mint	0.1529	0.3519	0.6971	8
Rosemary	0.1628	0.3494	0.6821	9
Linden	0.1661	0.3505	0.6785	10
Carobs	0.1478	0.3417	0.6980	7
Fenugreek	0.1669	0.3502	0.6772	14
Flax seed	0.2097	0.2371	0.5307	17
Poppy seed	0.0397	0.3780	0.9051	1
Safflower seed	0.1731	0.2784	0.6166	16

In the last part of the study, sensitivity analysis was performed to test the stability and robustness of the proposed model (Entropy-TOPSIS method). One of the approaches used in sensitivity analysis is to determine how the ranking of the alternatives changes due to the variability in the criteria (Lee & Chang 2018). The executed calculations for sensitivity analysis are based on the equations given in Yazdani et al. (2020), which can be consulted for details. First, the weight elasticity coefficients of the criteria are calculated and the results are given in Table 5. The weight elasticity coefficient of the most important criterion is always assumed to be 1. Then, the limiting bounds of weight change (Δx) for the most important criterion are calculated. This is between -0.3304 and 0.6696.After defining these limits, 9 new weights are calculated based on different values for Δx, as seen in Table 6. The rankings of medicinal and aromatic plants obtained for new criteria weight values are given in Table 7.

Table 5-Weight coefficient of elasticity used changing weights

Criteria	α_c
Import quantity (w_3)	1.0000
Production (w_1)	0.1777
Export quantity (w_2)	0.2545
Export value (w_4)	0.2720
Import value (w_5)	0.2958

Table 6-New criteria weights

Scenarios	Δx	w_1	w_2	w_3	w_4	w_5
Original value	0.0	0.1777	0.2545	0.0000	0.2720	0.2958
Scenario 1	-0.3	0.1723	0.2467	0.0304	0.2637	0.2869
Scenario 2	-0.2	0.1545	0.2213	0.1304	0.2365	0.2573
Scenario 3	-0.1	0.1368	0.1958	0.2304	0.2093	0.2277
Scenario 4	0.1	0.1012	0.145	0.4304	0.1549	0.1685
Scenario 5	0.2	0.0835	0.1195	0.5304	0.1277	0.1389
Scenario 6	0.3	0.0657	0.0941	0.6304	0.1005	0.1093
Scenario 7	0.4	0.0479	0.0686	0.7304	0.0733	0.0798
Scenario 8	0.5	0.0301	0.0432	0.8304	0.0461	0.0502
Scenario 9	0.6	0.0124	0.0177	0.9304	0.0189	0.0206

Table 7-The rankings of alternatives based on new weight criteria

Alternatives	*Original ranking*	*S1*	*S2*	*S3*	*S4*	*S5*	*S6*	*S7*	*S8*	*S9*
Laurel leaves	3	3	3	3	3	3	3	3	2	2
Thyme	2	2	2	2	2	2	2	2	3	3
Anise	5	5	5	5	5	5	5	5	5	12
Cumin	4	4	4	4	4	4	4	4	4	4
Coriander	15	15	15	15	15	15	14	14	14	13
Black cumin seed	11	11	11	10	13	14	15	15	15	14
Sesame seed	18	18	18	18	18	18	18	18	18	18
Hop	13	16	16	14	12	12	11	11	11	10
Salvia	6	8	7	6	6	6	6	6	6	6
Lavender	12	13	13	12	11	11	12	12	12	8
Mint	8	7	6	7	8	8	7	7	7	5
Rosemary	9	10	10	9	9	9	9	9	8	9
Linden	10	12	12	11	10	10	10	10	10	7
Carobs	7	9	8	8	7	7	8	8	9	15
Fenugreek	14	14	14	13	14	13	13	13	13	11
Flax seed	17	17	17	17	17	17	17	17	17	17
Poppy seed	1	1	1	1	1	1	1	1	1	1
Safflower seed	16	6	9	16	16	16	16	16	16	16

As can be seen in Table 6, setting different weights to the criteria causes a change in the ranking of some alternatives. However, for all the scenarios, while poppy seed is found as the most valuable medicinal and aromatic product for Turkey, the least valuable medicinal and aromatic product is sesame seed. This result is an indication that the proposed model is stable. Moreover, these changes are confirmed by the values of the Spearman rank coefficient correlation the rankings for different scenarios and are displayed in Figure 1.

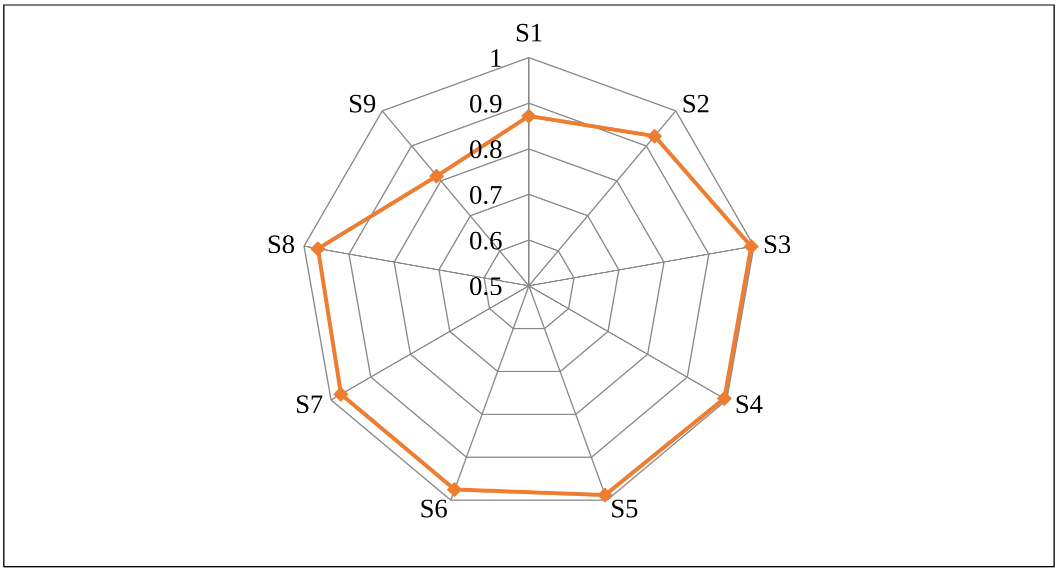

Figure 1- Spider diagram of Spearman rank coefficient correlation for 9 scenarios

According to the Spearman rank correlation analysis, it is seen that there are 87.2%, 92.8%, 99.4%, 99.4%, 98.8%, 97.5%, 97.5%, 96.9% and 81.4% similarities between the original ranking and the scenarios, respectively. The overall mean Spearman rank correlation coefficient of all the scenarios is found as 0.945, which emphasizes the reliability of the original ranking.

4. Conclusions

Medicinal and aromatic plants support the national economy as well as the well-being of forest communities. Furthermore, these plants are commonly employed in a range of sectors including medicine, food, paint, and fragrance. The value of several medicinal and aromatic plants on the national economy was investigated in this study. The following findings were obtained: Using the Entropy approach, it was discovered that the import amount was the most significant criteria, while the production quantity was the least significant. Given the requirements and alternatives, the most economically significant items among the therapeutic aromatic plants under consideration are poppy seed, thyme, and laurel leaves. Among the therapeutic aromatic plants, seed plants contribute the least to the country's economy.

Cumin, anise, and salvia have also been found to have economic potential. These products are usually exported unprocessed in Turkey and therefore they create low added value to the country's economy.

In order to test the robustness and the reliability of the method used in the study, a sensitivity analysis consisting of 9 scenarios and the Spearman rank correlation analysis were performed. Regarding 9 scenarios, supporting the study, poppy seed is found as the most valuable and sesame seed is found as the least valuable medicinal and aromatic product. Spearman rank correlation coefficient also was found higher than 0.80 for all scenarios. Thusly, the robustness and the reliability of the methodology are shown.

This study could add a new dimension to medicinal and aromatic plants research. Generally, there are studies related to the classification, usage areas, production and foreign trade of medicinal and aromatic plants. There is no known research on the economic contribution to Turkey. As a result of this research, this gap in the literature will be filled. In this respect, this research is one of the pioneering studies and provides both a theoretical and practical contribution. With this and similar studies, decision makers can determine which products are of greater economic significance.

Although this research has advantages, it also has limitations. While determining the criteria and alternatives in the study, attention was paid to whether the data were available and to receive the data from a reliable source. By accessing data from various databases, the number of criteria and the number of alternatives can be increased. In addition, different criteria weighting and alternative ranking methods can be used. Therefore, the use of only five criteria in the study can be seen as an important deficiency of the study.

According to the findings obtained from this study, suggestions for the future are as follows:

- Most of the medicinal and aromatic plants exported in our country are collected from nature. However, when the plant collectors do not have information about the harvest period, sustainability, etc., they are collected unconsciously, which causes both extinction of the plants and not the desired standards of the collected plants. Therefore, a regulation on the collection of medicinal and aromatic plants should be issued and necessary legal regulations should be made.
- Since the demand for medicinal and aromatic plants has increased with the emergence of Covid-19 disease, studies should be carried out to cultivate as many plants as possible, especially plants with high commercial value and used in Turkey. For this, an inventory of medicinal and aromatic plants in all provinces should be taken and then the most suitable places for the habitat of the species should be determined. Thus, the production of medicinal and aromatic plants will increase and country's exports will be much more than imports.
- In particular, plants grown in nature can be used as a gene source instead of meeting the demand and exporting, and sustainability can be ensured in these plants.
- Incentive supports can be provided for the production of medicinal and aromatic products with high commercial value. For example, VAT reduction, tax exemption, support of production services such as seeds, saplings, spraying, diesel, certification, etc.
- In order to increase production, the contracted production model, which has been successfully applied in thyme production, can be applied in other medicinal and aromatic plants.
- In Turkey, certified seed production is carried out with domestic facilities of many species. Seed production is carried out especially in vegetables, field and some forage plant species. However, certified medicinal and aromatic plants seed is not sufficient. It is seen that the seed production for medicinal and aromatic plants does not meet the domestic demand and the country is foreign-dependent for these products. For this reason, it is necessary to carry out agronomic studies, breeding studies, and registration and certification procedures for species and varieties. Seed producers who want to produce seeds of medicinal and aromatic plants should be encouraged and public and private sector cooperation should be increased. Furthermore, seed subsidies and subsidized loans should be determined according to the policy of producing domestic varieties instead of imported varieties. In order to prevent seed imports, import quotas may be set and customs tax rates may be increased.

- A large part of Turkey's exports of medicinal and aromatic plants are realized in unprocessed form and the contribution of these products to the country's economy is low. The products should be processed in processing and packaging facilities and converted into high value-added products. For the establishment of such facilities, incentives, for example grants and zero-interest loan support to producers, tax exemption etc., can be provided to the producers.

- A supreme committee may be established, consisting of experts on medicinal and aromatic plants, affiliated to the Ministry of Agriculture and Forestry, operating for the purpose of determining all kinds of national policies regarding medicinal and aromatic plants.

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