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Assoc. Prof. Dr. Vedat Çavuş

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CHAPTER 1

CONTRACTED PRODUCTION MODELS IN AGRICULTURE SECTOR

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Introduction

Agriculture in our country has been the driving force in other sectors, especially in industry, throughout history. There have been important developments in exports, agriculture and agro-industrial products. Considering the developments in the economy in recent years, it is seen that both the contribution of the agricultural sector to the national income and its share in the total labor force tend to decrease. The share of agriculture in national income was over 30% in the 1960s; this rate was between 25-30% in the 1970s and 20-25% in the 1980s; In the 1990s, however, it first fell below 20%, then gained a fairly "stable" or "stable" level of around 12.5-15%. This is because more emphasis is placed on development in the industrialization and services sectors (Kepenek 2012).

In Türkiye, the idle capacity in the food industry is 50% and the rate of processing of agricultural products in the industry is 10%. It is necessary to establish a relationship based on the principle of equality between the agriculture, industry and trade sectors and to establish a system for the healthy sharing of the added value created. For this purpose, contracted production is carried out directly between individual producers or producer organizations and industrial and commercial enterprises in many countries around the world. The issue of producing and supplying raw materials suitable for the industry in sufficient quantity and regularly has led these companies to establish direct relations with the producers and the enterprises have started contract agriculture. Contract manufacturing is a production and marketing model preferred by manufacturers and companies in many countries as it is a guarantee against various risks. In contract agriculture, although the producers undertake to deliver the product of a certain time, quantity and quality to the contracting organization, the said organization must guarantee to purchase this product at a certain price and provide the necessary input, technical information and services for these production activities. In this model, the amount, properties, usage time, application methods and other applications of the inputs used in production can be determined in the contracts made between manufacturers and companies (Özçelik et al. 1999. Michelson 2018).

This method has made it easier for farmers to market their products profitably. Product production is guaranteed by making contracts based on various conditions between the manufacturer and the company. Farmers and companies have various problems related to this issue. One of the biggest problems for both sides is climatic conditions. Depending on the climatic conditions, the situation of collecting the harvest late or not getting the harvest occurs. This situation causes great losses for the manufacturer and the company. Other important issues that are emphasized in contract production are the type of production, technique and technology, quantity, quality, time and product price. Contract production also has advantages for the farmer and the company. With contract farming, producers are guaranteed to receive the amount of product specified in the contract. Thanks to organic agriculture, which is within the scope of contract agriculture, new employment areas are created for agricultural engineers. Farmers carry out production with seedlings and seeds provided by the company, which ensures an efficient product in terms of quality. There is a price payment guarantee at the end of the manufacturer's delivery between the dates specified in the contract. Due to some reasons, companies may delay their price payment transactions, which causes the manufacturer's reaction. Therefore, manufacturers do not give their goods to the company in the next period and market their products in the free market.

In this section, the concept of contract farming is explained and its development is mentioned.

1. CONTRACTED PRODUCTION

1.1. Definition and Importance

Through the 1980s and 1990s mainstream agricultural economics and new institutional economics examined emerging contract farming schemes to evaluate their possible contribution to agricultural development and to the welfare of smallholder farmers in developing countries. Contract farming had expanded rapidly in the late 1970s and through the time of publication of Living Under Contract (Vicol et al. 2021).

Contract farming is an approach that can be followed in all proposed alternative strategies for vertical integration. In this model, direct producers can establish relations with industry and trade companies, as well as producer organizations, especially unit cooperatives and cooperative superior organizations, by binding their members to themselves within the framework of their main contracts, to sell a certain quantity and quality of product to buyers at a certain price (Özçelik et al. 1999). In contracted production, the contracts that the producers make with the companies individually or through their organizations are binding on both parties. It is not easy to make a general definition of contract manufacturing. According to a classical definition made by Roy (1963), written or oral agreements between the farmer and other firms that regulate one or more issues related to the production and marketing of an agricultural product (Adams et al. 2019, Rehber 2016, Meemken and Bellemare 2020).

With the agreements made between manufacturers and companies, the company in question can provide in-kind and cash loans and technical assistance to the manufacturers. Such small farmers can be integrated to some extent with the national economy, accelerate technology transfer and provide significant potential for agricultural development. With this system, the production of vegetables and fruits, which can rationally evaluate the family workforce, require careful care and provide high income per unit, can be successful in small businesses. Being able to bring ancillary services to small businesses is also an important advantage. When the contract production model is well planned, it enables the preparation of sales programs and future evaluations, especially in marketing management (http://samsun.tarim.gov.tr). With contracted production, consumers can become conscious and the resulting demand can be met continuously. Contract agriculture makes a significant contribution to the rapid transfer of new production techniques to the field of application. If agricultural activities are carried out in large numbers and in small enterprises, deficiencies may occur in terms of semaya and management. With the contracted production model, it is aimed to eliminate these deficiencies. In addition to these, contract manufacturing provides risk reduction, cost reduction, improvement of management, providing appropriate input, adaptation and development of new technologies, and capital supply. The contracted production model can be defined as an agreement-based production and marketing model in which the companies guarantee to receive the product to be obtained under certain conditions, despite the fact that the planting and planting of the product or the responsibility of the farmer to realize a certain cultivation area and production between the producers and companies.

1.2. Historical Development

1.2.1 World

It is not a type of production based on contractual relations, which is a form of vertical coordination, but was used in sugar production in Taiwan, the colonial state of Japan, after 1885, and in banana production by US companies in Central America until the early 20th century (Watts 1994). In advanced capitalist countries, contract farming practices were widely featured in North American vegetable and canning businesses and in Western Europe in the seed sector in the 1930s and 1940s (Rehber 2016).

Truly contract farming has its roots in the seed industry in Europe and North America. After 1945, the seed industry was restructured, and in the 1970s and early 1980s, mergers and cooperation among seed companies became widespread. Globalization trends in this sector are parallel to the expansion and spread of contract production in the seed industry. Here, in general, local companies report the demands of international companies to the manufacturers; thus, two separate contracts are made, one between the manufacturer and the local company, and the other between the local company and the international company. Towards the end of the 20th century, contract farming became a critical element of the food industry in Western Europe, North America, and Japan. In the last two decades, there have been significant developments in this area in underdeveloped countries; multinational companies, international financial institutions such as the World Bank and Asian Development Bank supported these formations. They dealt with contract agriculture within the social organization model in the development of rural areas and used it together with rural development and resettlement projects (Hekimoğlu and Altındeğer 2012, Federgruen et al. 2019, Otsuka et al. 2016 Rehber 1997a).

By the end of the 20th century, contract farming had become an integral part of the food and agricultural products processing industry throughout Western Europe, North America, Japan and many other countries. Contract in general is a multifaceted concept. There are written and verbal agreements between individuals regarding many activities in rural areas. The convention is used in different fields and in different ways in agriculture as in other fields. Market-facing agreements, e.g. purchasing products agreement (typically specifying price, quantity and delivery time) is one of these examples (Özçelik et al. 1999). Contract agriculture has been widely applied in recent years as an institutional innovation and sometimes a key element in rural development and settlement projects to improve agriculture in underdeveloped and developing countries. Some international aid and credit institutions such as local governments, private local firms, multinational companies, the US Agency for International Development, the World Bank, the Asian Development Bank, the Commonwealth Development Association have taken part in such contracted agricultural projects (Özçelik et al. 1999).). From this point of view, contract agriculture can be divided into two general groups, taking into account the practice. The first of these is the "private contract" group, which is applied in the private sector as explained above. The second group is "contracted agricultural projects".

The future development of agriculture in developing and third world countries depends to some extent on a well-organized cooperation between agriculture and industry and trade. In developing countries, a dynamic partnership can be established with a contract between international companies and small farmers, technology transfer is ensured, small businesses can be modernized and they can be protected from negative economic developments. (Anonim 2016, Özçelik et al. 1999). There is also the possibility that a large number of unorganized small operators in developing countries can be exploited if faced with a single buyer in the market. Contract production, which started to be applied intensively in fruit and vegetable production especially since the 1960s, later found application in livestock breeding, meat poultry, dairy cattle, sugar cane and sugar beet cultivation. It is seen that contracted production is concentrated in the production of products that are generally industrial raw materials (Duymaz 1985).

Although contract farming varies by country, it has found application in almost every country. For example, companies such as Heinz, Del Monte and United Brands in Central America have a large market share, especially in the export of fresh fruits and vegetables. These firms make contracts with the producers either during the harvest or at the beginning of the production activity. Multinational or international companies have adopted the contract production model in the agro-industry. Agri-industry relations in Canada and Latin America can be a model for developing countries. In developing countries, contracts can be made with the participation of both public and private enterprises. The participation of the public in this system can be either directly as the receiving party or indirectly through the financing of the system. In the USA, according to 1990 data, contract farming practice was 8% in pig farming, 7% in food and feed grains and 12% in cotton, while it reached 90% in broilers and 80% in vegetable processing. (Kelley 1994, Singh 2002).

National and international companies turn to various measures such as credit, price and market security, technical assistance in order to bind the producers to themselves, which can cause unilateral dependence for farmers. This dependency may lead to the transfer of positive values created by agricultural workers to industrialists. As a matter of fact, due to the unilateral dependence of producers on buyers, contract farming has not been widely accepted in some EU countries such as France (Güler 1996, Özçelik et al. 1999).

1.2.2 Türkiye

It is very difficult to reach national figures on contract farming practices. Almost all of the sugar beet processing and commercial butchery chicken production is carried out under contractual relations. In the vegetable and fruit processing sector, contract production has started to be used as a common way of providing input. The most common application in this field is in the tomato processing industry. The development that emerged with partnerships with local companies and especially multinational seed companies in the seed sector in Turkey after the 1980s has led to an increase in contractual relations in this sector as well. In the dairy sector, which is developing on the way to industrialization, it is seen that the industry-producer relations in this sector will become contractual with the decision to purchase and sell the raw milk supplied to the industry with the regulation issued in 2015, on a contractual basis. In addition, the credit applications of banks based on product contracts are also important for the spread of contract agriculture. (https://www.aydinlik.com.tr/sozlesmeli-tarim-ve-turkiye)

Since the establishment of the republic in 1923, Turkey has been a country in an effort to transition from an agricultural economy to an industrial economy. Although significant progress has been made in this area, the main problems of the agriculture and food sector still await solutions when compared to developed countries. The share of agriculture in national income and export value is gradually decreasing, and in 2010 it was 8.4% and 4.32%, respectively. In 2010, the shares of the rural population and the active labor force employed in agriculture were approximately 23.75% and 25.15%. State-owned agricultural enterprises have played an important role in Turkey. Their numbers have dwindled in recent years through privatization and direct sales. According to 2015 data, there are still 18 agricultural enterprises with 3.3 million decares of land in different regions of Turkey. These enterprises have played an important role in the development of contracted agricultural practices in agriculture in Turkey, as in other areas. The development of the food industry in Turkey, like other sectors, started with the republican period. The first sugar factory was established in 1926. After the transition to the planned economy in 1963, there have been remarkable developments. These developments accelerated in the 1970s with market-oriented trends rather than inward-looking policies. After 1980, Turkey started a structural change and entered a period of liberalization and privatization. Despite the many incentives given to the sector in the five-year development plans since 1960, the food sector has not reached the desired level. Although it is difficult to find reliable data, it can be said that while the share of processed foods in total food consumption is around 60% in developed countries, this rate is around 10-30% in Turkey. In general, there are three different systems in the marketing of agricultural products in Turkey. Some products are marketed in a more organized manner through State Economic Institutions and existing cooperatives. These institutions have been very influential in the historical process, especially meat and fish, milk, tobacco, sugar, etc. They have fulfilled important functions in the processing and marketing of products. Agricultural sales cooperatives (TSK) had an important place in the price support system. The contribution of cooperatives in the development of the Turkish food industry is also great. The first agricultural sales cooperative was established in 1911 to process figs. According to 2006 data, there are 328 Agricultural Sales Cooperatives with 595439 members under 17 Unions. As of April 2015, 13 of these 17 unions are active and there are 289 cooperative members with a total number of 393292 members to these active unions (Rehber, 2016). When the structure of the Turkish food industry is evaluated in terms of vertical coordination, it is seen that the relations have a structure that changes from spot market transactions, deep-rooted customer relations to contractual arrangements. As observed in the examined region, while the contract is the only way of vertical coordination in some agricultural products, spot market operations are dominant in some sub-sectors. National figures on contract farming practices are not available. The commercialized part of beet sugar processing and butchery chicken production is carried out under contractual relations. In the vegetable and fruit processing sector, contract production has started to be used as a common way of providing input. The most common application in this field is in the tomato processing industry. 80-85% of the tomatoes produced are used in tomato paste production. The Tomato Paste Exporters and Manufacturers Association, which they established with 14 big companies dealing with tomato paste production and trade, can act jointly in determining the prices of industrial tomatoes, which is the most important issue in contract farming, among other activities (Ulukan 2009). Later, the name of the association, which was expanded to include food canned producers, was changed to Paste Frozen and Canned Food Industrialists' Association (SALKONDER). After the 1980s in Turkey, production has been rapidly developed with multinational seed companies through joint ventures or production agreements with local seed companies in the seed sector. Seed production is aimed not only at the domestic market, but also at foreign markets. The export value, which was only 17.3 million dollars in 2002, reached 109 million dollars in 2011. Due to its nature, this production took place under contractual relations. In the dairy sector, which has not shown a full development until today, with the regulation published in the Official Gazette dated 16 April 2015 and numbered 29328, it is seen that the industry-producer relations in this sector will become contractual with the decision to purchase and sell the raw milk supplied to the industry on a contractual basis. (Rehber 2016). In addition, the credit practices of banks based on product contracts are also important for the spread of contract agriculture. For example, Ziraat Bank offers contracted production loans to contracted producers or contracted producers by providing agricultural inputs in whole or in part, paying advances, providing technical services related to production and guaranteeing the purchase of the product. Other commercial banks are making loan applications within this framework. Until 1996, there was no special legal regulation regarding the contract in agriculture in Turkey. On 30 June 1996, the Ministry of Agriculture published a communiqué to control the contractual arrangements (Official Gazete No. 22682). While this communiqué should have been of a general nature, it was extremely detailed, explaining a certain pricing formula. It is certain that a comprehensive regulation up to the price system would not be correct in a sector such as agricultural production, where there are many products with very different characteristics. This communiqué was amended two years later in 1998. This communiqué was not more than a standard contract form that gave the Ministry of Agriculture the right to control and participate in the arbitration process as a third party at the provincial and district levels. Later, the aforementioned "Communiqué on the Procedures and Principles Regarding Contract Agricultural Product Cultivation" was repealed, and the related decision was published in the Official Gazette dated 8 May 2008 and numbered 26870. The Agriculture Law, published in 2006, gave some responsibilities to the Ministry of Food, Agriculture and Livestock. Among these was the responsibility of making some arrangements for the development and dissemination of contract agriculture. As a result of this, in April 2008, "Regulation on the Procedures and Principles Regarding Contract Production" was published. In the regulation, the obligation to register in the farmer registration system and the ministry's involvement as a third party were criticized by the lawyers in terms of violation of freedom of contract (Rehber 2016).

1.3. Advantages and Disadvantages of Contract Agriculture

Contract manufacturing is often preferred in order to provide sufficient raw materials for the effective use of the existing capacity in the industrial sector and to protect the business performance from fluctuations in the economy (Bellemare 2012). Generally, the reasons why food industries prefer contract production; The relatively high fixed costs, the adequacy and continuity in the supply of raw materials create a very important advantage. It is not a healthy way for food businesses to provide daily raw materials in free market conditions. By making a contract, the raw material demand of the company and the uncertainties that it may encounter in the production process can be reduced. (Özçelik et al. 1999). Depending on the natural and economic conditions in agriculture, there may be monthly, seasonal and annual changes in basic economic factors such as supply, demand and price. Excessive fluctuations may adversely affect buyers, sellers and consumers. Synthetic chemicals are used little or not at all by most of the farmers in Turkey. Therefore, it can be expected that the transition to ecological agriculture will be easy. With contract farming, the entire product of the producer is guaranteed. The export price of ecological products is 10-20 percent higher than other products. With the export of organic products, an additional capacity is created for Turkish agricultural products. Therefore, every ton exported goes to a previously unreachable consumer group. The organic farming model, which requires special knowledge, creates new employment areas for agricultural engineers. Apart from these, we can list the advantages of the contract production model as follows;

- Eliminating the marketing problem of the manufacturers with the purchase and price guarantee provided by the company to the manufacturers,

• Ensuring that the manufacturer receives technical support and training from the contracted company at every production stage until the sale, increasing the yield and product quality as a result of reducing the costs by using the qualified inputs at the right time and with the right technology, and improving the product standards,

• Easing the financial burden on the company,

• Ensuring that agro-industrial organizations provide regular and high-quality raw materials and ensuring the flow of goods, cash and technical information between the farmer and the industrialist through technology transfer, creating synergies between the Bank, the company that made the production, the input seller and the manufacturer,

•Providing a balanced and continuous source of income for small farmers,

• Providing alternative employment opportunities to small farmers

• Evaluation of labour underutilization, land, buildings and miscellaneous equipment,

• Effective communication and close dialogue with manufacturers,

• It is preferred for reasons such as minimizing the loss of production with the integration it creates between production and agriculture-based industry. (http:// www. udybelgesi. com).

As the disadvantages of contract agriculture, there are significant fluctuations in the supply of agricultural products from year to year in Turkey, and this factor creates a significant disadvantage. Due to the rapidly increasing and developing population, the continuous increase in consumption level and diversity, and the characteristics of almost all of the surrounding countries demanding agricultural products, it seems difficult for organic agriculture to develop in the short term (due to the decrease in yield). A problem that arises in plant production with organic farming method is that the lands are very small, fragmented and close to each other. This situation affects organic production negatively. Because it is not possible for an organic production enterprise not to be affected by the chemicals used in other classical enterprises producing in the environment. Marketing of products grown in the ecological farming system is a new and uncertain issue, especially for the domestic market. While the absence of rotation (alternation) in the production of plant products subject to contractual production and the continuous planting of the same product cause the soil to get tired and reduce its productivity, the intense chemical inputs used in industrial tomato or American type tobacco farming pollute underground and surface water resources.

1.4. Classification of Contract Production

With contracted production, it is aimed to ensure a coordination in the decision-making, activities, planning and behavior of the economic units at successive levels. The exchange of goods, money and information flows between the two contracting parties. Thus, coordination, stability and certainty are ensured in the flow of goods between agriculture and industrial and commercial enterprises. If the legal infrastructure of the contract is strengthened, the contracts made are binding for the parties. It is possible to define contract farming as a production and marketing model based on an agreement between companies and producers before the planting, planting or production of the product, in which the farmer undertakes the responsibility of realizing a certain cultivation area and production, but guarantees to receive the product to be obtained in their companies under certain conditions. Various forms of contracted production are encountered in practice. What is essential in all these types of contracted production is the delivery of the product with certain qualities in the contract, at the specified time, and the buyer's obligation to purchase and evaluate the product to be delivered. The most important issues discussed in the contract; There are subjects such as the type of production, technique and technology, quantity, quality, time and product price. The most important disadvantage is that individual agricultural enterprises that are parties to the contract are weak and scattered. On the other hand, mostly organized industrial and commercial firms have a more effective weight in bargaining. For this reason, agriculture-industry-trade integration, which is achieved through contracted production, is generally realized and shaped under the leadership and influence of companies. The amount, quality and price of the product connected with this method are mostly determined by industry and trade companies (Vural, 2020). The fact that agriculture is increasingly under the umbrella of industry and commerce causes the agricultural surplus, which is the source of capital accumulation in agriculture, to be absorbed by other sectors and slows down agricultural development. (Özçelik et al. 1999). Vertical cooperation between agriculture, industry and commerce can be examined in 4 groups (Rehber 1996; Rehber 1997b).

Non-Contractual Relations: There is no written or verbal connection between the producer and the industrialist in this relationship. In this relationship, farmers are given full freedom with the amount of production and marketing, but there is no solution to the problems of price and quantity uncertainty of products, which are one of the most important features of agricultural production.

Integration-Like Relations: It is like the relations established between contract production and agriculture, industry and trade sectors.

Ownership-Based Integrations: In these relations, the industrialist owns the ownership of capitals such as land and buildings by purchasing or leasing, and the farmer is the employee of the company and has to perform the duties assigned to him by the company managers. In this relationship, the production can be fully controlled in terms of quality and quantity.

Relations with Producer Cooperatives: Since exchange is essential in market economies, producers and consumers need to be organized. Agricultural cooperatives established for this purpose provide inputs to producers, process and market their products. Thus, cooperation between agriculture, industry and trade sectors is established. (Özçelik et al.. 1999).

Vertical integrations established by manufacturers by making agreements directly with industrial and commercial enterprises can take three different forms. First, the manufacturer makes a contract with an industry and trade firm directly, and this method is very common. Secondly, it can be in the form of merging and expanding their activity volumes, establishing factories that process the products they produce and producing the inputs to be used in the production of these products, or making participations in the factories established for this purpose, individually or through their cooperatives. Industrial facilities to be established in the field of activity or participations to commercial and financial institutions to be established in the field of activity through individual producers or cooperatives, as well as product exchange relations in the vertical marketing channel, as well as the capital factor that has important results in terms of capital invested in subsidiaries and ownership are activated. The third is that the raw material requirements of industrial facilities are produced by their own staff on the lands they buy. Especially in large tea producing countries such as India, Indonesia and Kenya, it is the property of the same company, along with the tea garden and the operating facility established in the garden, of the large tea enterprises. These enterprises are in a structure that can greatly affect the world dry tea production and trade. (Özçelik et al. 1999).

CONCLUSION

From the producer to the consumer, the agriculture and food sector includes a series of independent but complementary activities ranging from the supply of inputs for the agricultural enterprise to the consumption of agricultural products. When the world-wide practices of contract manufacturing are examined, examples of contracts that are unlike each other, differ from product to product and reflect the experiences of each country are seen. Some peculiarities of agricultural products make it more advantageous to use contractual relations rather than full integration under ownership. The problems experienced in the contract production practice and other reasons cause the contract to be interrupted. For example, the industrialist's inability to obtain products of the desired quality, the manufacturer's inability to fulfill the technical conditions, and the problems experienced in post-contractual payments create major problems for both the manufacturer and the industrialist and may emerge as sources of risk. It is not possible to reveal all uncertainties and it is not possible to identify and include uncertainties in the contract. Costs may arise from such uncertainties. In general, the incompleteness of contracts leads to imperfect commitment problems. As a result of incomplete information, problems such as wrong selection and unethical behavior that limit the writing and implementation of contracts arise. In contractual relations, the length and detail of the contract depend on the freedom of capital, the programmability of the purpose and the separability of the vertical cooperation.

A number of measures can be taken to prevent such problems of contract production. First of all, there should be full coordination and cooperation between the producer and the industrialist. Mutual trust, understanding and economic conditions must exist in order to establish strong cooperation between the parties. According to what is presented in the theory section, the industrialist-processor needs to be aware of the need for the agricultural producer and the producer needs the industrialist-processor. Quality and quantity control are among the most important issues at every stage of the agriculture and food industry. There should be a common understanding of quality between the parties to these stages. Quality requirements may be provided from within the food chain itself, or may be determined by the government or a third party as an independent body.

In contractual relations, the role of the industrialist and the producer is important in determining the terms of the contract. For this reason, the degree of efficiency of these companies directly determines the efficiency of the contract. The action to be taken in this regard, the company should have an independent management unit that can establish healthy relations with the producers. Contracts vary from company to company. Therefore, every company should have a special management unit with the necessary infrastructure. This special unit should be recognized and managed in cooperation with other units of the firm.

An independent arbitrator can be chosen to resolve the problems between the industrialist and the producer in contracted production, so that the solution of the problems can be short and easy. The contribution of the state in contracted production is also an important solution.

The opportunities provided by the state are the development of rural infrastructure, legal regulations for the benefit of small farmers, fair trade practices, food security, development of domestic markets, etc. These issues are the main responsibilities of the state and are good solutions. However, not all contractual problems can be resolved legally in this way. For this purpose, a general framework for contracts should be determined and action should be taken in this direction. Mandatory conditions may be included in the regulations in general terms. However, contracts that go into full detail can create problems in practice. It is an important factor in the technical support provided by the firm in contracted production. In this way, the manufacturer can realize quality production. It is important to evaluate contract agriculture as a way for small-scale family businesses to access information and technologies more easily with credits and inputs, and to work on improving these features. In addition, in order to benefit from the advantages of contract agriculture, it should not be forgotten that measures must be taken to prevent and eliminate the exploitation of small producers and the exploitation of natural resources by domestic and foreign companies and multinational states. Not only we, but also large agricultural and food companies know the critical role of capitalist control and management in the reproduction of production relations. Their influence over international organizations and governments makes it easier for them to present their private interests as public good in parliaments and the public. At this stage, the Council of Ministers Decision No. 2009/15173, which envisages that Turkey's 30 agricultural basins will be divided and agricultural supports will be given by taking into account the products determined for each basin, is only a small step in the process. The next step is to change the name of the Ministry of Agriculture and Rural Affairs to the Ministry of Food, Agriculture and Livestock and to redefine the authorities and duties of the aforementioned companies to carry out their general business.

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CHAPTER 2

DETERMINATION OF THE VOLATILE COMPONENTS OF THE LEAVES OF LEMON-SCENTED EUCALYPTUS (*CORYMBIA CITRIODORA* HOOK.)

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1. INTRODUCTION

Medicinal and aromatic plants have been used as painkillers, pleasure-inducing substances, cures for diseases, and in religious rituals since the earliest times of humankind in terms of the diversity of their potential bioactive compounds. Medicinal and aromatic plants used in the treatment of diseases internally or externally by substances obtained from various parts (roots, tubers, branches, fruits, and seeds) are called medicinal plants; and, fragrant plants whose essential oils are used are called aromatic plants. Today, these plants are used in areas such as phytotherapy, pharmacy, food, spices, cosmetics, paints, and agriculture (Hakverdi and Yiğit, 2017). The use of medicinal and aromatic plants has started with the existence of humanity and continued to this day. Although the vast majority of medicinal aromatic plants are collected from nature, medicinal aromatic plants of various cultivation families are also cultivated in Turkey, as in many parts of the world (Baydar, 2013). The importance of medicinal and aromatic plants is increasing day by day. Thanks to the secondary metabolites they contain, they have gained more importance in recent years in the fields of complementary medicine, pharmacy, food, and cosmetics (Öztürk et al., 2006; Paek, 2014). Secondary metabolites with biological effects are in most cases low molecular weight compounds found in very small amounts in plants. In plants, secondary metabolites are divided into three groups (Terpenoids, Polyketides and Phenipropanoids) according to their biosynthetic origin (Öztürk et al., 2006; Verpoorte and Alfermann, 2000; Dillemann, 2014). Although secondary metabolites do not have a direct role in the vital functions of living beings, they have important roles in the protection and maintenance of health. Today, they are used as raw materials in many industrial areas such as medicines, perfumes and pesticides (Babaoğlu et al., 2001).

Plant essential oils have been used for many years for different purposes especially in scientific and commercial areas. Major areas of use include cosmetic, pharmaceutical, food industry, aromatherapy, and phytotherapy (Hammer et al., 1999). Since essential oils have a wide range of uses they have recently attracted the attention of many scientists, chemical structures of these essential oils have been studied and their biological activities have been investigated. As a result of these studies, the properties of natural products have been put into practice (Lahlou, 2004). Essential oils are obtained from the flowers, fruits, barks, leaves, rhizomes, resins, and wood parts of plants. Today, the extraction and utilization of the pure and especially the main active components of medicinal plants and the essential oils of these plants are very important both scientifically and economically. The results obtained show that the essential oils of these plants have antimicrobial activities. The pharmacological properties of essential oil and its components have also been analyzed and it has been stated that it would be beneficial to use them in medical, cosmetic and industrial fields (Kırbağ and Bağcı, 2004).

As a genus of the Myrtaceae family, *Eucalyptus* is native to Australia and is an extensive genus containing about 900 taxa. It is common in the entire Mediterranean basin, especially in tropical and subtropical regions in the world (Hillis and Brown, 1978; Brooker and Kleinig, 2004; Ergin et al., 2004). The homeland of eucalyptus, a genus of the Myrtaceae family, is Australia (William and Brooker, 1997). As an exotic tree, Eucalyptus is grown in Turkey close to the sea in the Mediterranean and Aegean Region, especially in the Eastern Mediterranean Region (Özkurt, 2002). Although eucalyptus species are widely cultivated in many countries of the world, most *Eucalyptus* species and subspecies have a natural spread in the continent of Australia and in islands close to this continent. The leaves of eucalyptus species contain rich bioactive compounds and essential oils with many biological activities, including antioxidant, antibacterial, antifungal, and anti-inflammatory properties as put forth by various studies, and are widely used in traditional medicine (Dhakad et al., 2018; Hassinea, 2014; Salehi et al., 2019). The most important of these compounds are alkaloids, terpenoids, steroids, phenols, glycosides and tannins (Bachir and Benali, 2008). Many species of eucalyptus are used in traditional medicine as an antiseptic and against upper respiratory tract infections, as well as to heal wounds and fungal infections with their leaves (Chevallier, 2001; Silva et al.,2003; Williams et al., 1998).

C. citriodora, (syn. *Eucalyptus citriodora*) is an evergreen tree native to Queensland, Australia, commonly known as the 'Lemon-Scented Eucalyptus' or 'Lemon-Scented Tree', belonging to the *Myraceae* family (Chen et al., 2007; Chippendale 2019). The genus *Corymbia* is one of the most important and widely cultured genera in the world. The leaves of *C. citriodora* (syn. *E. citriodora*) also contain eucalyptol, which is used in cough treatment. *E. citriodora* or *C. citriodora*, is traditionally used in the perfumery, cosmetics, air fresheners, aromatherapy, and dentistry, as well as for many purposes such as antipyretic medicine in the form of infusions of dried leaves obtained with hot water, anti-inflammatory, painkillers, and relieving symptoms of respiratory infections such as colds, bronchitis, flu. Hence, it is one of the medicinal plants due to its biological and pharmacological properties (Silva et al., 2003; Kharwar et al., 2010; Sebei et al., 2015). Extracts obtained from the leaves and roots of *C. citriodora* (syn. *E. citriodora*) have been found to exhibit anticancer and antioxidant activities (Gilles et al., 2010).

One of the most important and represented species in pharmaceuticals is *Corymbia citriodora* (syn. *E. citriodora*), the main source of essential oils (Andrade and Gomes, 2012). *C. citriodora* (syn. *E. citriodora*), which grows in different parts of the world, is highly valued due to its citronella-rich essential oil obtained from its leaves. Its essential oil is widely used in a number of perfumery formulations, cleaners, and disinfectants. Citronelal, obtained from *C. citriodora* (syn. *E. citriodora*) oil, is mainly used in the production of synthetic menthol and citronelol. The antibacterial, antioxidant, anticandidal, anti-inflammatory (Sebei et al., 2015; Shahwar et al., 2012], antifungal, ascaricidal and insecticidal properties of its essential oil have been determined in different studies (Husain et al., 1988; Singh et al., 2002; Luqman et al., 2008;Olivero-Verbel et al., 2009;).

It is known in the literature that various species of the genus *Eucalyptus* spp. contain essential components, fatty acids, terpenes, hydrocarbons, and alcohols. It is intended to determine the volatile components of *C. citriodora* (syn. *E. citriodora*), an exotic species that is also grown as an ornamental plant in Turkey. Volatile constituents of *C. citriodora* (syn. *E. citriodora*) were determined by the solid-phase microextraction (SPME, Supelco, Germany) method.

2. MATERIAL and METHODS

2.1. Plant Material

The plant materials *C. citriodora* (syn. *E. citriodora*) (lemon-scented eucalyptus) leaves used in this study were obtained from Mugla-Gökova locality in Turkey, area (75m) in (January-February 2022). The collected samples were put in bags, the bags were coded and labeled, and their labels included information on the time of collection, location and altitude. After collection, the plant samples were kept at ambient temperature in a semi-dark and airy place to use in the analysis of volatile components. Following the process, the specimens were brought to the Forest Department Laboratory of the Muğla Sıtkı Koçman University, Köyceğiz Vocational High School. The identification of the plant specimens was made at the Biology Department Herbarium of the Faculty of Science and Letters at Muğla Sıtkı Koçman University, the identified plant specimens were preserved at the Faculty of of Science Herbarium at Muğla Sıtkı Koçman University.

2.2. Determination of floral volatile compounds by HS-SPME/GC-MS analysis

In our study, leaves specimens of *C. citriodora* (syn. *E. citriodora*) were collected where this plant was grown as an ornamental plant in Muğla (Gökova) in its vegetation period. The floral aromatic components of the *C. citriodora* (syn. *E. citriodora*) leaves were determined with the gas chromatography – mass spectrometry (GC-MS) method combined with the headspace solid phase microextraction (HS-SPME) method. Taking the method of solid phase microextraction (SPME, Supelco, Germany) as a basis, after keeping 2-g leaves specimens put into a 10-mL vial at 60°C for 30 min, volatile compounds were absorbed from the headspace using 75-µm-thick Carboxen-Polydimethylsiloxane (CAR/PDMS)-coated fused silica fiber and immediately injected into the capillary column (Restek Rx-5 Sil MS 30 m x 0.25 mm, 0.25 µm) or an HS-SPME-compatible GC-MS device (Shimadzu 2010 PLUS). After the oven temperature was kept at 40ºC for 2 min, it was programmed to increase up to 250ºC at a heating rate of 4ºC per min. The injector and detector temperatures were set at 250ºC. The ionization mode was selected as EI (70 eV), while the carrier gas was helium (1.61 mL/min). The Wiley, NIST, Tutor and FFNSC libraries were utilized in the identification of the volatile compounds of the essential oil.

3. RESULTS AND DISCUSSION

In our study, the volatile compounds of *C. citriodora* (syn. *E. citriodora*) leaf samples was determined by the SPME analysis. The identified volatile components are given in the table (Table 1). In our study, 58 volatile components were determined in *C. citriodora* samples, and Citronellal (54.03%), Caryophyllene (21.46%), and Citronellyl acetate (10.01%) were determined as the main components.

Table 1. *Floral volatile compounds of Corymbia citriodora (syn. Eucalyptus citriodora)*

R.T	Components	Amount%
8.628	Pentanol	0.01
4.006	2-Penten-1-ol, (Z)-	0.03
4.660	Hexanal	0.05
6.148	(E)-2-Hexenal	0.53
6.269	3-(Z)-Hexenol	0.11
8.588	α-Tujen	0.02
8.828	α - Pinene	0.15
10.317	β Sabinene	0.10
10.470	β - Pinene	0.67
11.015	β - Myrcene	0.87
11.702	Isobutyl isovalerate	0.02
11.917	isoamyl Isobutyrate	0.03
12.331	Cymole	0.02
12.509	Limonene	0.25
12.614	Eucalyptol (1,8- Cineole)	0.28
12.834	cis-Ocimen	0.02
13.240	β - Ocimene	0.02
13.481	Melonal	0.08

13.663	ɤ- Terpinene	0.07
14.159	3,8-p-Menthadiene	0.03
14.726	α - Terpinolene	0.06
15.520	Nonanal	0.04
15.586	Solusterol $$ Isoamyl valerianate	0.03
15.724	Rose oxide A	0.09
16.348	Rose oxide trans	0.03
17.230	Isopulegol	3.25
17.629	Citronellal	54.03
17.706	iso-Isopulegol	1.61
20.242	β -Citronellol	1.34
21.772	Isopulegyl acetate	0.05
23.945	Bicycloelemene	0.10
24.470	α - Cubebene	0.05
24.623	Citronellyl acetate	10.01
24.870	Neryl acetate	0.08
25.556	Linalyl acetate	0.12
25.880	β -Cubebene	0.05
25.943	β - Elemene	0.13
26.046	cis- Jasmone	0.16
26.360	Tridecane	0.02
26.455	Caryophyllene	0.04
26.535	alpha- Gurjunene	0.03
27.069	Caryophyllene	21.46
27.445	Selina-3,7(11)-diene	0.02
27.576	Aromadendrene	0.17
27.806	Sativene	0.03
27.934	Humulen-(v1)	0.06
28.133	α-Humulene	1.57
28.275	Alloaromadendrene	0.17
28.901	Citronellyl isobutyrate	0.09
28.960	Germacrene D	0.03
29.297	Viridiflorene	0.07
29.442	Bicyclogermacrene	1.16
29.593	Chlorooctadecane	0.04
29.863	γ- Elemene	0.09
30.158	δ- Cadinene	0.03
32.002	Spathulenol	0.07
32.144	Caryophyllene oxide	0.24
33.072	Nerolidol	0.02
		100.00

*"R.T." Retention Time

Essential oils obtained from plants are various complex phytochemicals with different concentrations. Essential oils, which are characterized by a strong odor, contain a complex of essential components (Bakkali et al., 2008). The biological properties of essential oils are often defined by major components. These components are usually terpenes/terpenoids, which are of two different biosynthetic origins, and aromatic/aliphatic, both of which are characterized by their molecular weight (Croteau et al., 2000; Pichersky et al., 2006).

Although there are about 300 species of *Eucalyptus* in the world, *Eucalyptus* essence is obtained only from 30 species. As a medicine, oil obtained by distillation of water vapor from dry or fresh leaves of eucalyptus is used (Asımgil, 1997). The most common Eucalyptus species in Turkey is *E. rostrata* (*E. camaldulensis*). *E. rostrata* is known as one of the species that does not carry eucalyptol in its essential oil. However, it is stated that the essential oil called "eucalyptol", which is obtained from the leaves of the eucalyptus tree, was used for various purposes in the 1800s, and that eucalyptol was listed in the drug codex and is still used today (Gökçe and Karlıkaya 2002; Yazgan and Uygunlar, 1986).

Although there are many chemical components in eucalyptus ssp. essential oils, the main component is 1,8-cineole (Eucalyptol). The amount of 1,8-cineole (Eucalyptol) in different eucalyptus species was determined in the literature. As a result of the analysis of essential oils, the amount of 1,8-cineole, which is the main component, ranged from *E. globulus* ssp. *globulus* 61.0-65.8%, *E. globulus* ssp. *bicostata* 64.7-79.3%, *E. globulus* ssp. *maidenii* 69.1-75.7%, *E. camaldulensis* 12.2-55.7%, and *E. grandis* 3.4-31.2%. The 1,8-cineole ratios in the essential oils of *E. camaldulensis* and *E. grandis* were determined well below the standards. The highest 1,8-cineole ratio in *E. grandis* oil was 31.2%, while the highest ratio for *E. camaldulensis* was 55.7%. In addition, other components with a high content include α- pinene and limonene (Başer et al., 1998). Essential oil components have been identified in the leaves of two 30-year-old eucalyptus species (*E. camaldulensis* and *E. globulus*) grown in Karaisalı central village of the district of Dörtyol in the Hatay province, Turkey, at an altitude of approximately 150 m. The active substances of *E. camaldulensis* species were p-cymene (29.54%), spathulenol (16.40%), caryophyllene oxide (8.24%), 4-isopropyl-2-cyclohexen-1-one (9.89%), 1,8-cineole (eucalyptol) (8.06%), terpinen-4-ol (5.78%), sabinene (5.75%), and cuminal (3.28%), respectively. In the *E. globulus* species, 1,8-cineole (eucalyptol) (66.34%), pcymene (10.95%), spathulenole (4.24%), gamma-terpinene (2.61%), and terpinene-4-ol (2.18%) components were determined as the main active ingredients, respectively. In addition, in terms of the main chemical components, it was found that the two species have very different components and proportions from each other. (Alma et al., 2008). In addition, in a different study, the leaves of *C. citriodora* (syn. *E. citriodora*) were found to contain approximately 1.36% essential oil, and the major components were found as citronellal (57%), citronellol

(15.89%), and citronellyl acetate (15.33%) (Tian et al., 2005; Chalchat et al., 1997). In another study, the chemical composition of the essential oil of the leaves of *C. citriodora* was found to consist of 22 compounds, of which citronellal (69.77%), citronellol (10.63%), and isopulegol (4.66%) were the main components (Tolba et al., 2015). Manika et al. (2012) identified high proportions of citronellal (69.7% to 87.4%) as the main essential oil components in samples collected at different times of *C. citriodora* (syn. *E. citriodora*) leaves. Other components identified were citronellol (5.1 to 9.9%), linalool (2.1 to 6.4%), isopulegol (0.9 to 3.1%), and citronellyl acetate (0.4 to 1.2%). Singh et al. (2012) found that the main essential components of *C. citriodora* (syn. *E. citriodora*) consist of monoterpenoids, which include citronellal (60.6%), β-citronellol (12.5%), and isopulegol (8.1%). Mittal et al. (2011) also identified citronellal and β-citronellol as the main components. Hussein, et al., (2017) identified the main components of essential oil of the leaves of *C. citriodora* (syn. *E. citriodora*) as α-citronellal (56%), α-citronellol (14.7%), citronellol acetate (12.3%), isopulegol (7.6%), and eucalyptol (2.0%). Benchaa et al. (2018) reported that the main components in the essential oil obtained from the leaves of *C. citriodora* (syn. *E. citriodora*) were Citronellal (64.7%) and Citronellol (10.9%), while Gbenou et al. (2013), and Araujo-Filho et al. (2018) reported that the main components of the essential oil of *E. citriodora* leaves were citronellal (83.50 %), and citronellol (63.9%), respectively. In the essential oil isolated from the leaves of *C. citriodora* (syn. *E. citriodora*) in different regions, the components of citronellol, cytonellol, geranil acetate, limonene, and terpene-4-ol were identified as the main components (Dagne et al., 2000; Manika et al., 2012; Husain and Ali, 2013). However, in different studies, citronellal components were found at high proportions, such as 53.1% (Hussein et al., 2017), 60.7% (Singh et al., 2012), 67.5% (Ribeiro et al., 2014), 71.8% (Macedo et al., 2011), 75% (Ootani et al., 2017), and 86.8% (Ribeiro et al., 2018). Looking at the literature, it is seen that citronellal and citronellol have been identified as the main components in the essential oil obtained from the leaves of *C. citriodora* (syn. *E. citriodora*). In our study, Citronellal (63.9%) emerged as the main component as a result of chromatographic analysis of the essential components of *C. citriodora* (syn. *E. citriodora*) samples, and it was observed that this result is in harmony with other studies where it was determined that citronelal was the main component of *C. citriodora* (syn. *E. citriodora*) essential oil. The composition of essential oils can vary considerably depending on many factors, including genetic variation, plant ecotype or diversity, plant nutrition, geographical location of plants, environmental climate, seasonal changes, stress during growth or ripening, post-harvest drying and storage and its characteristic biological properties.

4. CONCLUSION

Essential oils and aromatic extracts are used by the fragrance and food industries in the composition of perfumes, food additives, cleaning products, cosmetics, and medicines, as a source of aroma chemicals or as a synthesis starting material of naturally identical and semi-synthetic aromatic chemicals (Başer, 1998). The leaves of *C. citriodora* (syn. *E. citriodora*) have been used both as infusions and in steam baths to treat respiratory tract diseases such as flu, cold, and pneumonia, as well as to treat rheumatic pains (de la Torre et al. 2008), and the entire plant, fresh or dried is used for diabetes treatment (Rainer and Ashley, 2011). Essential oil, which is obtained from the branches and leaves of *C. citriodora* (syn. *E. citriodora*) and is a source of citronelal, is used in soap making, soap perfume, soap base, detergents, and sprays (Lee and Chang, 2000).

There are many plants that grow wild in Turkey that can be cultivated when necessary, and the essential oil industry to be developed in this context will make multifaceted contributions to the country's development in terms of employment, export and foreign exchange inflow, decrease in imports, and cooperation with other countries. Eucalyptus species are being researched all over the world due to their unique medicinal properties. Eucalyptus is grown in Turkey only for producing wooden raw materials. However, its leaves are not put into good use in any way. However, its essential oils, which are at least as valuable as wood, can also be utilized. With a specific investment and technology, essential oil can be produced from these leaves for an additional income.

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CHAPTER 3

ARTIFICIAL NEURAL NETWORKS APPLICATIONS IN FOREST INDUSTRY

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INTRODUCTION

The rapid progress in technology and science has led to significant changes worldwide. This process led to economic, political and cultural change in societies and required them to change their production methods and policies. In this period, it was essential to ensure competition for production in industrial societies and to develop technology in information societies.

The forest industry is accepted as an industry branch that contributes the production and economy of the country due to its close relationship with multiple industries. The importance of this industry branch is increasing as it contributes to the national economy's employment, production, economic growth, trade volume and tax revenue (Kurt and Imren, 2021). Within the scope of industrial programs, it is explained that the forest industry can produce all kinds of contributions. On the other hand, the forest industry constantly improves itself in parallel with technological developments.

Predicting the future state of a process in industrial studies is crucial in terms of obtaining better results with less measurement and reducing operating costs. Today, there are many statistical methods used for forecasting. Artificial Neural Networks (ANN), which was created by being inspired by the working principle of the human brain with the developments in technology and emerged as a result of transferring the learning process to computer systems, is a method that is widely used for prediction purposes in many fields from the finance and marketing sector to various engineering fields (Kurt et al., 2017).

Various artificial intelligence studies have been carried out in the forest industry which helps today the rapid progress of digital technologies and the development of unnatural intelligence practices.

The human brain is still a great unknown. The development of electronics and technology triggers the desire to discover this unknown. The researchers have aimed to use the complex system of thought of the human mind to develop artificial intelligence practices (Yılmaz, 2019). Their works have brought results. Artificial intelligence and its sub-branch ANN have brought some innovations to computer science such as parallel programming, distributed programming and so on (Da Silva et al, 2017).

ARTIFICIAL NEURAL NETWORKS

"Artificial Neural Networks (ANN)", a product of artificial intelligence studies, are computer systems developed to automatically realize abilities such as deriving new information, creating and discovering new information through learning without assistance. These are the characteristics of the human brain, (Imren et al., 2021). ANN are systems that are inspired by the structure of nerve cells in the human brain and consist of processing elements connected to each other with different weights. (Taşar, 2018). If we ignore human weaknesses (hunger, fatigue, emotional deterioration, etc.), many processes that the human brain can perform, can be easily performed with ANN (Aytekin, 2017). ANN are called connectionist networks, parallel distributed networks, and neuroformic systems.

ANN consists of artificial cells which are hierarchically connected and operating in parallel. The most essential task of a ANN is to determine an output set. To do this, the network is trained with examples of the relevant event. This network provides the ability to generalize (learning). Thanks to this generalization, the output corresponds to similar events. This process can be seen as a decision-making tool and calculation method that can be used very effectively in cases where there is no information about the events but where there are examples (Altaş and Gülpınar, 2012).

Since ANN can produce solutions similar to the problem-solving feature of the human brain, it has a wide range of uses. In case a mathematical model and algorithm cannot be created, successful results are achieved in solving problems by using ANN applications. Therefore, the developed networks generally perform the probabilistic function as estimations modeling, classification, data association and pattern identification, time series analysis, signal filtering, data compression, nonlinear signal processing, nonlinear system modeling, clustering, optimization, intelligent and nonlinear control functions (Zaknich, 1998). We can find ANN applications in real life for data mining, optical character recognition and check reading, evaluating applications for loans from banks, estimating the performance of the product in the market, detecting credit card fraud, determining the optimum route for intelligent vehicles and robots, speech and fingerprint recognition in security systems, robot movement mechanisms. ANN are the most used examples of application areas such as controlling the life and breaking of mechanical parts such as quality control, job scheduling and job sequencing, controlling and switching traffic density in communication channels, radar and sonar signals classification (Gönül et al.,2015).

The structure of ANN is similar to the biological nerve cell (Figure 1). My research aims to learn the relationships between the events by running the perception and understanding mechanisms developed in light of the information from the sensory organ (Shanmuganathan, 2016). An artificial nerve cell consists of five main parts: weights, total function, activation function and output (Terzi and Köse, 2012; Ataseven, 2013; Tüzüntürk et al., 2016). Once, the inputs enter the nerve cell, they are subjected to multiplication with the corresponding connection intervals, then they combine with a merging function, for this reason, the net input of the neuron occurs. Finally, net input is processed with an activation. The net output of the neuron is determined with the help of the activation function (Aydın and Yazıcıoğlu, 2019).

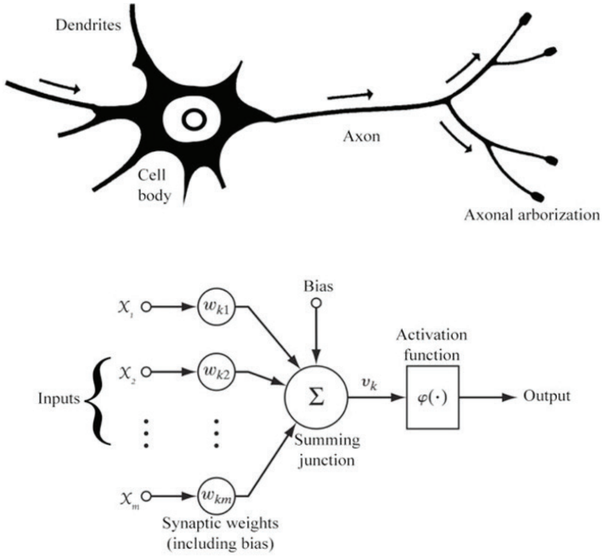

Figure 1. A biological and an artificial neuron (Arbib, 2003; Haykin, 2009)

The information received from the external environment is transmitted to the cells in the intermediate (hidden) layer without any changes in the input layer. (Çuhadar and Kayacan, 2005). The inputs to the neurons in the hidden layer are summed and similarly, the connection weights between the hidden layer and the output layer are multiplied and transmitted to the output layer. (Figure 2) (Akgün and Demir, 2018). Some ANN may not use hidden layers, and some may have more than one middle layer. Information can be transmitted directly to the output layer without a hidden layer. The neurons in the output layer collect these inputs coming to their own cell and produce an appropriate output. Here, there is a one-way communication from the input layer to the output layer over the hidden layers (Zupan, 1994).

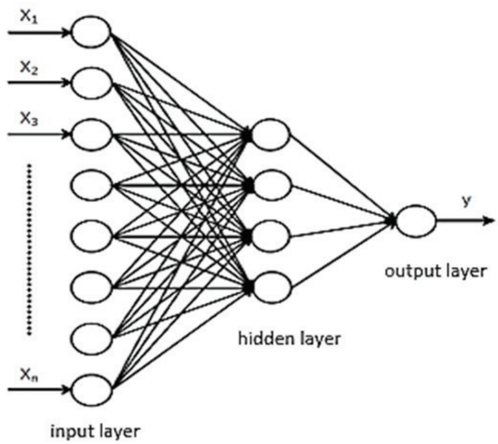

Figure 2. A typical Neural Network (Kurt, 2018).

Determining the connection weight values of the process elements is called "training the network". In order to find the most accurate weight values, the samples are studied by showing them to the network many times (Bala and Kumar, 2017). A network achieves correct weight values, which means it can make generalizations about the events represented by the samples. The process of having this generalization property is called "network learning". Changing the values of the weights is applied according to specific rules. These rules are called "learning rules". The sample set used in these stages is called the "training set", and the set used for testing is called the "test set" (Çuhadar, 2013).

ANN models have been developed according to the connection structure of the cells, the learning rule and the number of layers (Figure 3).

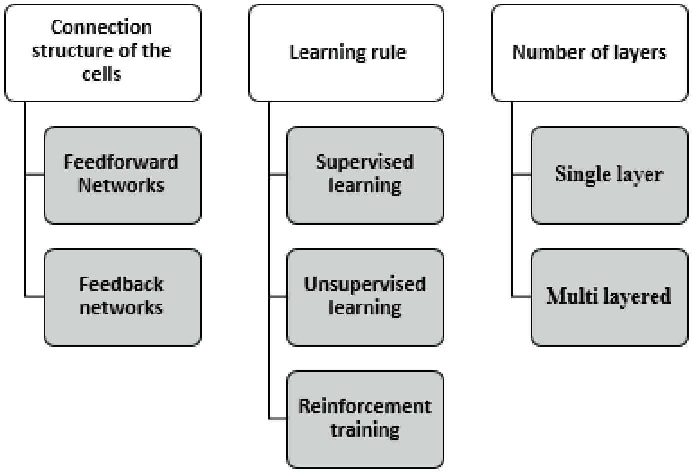

Figure 3. ANN models (Haykin, 2009)

Feed Forward Networks: In a feedforward network, cells are fed only by cells of the previous layer. In feedforward neural networks, cells are arranged in layers and the outputs of cells in one layer are input to the next layer over. The network output is determined by processing the information in the hidden and output layer. Through one-way links signals are transmitted from input layer to output layer. (Figure 4). While they make a connection from one layer to another layer, they do not have connections within the same layer (Alavala, 2008).

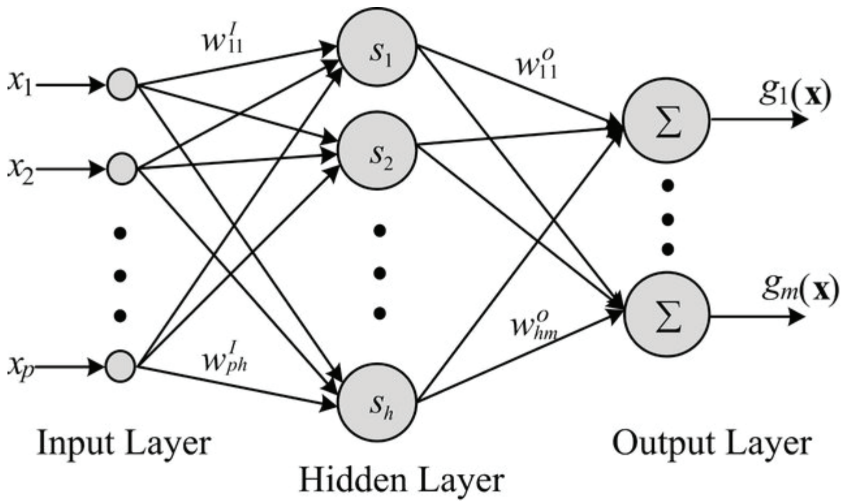

Figure 4. Feed Forward Networks ANN (Li et al. 2016)

Feedback networks: Unlike the feed-forward ones in the ANN with feedback, the output of a cell is not only given as an input to the layer of the next cell. It can also be connected to any cell in the previous layer or in its own layer as an input (Ergezer et al., 2003). These types of neural networks have dynamic memories. The output of neurons in this structure is not only dependent on the current input values, but also on the previous input values (Figure 5). Therefore, this network structure is particularly suitable for forecasting applications. These networks have been particularly successful in estimating various types of time series (Thakur and Konde, 2021).

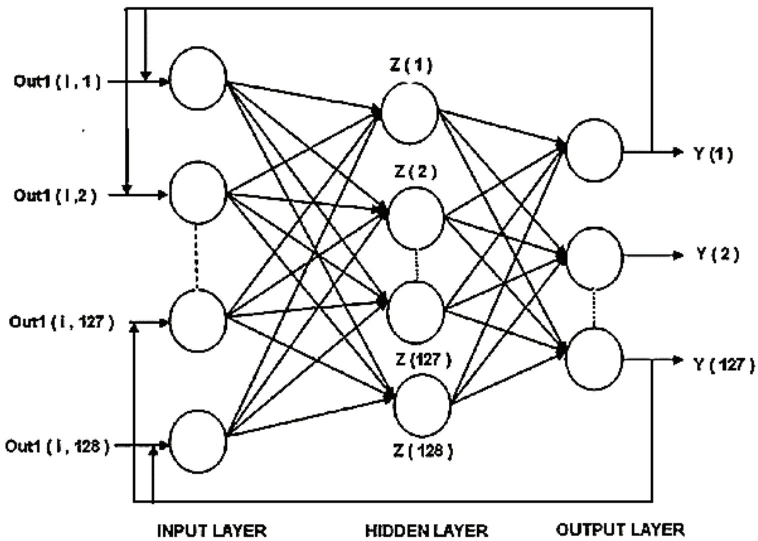

Figure 5. Feedback networks ANN (Desai and Rao, 2013)

Supervised learning is the training process before starting to use the network. This process is the process of presenting the output information for the input values to the neural network. It compares the value generated output from the network information input with the required value to obtain information to change the weight. By calculating the error between the network output and the expected output, the new weights of the network are arranged depending on the margin of error and the process continues until the error value is less than the predetermined value (Kurt, et al., 2017).

There is another learning type "unsupervised learning". The learning process is carried out independently without the supervision of the instructor. During ANN training under unsupervised learning, input vectors that are composed of similar types of vectors are becoming to form clusters. When a new input model is applied, the neural network returns an output response indicating the class to which the input model belongs. In this context, there will be no feedback about the desired output from the environment, whether right or wrong. Therefore, in this type of learning, the network itself should discover patterns, features from input data, and the relationship of input data over output (Kosko, 1988; Meshref, 2013).

The supporting learning algorithm does not need to know the desired output. For example, the reinforcement training method is similar to the supervised learning method. However, instead of target outputs, a score or rating is reported to the network, indicating how accurate the network outputs are (Meshref, 2013).

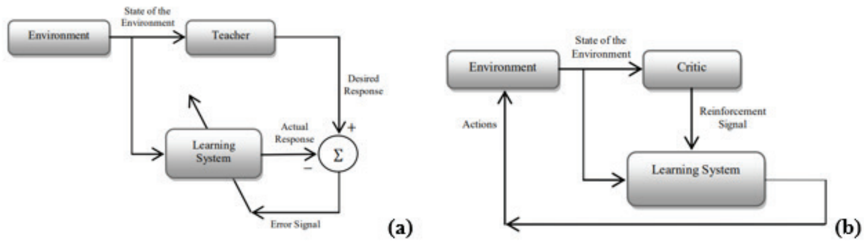

*Figure 6. **(a)** Supervised Learning of ANN, **(b)** Reinforcement Training of ANN (Meshref, 2013)*

Single-layer sensors consist of inputs, a body that performs the collection-activation tasks, and an output (Figure 2). Therefore, it is a multi-input, single-output structure. In multi-layer sensors, apart from the input and output layers, there are intermediate layers (hidden layers), the number is determined by the designer (Figure 6) (Wibowo, and Wihayati 2021). Since the Multi-Layer Sensor (MLA) network uses the supervised learning strategy, the information is presented to the network from the input layer and passes through the intermediate layers to the output layer. Then, the response of the network is transmitted to the outside in reaction to the inputs presented to the network. In the MLA network, information is presented to the network from the input layer and goes through the intermediate layers to the output layer, and the response of the network is transmitted to the outside world in reaction to the inputs presented to the network. Therefore, the MLA network uses the supervised learning strategy (Lin et al., 2021).

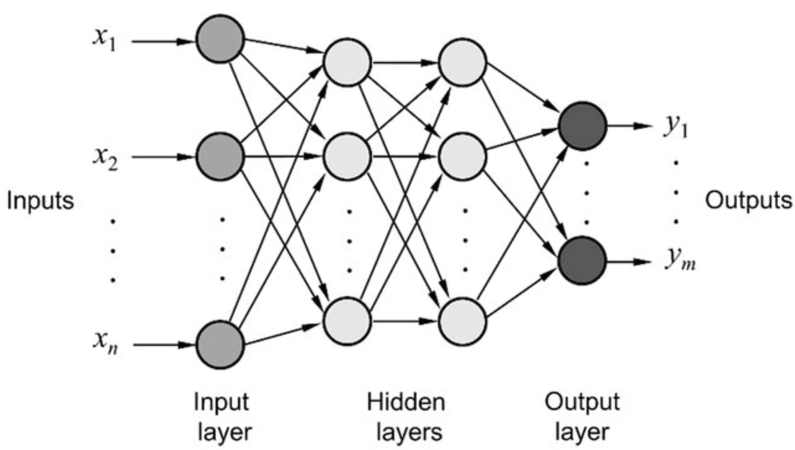

Figure 6. Feed-forward multilayer neural network ANN (Pouliakis, 2016)

FOREST INDUSTRY AND ARTIFICIAL NEURAL NETWORKS

Accordingly, this gap should be filled by exploring which processes of the forest product supply chain can benefit through which technologies are similar to ANN and in what way.

Singh et al. (2021) have proposed cutting-edge technological applications to develop the idea of "digitalizing the forest" for research such as forest environment monitoring, data collection and analysis in research and development activities. For this purpose, they have proposed advanced technological systems that will make predictions by integrating intelligent system detection, monitoring and analysis methods into applications that will prevent forest fires, illegal tree cutting, poaching, etc. by using technologies such as Internet of Things, Wireless Sensor Networks, Internet of Trees, Deep Learning.

Using computer vision and machine learning, Hwang and Sugiyama (2021) have added a new example to scientific discipline methodology. By creating an automatic wood identification system, they helped develop the wood industry and market. They have established an image-based wood identification system. For this purpose, they examined artificial intelligence-based wood anatomy and engineering methods under computer vision and machine learning techniques.

Martineau et al. (2021) have solved the problem of estimating timber products by splitting logs by constructing multilayer perceptron, residual network, and ANN neural network architectures such as PointNet, to estimate timber production. They used a combination of industry-based features, 2D projections and 3D point clouds as input dataset. They found it valuable in merging 3D point clouds in different network architectures.

Shugar et al. (2021) aimed at rapid identification of tree species. In machine learning, 48 different wood samples with convolutional X-ray fluorescence spectrometry were identified with 99% accuracy. Other alternative options for identification are time consuming and costly. Thus, the timber will be identified and used more quickly.

Socha et al. (2020) in their research, made ANN estimation and regression models for tree trunk diameters in different environmental parameters. Data were estimated by taking information from 2856 tree species in Polish forests. In the results, it was revealed that ANN gave the most accurate results. Furthermore, the ANN model gave the most accurate prediction for coniferous trees and beech. Here, the flexibility and prediction performance of ANN is better than regression. The variable exponent conicity equation was used for the estimation.

In the research of Cheta et al. (2020), low-cost systems based on artificial intelligence have been developed by monitoring the data collected through sensors in small-scale wooden production facilities. An external sensor system consisting of two data recorders (three-axis accelerator and a sound pressure level meter) was used to provide input signals and a video camera to train and test an artificial neural network. The system requires free software that can be directly connected to low-cost devices and devices to feed data to local computers. Therefore, it has been seen and analyzed production data that can be used to maintain the competitiveness of traditional technologies.

Lopes et al. (2020) built a Convolutional Neural Network (CNN) using macroscopic images to identify tree species. The data coverage was expanded by rotating, zooming and flipping the images in the created data training sets. Thus, great success has been achieved in the determination of tree species. They predicted that wood identification would be easier thanks to the mobile applications to be made with this method in the future.

Kurt and Karayılmazlar (2019) estimated the elasticity modulus values of particleboards by using ANN and mechanical properties of particleboards in order to reduce the costs arising from measurements in particleboard enterprises. They also estimated future modulus of elasticity values by using the same variables to monitor the condition of the product.

Sözen et al. (2018) developed deformation prediction models in nanocomposites using ANN and deep learning algorithms and investigated the validity of the models. Models were created with the data mining method, and the models were simulated separately. Thus, the need for time-consuming and costly experiments is reduced. Correlation coefficient and percent error criteria were used to evaluate the predictive performance of the models. The deep learning model showed a higher prediction performance.

Özdağ et al. (2017) estimated the furniture foreign trade (import and export) of German and Turkey for the years 2017-2023. ANN were used as a method. Selected independent variables are population of countries, Gross Domestic Product (GDP), real exchange rate index. Foreign trade values of the furniture industry and time were used as dependent variables. The 16-year data set obtained was divided into two parts as test and training, so that the network gained the best coefficients and the closest estimation was made on the test data with 5000 iterations.

Kurt et al. (2017) Turkey's paper-cardboard production, wastepaper, industrial wood, log production, population, GDP, CPI, PPI, exchange rates and economic growth figures were used as input data, and the export values of the Turkish paper-board sector were estimated by ANN method.

CONCLUSION AND SUGGESTIONS

Artificial intelligence applications increase the development of the digital world and technology, its impact on human life and the world of science in every field. As a result of these applications and researches, ANN as a process tool can be used more efficiently in the industrial and scientific fields and are mainly focused on Research and Development. ANN applications are predicted to prevent negatives with the information obtained in the industrial production process. When examined scientifically, it is stated that it saves time for researchers and offers similar predictions. Thus, scientific results will be reached more quickly. In addition, with the integration of software made on estimation into mobile applications, its accessibility to more areas will increase.

The ability to learn ANN provides an important advantage to be able to use different algorithms. Thus, it can solve problems that are difficult to explain mathematically. In addition, it is preferred as an economical and method since the result is achieved with the use of a simple program. ANN do this automatically, as it is difficult to predict the connection between events and events in reality. Therefore, since there are systematically examples, machine learning takes a short time in different examples by creating the network architecture of the problem.

The use of real-time applications has increased with the change in artificial intelligence that has begun to be experienced throughout the world. These applications are spread over a very wide area. In the extensive researches in the forest industry, it is seen that this system has been adopted, and even R&D studies have been carried out with the support of software. This situation should be considered as a new and promising tool in the forest industry field. However, artificial intelligence applications will be the focus of research in every field in the future.

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