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The Impact of the Introduction of Norms of Fertilizers and Irrigation on the Change in the Nutritional Regime of the Soil in Mixed Crops of Barley and Alfalfa

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ABSTRACT

The article quotes questions of the influence of fertilizer rates and the number of irrigations on the change in the nutrient regime of the soil when growing mixed crops of barley and alfalfa in the conditions of the Karabakh zone of Azerbaijan. In this regard, one of the main issues considered was the development on a scientific and practical basis of the nature of changes in the nutrient regime of the soil and the effect of optimal fertilizer rates and the number of irrigations on crop yields in mixed crops in long-irrigated gray meadow soils.

To study the effect of irrigation and fertilizer rates in mixed crops on changes in the nutrient regime of the soil, soil samples were taken from two soil layers (0-30 and 30-60 cm) after cutting. In the soil samples taken, compounds of nitrogen, phosphorus and potassium that are readily absorbed by plants were analyzed. Analysis of soil samples shows that the application of mineral and organic fertilizers against the background of different amounts of irrigation fundamentally affects the effective fertility of the soil.

Against the background of 4-fold vegetative irrigation (3800 m3 / ha) in the control variant without fertilizers in the 1st mowing, analysis of soil samples makes it known that in the variant without fertilizer in the first crop the amount of absorbed ammonium was 5.2-6.6 mg / kg, nitrates 3.3-4.9 mg / kg, mobile phosphorus 7.2-12.7 mg / kg, and exchangeable potassium 217.5-254.7 mg / kg, and in the variant with the norm N45P120K90 in the soil layer of 0-30 cm after the first mowing, the amount of absorbed ammonium was 6.2-8.3 mg / kg, nitrate nitrogen 4.5-5.4 mg / kg, mobile phosphorus 9.4-13.2 mg / kg, and exchangeable potassium 256-263 mg / kg. As a result of the analysis, it becomes clear that the introduction of irrigation and fertilizer rates increases the number of digestible nutrients. And this in turn has the necessary effect on the yield of alfalfa in mixed crops with barley, as a result, the effective fertility of the soil is maintained.

1. INTRODUCTION

On mixed senosy, the digestibility of nutrients and water is improved. Legumes with taproot, assimilating water and mineral substances from the deep layers of the soil, enrich the upper layers of the soil. Mixed crops with different biological features and rich in nitrogen, phosphorus, potassium, calcium and magnesium are of particular importance. Thus, the difficultly digestible bivalent calcium and magnesium compounds, which are very important for grain crops, are absorbed by the roots of legumes and, passing into mobile forms, create a reserve (reserve) for the grain crops. And grain, converting the elements of phosphorus and potassium contained in the soil into mobile forms, enrich legumes with these components. The enrichment of soil with nitrogen by leguminous crops is known and the application in the experience of these plants is important. The above are the cause of increasing the yield of mixed crops and prove the advantage of mixed crops over crops of the same crop.

The total stock in soil nutrient matter describes its potential fertility. Effective soil fertility is determined by the amount of nutrients contained in the soil that can be absorbed by plants. One of the main factors for increasing the effective and potential fertility of the soil is the use of organic and mineral fertilizers. Fertilization in the desired rate and proper agricultural technology may improve the agrochemical characteristics of the soil. And this is due to the creation of favorable nutritional conditions for plants.

V. G. Mineev, in studying the soil potassium regime, took the amount of exchangeable potassium as a basis. If potash fertilizers are not introduced, then the compounds of this element in the soil decrease, the productivity of plants decreases sharply. Especially one-sided application of nitrogen and phosphate fertilizers again increases the need of plants for this element [5].

The systematic use of phosphate fertilizers increases the stock of total phosphorus, as well as the content of mobile phosphorus in it. This increase is mainly observed in the topsoil. But it should be noted that in light soils it can leach into the subsoil layers.

The systematic use of nitrogen and phosphate fertilizers increases the plant's need for potassium. As a result of the experiments, it was found that the use of potash fertilizers significantly reduced potassium deficiency in the soil, as a result, the yield of agricultural plants and its quality increased significantly [6].

Studies show that the following factors affect the movement of phosphorus in soil: soil characteristics, mainly its particle size distribution, the number and composition of colloids, the chemical composition of the soil, the soil solution environment, the amount of organic compounds, water regime, climatic conditions, precipitation, humidity, temperature, plant cover, forms of phosphate fertilizers, soil phosphates, etc. [four].

In connection with the use of organic and mineral fertilizers, researchers have long been interested in the study of their effect on the nutrient regime of the soil. Such work as F.V.Turchin (1964), D.A.Korenkov (1965), RKGuseinov (1965), V.G. Mineev (1973), Z.R. Movsumov (1978) engaged in this work at different times. , M.I. Jafarov (1982), F. Kh. Akhundov (1989), P. B. Zamanov (1995), E. R. Allahverdiyev (2002), R. K. Mamedov (2011) and others [1].

The main source of plant nutrition is the mineral elements of the soil and nitrogen. The richness of soil minerals is determined by the specific feature of the rocks and the activity of microorganisms.

One of the factors on which soil fertility depends, and because of this, the whole complex of mineral nutritional conditions of plants is the soil microflora.

The decomposition products of organic residues not only enrich the soil with assimilable nitrogen and phosphorus compounds and increase the supply of CO2 in the lower atmosphere. They also have various stimulating effects. The processes of mineralization of organic residues also significantly affect the state of other important elements (sulfur, phosphorus, etc.) [2].

The decomposition of organic residues also affects the balance of phosphoric acid compounds in the soil. J. Liebig proved the indispensable and uninterrupted application of fertilizers as the main means of soil fertility management.

In the field by means of fertilizers it is quite possible directional placement in the formation of the root system. Thus, according to AB Sokolov, nitrogen fertilizer enhances the development of the roots in the layers of the soil, where its compounds are directly located. And in the layers where the soil is fertilized with phosphorus, the roots grow at the lowest intensity. They, bypassing this layer without branching, develop most intensively in the lower layers.

Knowing these features, it is possible to regulate the placement of the main mass of roots in the soil. For example, in arid zones, the application of phosphates to the upper layers of the soil can help the development of roots on moisture-rich deep soil horizons. And the development of the roots can be enhanced by the introduction of nitrogen fertilizers on these soil layers.

Researches of the Kazan School of Physiologists show that additional mineral fertilizer can be a significant factor affecting the water regime of plants. The nature of this influence depends on the type and time of additional fertilizer. Nitrogen fertilizers applied as an additional fertilizer, if the amount of bound and colloidal water is reduced, then phosphate and potash fertilizers, on the contrary, increase these indicators. When fertilized with nitrogen fertilizers, these fertilizers also have a positive effect.

In 2010, according to the plan, the ways of growing mixed crops of barley and alfalfa in the conditions of the Karabakh zone, as well as the effect of fertilizer rates and the number of irrigations on the change in the soil of the nutritional regime, were studied in research work. In this regard, it was considered one of the important issues to develop on a scientific and practical basis the optimal rates of fertilizers and the number of irrigations and their effect on the change in soil and plants of nutrient regimes in mixed crops, under conditions irrigated from antiquity on serum soils.

Water plays a crucial role in plant life. If even some primitive plants can definitely live without air and light, then there is no water without water. Ox is an integral part of living plasma of plants. Water inside the plant moves with different substances. As a result of evaporation, plants lose water and it retains increasing water tension, normalizes temperature, and protects the soil from excessive heating. Plant organs usually store 50-90% of water, and sometimes more. The value of water that is not part of plants is also great. Precipitation, soaking into the soil and assimilated by the roots of plants from the deep layers, is used by plants. It also influences the change in the nutritional regime of the soil, creates the conditions for providing plants with water [7].

During the study, a significant effect of fertilizer introduction was observed against the background of a different number of irrigations under mixed crops of barley and alfalfa on the nutritional regime of the soil and a significant increase in the number of nutrient elements readily absorbed by plants. And this, in turn, proves a large increase in the effective fertility of the soil as a result of the use of fertilizers and irrigation.

There is a close connection between mineral nutrition and water exchange, as well as the possibility of active influence through a properly adjusted fertilizer system on water exchange. It is important to increase the effectiveness of nutrients introduced into the soil. Therefore, the urgent issue is the application of fertilizers in the soil to certain places by a local method [8].

Soil fertility, the provision of plants with water, oxygen and carbon dioxide, the amount of anaerobic decomposition products in the soil of organic compounds strongly influence the size of the root system.

To obtain a normal yield, it is necessary to apply these three nutrients (macro-fertilizers) to the soil in the form of fertilizers.

As a result of analyzes, the effect of irrigation and fertilizer rates on cuttings on the amount of nutrients in the aerial part of alfalfa has been studied.

In the republic, for the first time, we study the effect of irrigation and fertilizer rates on changes in the nutrient regime of the soil in various cuttings in mixed barley and alfalfa crops. For this, after cutting, soil samples were taken from two depths (0-30 v ə 30-60 sm). In the soil samples taken, compounds of easily digestible nitrogen, phosphorus and potassium were analyzed. Analysis of soil samples show that the use of mineral and organic fertilizers against the background of various vegetative irrigations has fundamentally affected the effective fertility of the soil. The test results were as shown in the table.

As can be seen from the table, after harvesting barley on the background of 4-fold vegetative irrigation (3800 m3 / ha) by analyzing soil samples, it becomes known that in the variant without fertilizer in the first crop, the amount of absorbed ammonium was 5.2-6.6 mg / kg, nitrates 3.3-4.9 mg / kg, rolling phosphorus 7.2-12.7 mg / kg, and exchangeable potassium 217.5-254.7 mg / kg. When applying fertilizers in various doses, these indicators continue to increase. So, when fertilizers were applied in the standard N30P90K60, the amount of absorbed ammonium was 5.7–8.0 mg / kg, nitrate nitrogen, 3.6–5.4 mg / kg, mobile phosphorus, 8.4–16.4 mg / kg, potassium 224.2-270.2 mg / kg, in the variant with the norm N45P120K90 in the soil layer 0-30 cm after the first cut, the amount of absorbed ammonium

was 6.2-8.3 mg / kg, nitrate nitrogen 4.5-5, 4 mg / kg, mobile phosphorus 9.4-13.2 mg / kg, and exchangeable potassium 256-263 mg / kg.

In the variant with the introduction of 10 tons of manure in the soil layer of 0-30 cm in the first cut, the amount of absorbed ammonium was 5.5-7.9 mg / kg, nitrate nitrogen 3.6-5.1 mg / kg, mobile phosphorus 8.1 -14.5 mg / kg, and exchangeable potassium 223.1-261.9 mg / kg. As a result of research in II, III, IV mowing, an increase in the amount of nutrients was observed.

As a result, the combined use of organic and mineral fertilizers in the normal 10 t / ha + N15P65K30 indicators changed and the amount of absorbed ammonium was 6.0-8.1 mg / kg, nitrate nitrogen 3.8-5.5 mg / kg, mobile phosphorus 8 , 5-16.2 mg / kg, and exchangeable potassium 225.4-271.5 mg / kg. Against this background, analysis of soil samples taken from under alfalfa makes it known that in the 2nd crop in the control variant without fertilizing, the amount of absorbed ammonium was 4.9-6.1 mg / kg, nitrate nitrogen 3.0-4, 6 mg / kg, mobile phosphorus 7.0-12.3 mg / kg, and exchangeable potassium 201.5-240.3 mg / kg.

When mineral fertilizers were applied in the norm of N30P90K60, these indicators were respectively 5.4-7.6: 3.3-4.8: 7.7-13.8: 203.8-250.6 mg / kg, and in the variant with the norm N45P120K90 in the second cut, they were respectively 5.2-7.4; 3.1-4.5; 7.4-12.3 and 208.0-247.1 mg / kg, and when using organic fertilizers, these indicators have changed a lot. So, in the variant with application of manure at a rate of 10 t / ha in the first cut at a soil depth of 0-30 cm, the amount of absorbed ammonium was 5.0-7.2 mg / kg, nitrate nitrogen 3.3-4.5 mg / kg , mobile phosphorus, 7.4-13.1 mg / kg, and exchangeable potassium, 202.4-247.6 mg / kg, and the variant at a rate of 10 t / ha of manure + N10P65K30, these indicators made up respectively 5.8-7.7 ; 3.5-4.9; 7.8-14.5 and 204.1-251.7 mg / kg.

The effect of irrigation and fertilizer rates in mixed crops of barley and alfalfa on changes in the nutritional regime of the soil

Table

	Options	Depth, cm	Date of taking soil samples															
			First mowing (07.02.09)				Second mowing (30.07.09)				Third mowing (29.08.09))				Forht mowing (24.09.09))			
			N/NH_3	N/NO_3	P_2O_5	K_2O	N/NH_3	N/NO_3	P_2O_5	K_2O	N/NH_3	N/NO_3	P_2O_5	K_2O	N/NH_3	N/NO_3	P_2O_5	K_2O
			3 time watering, 3800 m3/ha															
I	Control, no fertilizer	0-30	6,6	4,9	12,7	254,7	6,1	4,6	12,3	240,3	5,8	3,9	10,1	218,2	5,3	3,2	9,4	208,3
		30-60	5,2	3,2	7,2	217,5	4,9	3,0	7,0	201,5	4,6	2,9	6,3	179,0	4,2	2,3	5,6	179,0
II	$N_{30}P_{90}K_{60}$	0-30	8,0	5,4	16,4	270,2	7,6	4,8	13,8	250,6	6,8	4,3	10,5	228,2	6,2	4,1	9,7	215,5
		30-60	5,7	3,6	8,4	224,2	5,4	3,3	7,7	203,8	5,1	3,3	6,3	184,5	4,7	3,1	5,8	174,2
III	$N_{45}P_{120}K_{90}$	0-30	8,3	5,4	13,2	263	7,4	4,5	12,3	247,1	6,9	4,1	11,5	228,6	6,9	4,1	10,4	219,6
		30-60	6,2	4,5	9,4	256	5,2	3,1	7,4	208,3	5,1	2,9	7,4	190,4	4,9	2,7	7,3	188,4
IV	manure 10 t/hec	0-30	7,9	5,1	14,5	261,9	7,2	4,5	13,1	247,6	6,4	4,1	10,8	227,1	6,0	3,7	9,9	277,6
		30-60	5,5	3,6	8,1	223,1	5,0	3,3	7,4	202,4	4,8	3,0	6,6	184,2	4,5	2,7	6,2	174,3

V	manure 10 t/hec + $N_{15}P_{65}K_{30}$	0-30	8,1	5,5	16,2	271,5	7,7	4,9	14,5	251,7	7,3	4,4	11,9	237,1	6,8	4,1	10,2	228,2
		30-60	6,0	3,8	8,5	225,4	5,8	3,5	7,8	204,1	5,2	3,5	7,2	194,3	5,2	3,5	7,2	185,2
		4 time watering, 4800m^3/ha																
I	Control, no fertilizer	0-30	6,9	5,1	13,5	260,1	6,4	4,8	12,7	244,4	6,1	4,2	11,4	225,6	5,8	4,0	10,6	222,5
		30-60	5,5	3,6	7,8	219,4	5,2	3,1	7,1	201,5	4,5	3,0	6,9	184,2	4,3	2,9	6,4	181,4
I	$N_{30}P_{90}K_{60}$	0-30	8,8	6,1	17,4	277,5	8,0	5,1	13,9	253,6	7,6	4,7	12,2	238,1	7,2	4,5	11,8	235,4
		30-60	6,6	4,4	9,2	236,9	5,6	3,7	8,2	206,7	5,1	3,5	7,7	195,8	5,0	3,2	7,3	190,6
II	$N_{45}P_{120}K_{90}$	0-30	9,2	6,3	17,8	279,3	8,7	5,7	15,2	252,8	8,1	5,0	12,8	244,4	7,9	4,8	11,0	237,4
		30-60	6,7	4,6	9,9	258,1	6,0	4,1	8,7	207,2	5,8	3,8	8,1	200,3	5,4	3,6	7,7	198,5
V	manure 10 t/hec	0-30	8,2	5,5	15,2	268,3	7,9	5,0	13,5	250,2	7,2	4,6	11,4	234,5	6,8	4,2	10,3	228,4
		30-60	6,1	4,0	8,4	224,2	5,2	3,7	7,9	203,4	5,0	3,1	7,2	181,2	4,8	2,9	6,8	178,3
	manure 10 t/hec + $N_{15}P_{65}K_{30}$	0-30	8,5	5,9	17,1	273,9	8,1	5,2	15,1	253,6	7,8	4,4	12,4	239,2	7,3	4,3	11,4	232,3
		30-60	6,3	4,1	9,1	229,6	5,8	3,6	8,3	206,4	5,2	3,3	7,7	200,1	5,0	3,1	7,1	192,1

From analyzes of soil samples taken from under the plants at the 3rd mowing of alfalfa, it becomes clear that the amount of absorbed ammonia decreases to 4.6-5.8 mg / kg, nitrates 2.9-3.9 mg / kg, mobile phosphorus 6.3-10.1 mg / kg, and exchangeable potassium 179.0-218.2 mg / kg. When mineral fertilizers were applied in the norm of N30P90K60, these indicators were 5.1-6.8, respectively: 3.3-4.3: 6.3-10.5 and 184.5-228.2 mg / kg. In the variant with the application of fertilizers in the norm N45P120K90 in the 3rd cut, the amount of absorbed ammonium was 5.1-6.9 mg / kg, nitrate nitrogen 2.9-4.1 mg / kg, mobile phosphorus 7.4-11.5 mg / kg, and exchangeable potassium 190.4-228.6 mg / kg, and in the variant with the use of manure at a rate of 10 t / ha, the amount of absorbed ammonium was 4.8-6.4 mg / kg, nitrate nitrogen 3.0 -4.1 mg / kg, mobile phosphorus 6.6-10.8 mg / kg, and exchangeable potassium 184.2-227.1 mg / kg, and when applying manure at a rate of 10 t / ha + N15P65K30, these figures were respectively 5.2-6.8: 3.5-4.4: 7.2-11.9 and 194.3-237.1 mg / kg.

From analyzes of soil samples taken from under the plants at alfalfa mowing, it becomes clear that nutrients change significantly in the soil as a result of using mineral and organic fertilizers.

When the number of irrigations reached 5 during the growing season (4800 m3 / ha) as a result of the use of mineral and organic fertilizers, the indicators of effective fertility increased even more. Thus, analyzes of soil samples taken from under alfalfa after harvesting barley against 5 irrigations (4,800 m3 / ha) make it clear that in the control variant without fertilizers in the 1st crop the amount of absorbed ammonium was 5.5-6.9 mg / kg, nitrate nitrogen 3.6–5.1 mg / kg, mobile phosphorus 7.8–13.5 mg / kg, and exchangeable potassium 219.4–260.1 mg / kg. When fertilizers are applied in various rates, these indicators continue to increase. So, when fertilizer is applied in the norm N30P90K60, the amount of absorbed ammonium was 6.6-8.8 mg / kg, nitrate nitrogen 4.4-6.1 mg / kg, mobile phosphorus 9.2-17.4 mg / kg, and exchangeable potassium 236.9-277.5 mg / kg, and in the variant with the use of fertilizers in the norm of N45P120K90 in the 1st cut at a depth of 0-30 cm, the amount of absorbed ammonium was 6.1-8.2 mg / kg, nitrate nitrogen 4.0-5.5 mg / kg, mobile phosphorus 8.4-15.2 mg / kg, and exchangeable potassium 224.2-268.3 mg / kg. The combined application of organic and mineral fertilizers in the norm of 10 tons of manure / ha + N10P65K30 the amount of absorbed ammonium was 6.3-8.5 mg / kg, nitrate nitrogen 4.1-5.9 mg / kg, mobile phosphorus 9.1-17 , 1 mg / kg, and exchangeable potassium 229.6-273.9 mg / kg.

From analyzes of soil samples taken from under alfalfa against this background of irrigation, it becomes clear that in the 2nd crop in the control variant without fertilizers the amount of absorbed ammonium

was 5.2-6.4 mg / kg, nitrate nitrogen 3.1-4, 8 mg / kg, mobile phosphorus 7.1–12.7 mg / kg, and exchangeable potassium, 201.5–244.4 mg / kg. When using mineral and organic fertilizers, these indicators have changed a lot. So, when using mineral fertilizers in the norm N30P90K60, these figures were respectively 5.6-8.0; 3.7-5.1: 8.2-13.9 and 206.7-253.6 mg / kg, and in the standard N45P120K90 - 6.0-8.7: 4.1-5.7: 8, 7-15.2 and 207.2-252.8 mg / kg.

When applying organic fertilizer in the form of manure at a rate of 10 t / ha in the 1st cut at a depth of the soil layer of 0-30 cm, the above indicators were 5.2-7.9; 3.7-5.0; 7.9-13.5 and 203.4-250.2 mg / kg, and at a manure rate of 10 t / ha + N10P65K30 - 5.8-8.1: 3.6-5.2: 8.3 -15.1 and 206.4-253.6 mg / kg.

From the analyzes of soil samples taken from under the alfalfa at the 3rd mowing of alfalfa it becomes clear that in the control variant without fertilizers the above indicators were 4.5-6.1; 3.0-4.2; 6.9-11.4 and 184.2-225.6 mg / kg. When mineral fertilizers were applied in the norm of N30P90K60, these indicators were 5.1-7.6: 3.5-4.7: 7.7-12.2 and 195.8-238.1 mg / kg, and at the rate of N45P120K90 in 3rd cut - respectively 5.8-8.1; 3.8-5.0; 8.1-12.8 and 200.3-244.4 mg / kg. When applying manure at a rate of 10 t / ha + P35, the amount of absorbed ammonium was 5.0–7.2 mg / kg, nitrate nitrogen 3.1–4.6 mg / kg, mobile phosphorus 7.2–11.4 mg / kg, and exchangeable potassium 181.2-234.5 mg / kg, and when applying manure in the normal 10 t / ha + N10P65K30 - respectively 5.2-7.8: 3.3-4.4: 7.7- 12.4 and 200.1-239.2 mg / kg.

Nutrients, participating in biochemical processes, occurring with different intensities and in different directions in the period of plant development, fundamentally apply to plant organisms. Plants always feel a lack of such nutrient elements as nitrogen, phosphorus and potassium from the soil. Efficient use of nutrients by plants depends largely on the creation of an optimal water regime. For this, the amount of nitrogen, phosphorus and potassium in the soil layer was determined by cuttings to characterize the nutrient requirements of alfalfa against the background of different amounts of irrigation. As a result of the analysis, it becomes clear that the introduction of irrigation and fertilizer rates in the soil increases the number of digestible nutrients. And this, in turn, has the necessary effect on the yield and quality of alfalfa in its mixed sowing with barley.

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THE POTENTIAL OF AGRICULTURAL RESIDUES IN THE DISTRICTS OF ADANA

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ABSTRACT

The aim of this study was to determine the biomass potential and the energy value, being produced from agricultural residues in Adana province. Adana is a province of Turkey on the Mediterranean Region which is divided into 15 districts. The amounts of residues from the agricultural crops cultivated in Adana province were calculated using production data of crops with Turkish Statistical Institute for the 2018 seasonal years. The annual gross potential of agricultural residues was determined by using residue to product ratio. The energy potential of residues for each districts was calculated by multiplication of the calorific values of agricultural residues with the available residue amount. The total amount of agricultural residues was approximately 1,768.8 kt.year^{-1}. It was found that the total calorific value of the agricultural residues was around 31.48 PJ.year^{-1} for the production period of 2018 in the province. When districts put in order according to the amount of agricultural residues, the top five districts of Adana are Ceyhan (546.1 kt), Yüreğir (350.4 kt), Karataş (214.3 kt), Kozan (164.43 kt) and Seyhan (141.44 kt). The major crops included in the ratio of the total agricultural residues were maize (54.3%), cotton (18.9%), sunflower (11.2%) and citrus (6.3%). Additionally, the data obtained in order to see the distribution of residues more clearly is mapped.

1. INTRODUCTION

Energy is central to economic development, and there is a clear correlation between energy consumption and living standards. Energy sources are split into three categories: fossil fuels, renewable sources and nuclear sources (Karaca, 2015). The valid global energy supply depends heavily on fossil sources (crude oil, lignite, hard coal, natural gas). The World's economies are dependent on crude oil. Fossil fuels are limited resources, collected in few regional areas of the world. This creates a permanent and insecure status of dependency on import of energy for the countries of outside this region.

Conventional biomass plays a considerable role in energy production in Turkey. Wood is used as a major resource for direct cooking and heating in rural areas, but the use of modern biomass for energy production is a rather recent event. Turkey is an agricultural country; moreover, it has significant forestry potential, especially in the Central Anatolia, Çukurova, and Southern Anatolia regions. Even though the main goal is harvesting cereals and other seeds in agriculture, there is a strong wish to reclaim buried agricultural waste. Agricultural waste is a major source of biomass due to its high potential (Karaca and Başçetinçelik, 2014).

Turkey has always been one of the major agricultural countries in the world. The importance of agriculture is increasing for biomass energy is one of the major resources in Turkey. Biomass waste materials can be used in Turkey to provide centralized, medium- and large-scale production of process heat for electricity generation. Electricity generation from biomass has been found to be a promising method in the nearest future in Turkey (Karaca, 2015).

Biomass energy includes agricultural residues, domestic waste, fuelwood, animal waste and other fuel derived from biological sources. Estimation is based on the recoverable energy potential from the main agricultural residues, livestock farming waste, forestry and wood processing residues and domestic waste as given in the

literature. Biomass which comprising mostly wood and dung for heating and cooking is mainly used in rural areas (Başçetinçelik et. al. 2005)

Agricultural residues are defined as a biomass by-product from the agricultural system and include straws, husks, shells, and stalks. These residues can be divided into two groups: crop residues, which remain in the field after harvest including cotton stalk, and agricultural residues, which are the by-products of the industrial processing of crops such as rice husk. (Karaca, 2015)

This study aimed to determine the biomass potential and the energy value, being produced from agricultural residues in Adana province. The major benefits are environmental and relate to the reduction of GHG emissions (since crops are considered CO_2 neutral), conservation of natural resources, and avoidance of fossil fuel consumption. They are complemented by economic benefits (reduction of imported fuel consumption), regional development and investment increase.

2. MATERIAL AND METHODS

Adana Province is a province of Turkey on the Mediterranean Region. Adana province is divided into 15 districts, four of which (Seyhan, Yüreğir, Çukurova and Sarıçam) are included in the municipality of Center district. Other districts include Aladağ, Ceyhan, Feke, İmamoğlu, Karaisalı, Karataş, Kozan, Pozantı, Saimbeyli, Tufanbeyli and Yumurtalık.

Grains and industrial crops have the most important place regarding production area and amount of product in the production of agricultural products of Adana. The province has 486,102 hectares of agricultural land. Field crops constitute 75.7% of the agricultural land and fruit, vegetable and fallow lands constitute the rest. Maize, wheat, cotton, sunflower and groundnut are the prominent products in the province. (TUIK, 2018a)

The amounts of residues from the crops cultivated in Adana province were calculated using production data of crops with Turkish Statistical Institute for the 2018 seasonal years (TUIK, 2018b). The annual gross potential of agricultural residues was determined by using residue to product ratio (RPR) (Table1).

The net potential of residues was determined by using the availability of residues. The availability of residues is unused and completely wastes part of residues (Table1). The available potential of the agricultural residues in each district of Adana was calculated based on the Eq.1.

$$(AAR)_i = (AAP)_i \; x \; (RPR)_i \; x \; (A)_i \qquad (1)$$

where $(AAR)_i$ is the available amount of agricultural residues of i^{th} crop in ton, $(AAP)_i$ the amount of agricultural product in tons or number of tree for pruning wastes, $(RPR)_i$ residue-to product ratio of the i^{th} crop and $(A)_i$ the availability of residues.

The residues are material left over the field after agricultural production. Some agricultural residues have already been used for domestic purposes, heating, animal fodder, bedding. Mainly residues from the production of industrial, agricultural products are left over the field. The species are cotton stalk, maize stalk, sunflower stalk, cereal straw, pruning, etc.

The energy potential of residues for each district was calculated by multiplication of the heating values of a selection of agricultural residues which was taken heating value per each residue (Table 1) with the available residue amount (Eq. 2).

$$(THV)_i = (AAR)_i \; x \; (LHV)_i \qquad (2)$$

where $(THV)_i$ the total heating value of agricultural residues of i^{th} crop in GJ, $(AAR)_i$ is the available amount of agricultural residues of i^{th} crop in tons and $(LHV)_i$ lower heating value of air-dry residues of i^{th} crop in MJ kg^{-1}.

The energy content of the selected products for each district was calculated using the above equations. For each district, the calculated values that the total amount and the total energy potential of agricultural crop residues were mapped using the GIS software. The produced maps were provided to see more clearly in the differences of data among the districts. The mapping can provide the rise of public awareness and policy-makers' reference about these subjects.

Table 1. The ratio of product to residue, availability and heating values of a selection of agricultural crop residues (Başçetinçelik et. al., 2006; Velázquez-Martí et. al., 2013; Karaca, 2015)

Field Crops	Residues	Ratio of Product to Residue (*RPR*)	Availability (*A*) (%)	Heating Value (*LHV*) (MJ/kg)

Wheat	Straw	1.00	15	17.9
Barley	Straw	0.75	15	17.5
Maize	Stalks	1.60	60	18.5
	Cob	0.30	60	18.4
Cotton	Stalks	2.30	60	18.2
	Ginning residues	0.30	80	15.7
Sunflower	Stalks	2.50	60	14.2
Groundnut	Shell	0.40	80	18.4
Fruits Crops				
Olive	Cake	0.40	90	19.7
	Pruning	4*	50	18.1
Walnut	Pruning	10*	50	19.0
Almond	Pruning	7*	80	18.4
Peach	Pruning	8*	80	19.4
Lemon	Pruning	13*	80	17.6
Orange	Pruning	15*	80	17.6
Mandarin	Pruning	13*	80	17.6

* RPR kg/tree

3. RESULTS AND DISCUSSION

The total amount of agricultural residues, including annual crop residues (cereals, maize, cotton, sunflower, groundnuts), perennial residues (tree pruning) and agro-industrial residues (cotton-ginning, seed oil industries, olive oil industries), were calculated to be about 1,768.8 thousand tons in Adana (Table2). Its distribution by the source is field crops (91.95%) and fruit crops (8.05%). Major crops that included in the ratio of the total residue amount are maize (54.3%), cotton (18.9%), sunflower (11.2%), wheat (5.8%) and groundnuts (1.7%). On the other hand, the share of citrus pruning wastes in total agricultural waste is 6.3%.

Table2. The amount of agricultural product and available residues of Adana

Field Crops	Amount of Agricultural Product (*AAP*) (tons)	Residues	Available Residues (*AAR*) (tons)
Wheat	681,905	Straw	102,286
Barley	14,796	Straw	1,665
Maize	842,697	Stalks	808,989
		Cob	151,685
Cotton	206,143	Stalks	284,477
		Ginning	49,474
Sunflower	131,639	Stalks	197,459
Groundnut	94,954	Shell	30,385
Fruits Crops			
Olive	35,900	Cake	12,924
	2,848,927*	Pruning	12,820
Walnut	149,700*	Pruning	749
Almond	277,208*	Pruning	1,552
Peach	508,965*	Pruning	3,257
Lemon	2,416,308*	Pruning	25,130
Oranges	2,818,322*	Pruning	33,820
Mandarin	5,011,632*	Pruning	52,121
TOTAL		**Residues**	**1,768,793**

* Number of trees

When all districts of Adana are aligned according to the amounts of residue, an alignment is as in Table 3. Also, the distribution map of agricultural residues which mapped using a GIS Software for each district was given Figure1.

Table 3. The alignment of districts according to amount of agricultural residues

Districts	Field Crops Residues (tons)	Fruit Crops Residues (tons)	Total Residues (tons)	Share in Total Residues (%)
Aladağ	6,659	387	7,045	0.40
Ceyhan	539,616	6,485	546,101	30.87
Çukurova	18,403	2,955	21,359	1.21
Feke	1,119	243	1,363	0.08
İmamoğlu	72,727	2,413	75,140	4.25
Karaisalı	56,506	5,872	62,377	3.53
Karataş	199,027	15,247	214,274	12.11

Kozan	140,345	24,085	164,430	9.30
Pozantı	80	233	313	0.02
Saimbeyli	1,124	154	1,278	0.07
Sarıçam	78,917	5,059	83,975	4.75
Seyhan	116,768	24,670	141,438	8.00
Tufanbeyli	5,498	267	5,766	0.33
Yumurtalık	88,416	5,113	93,529	5.29
Yüreğir	301,216	49,190	350,406	19.81
TOTAL	**1,626,420**	**142,373**	**1,768,793**	**100.00**

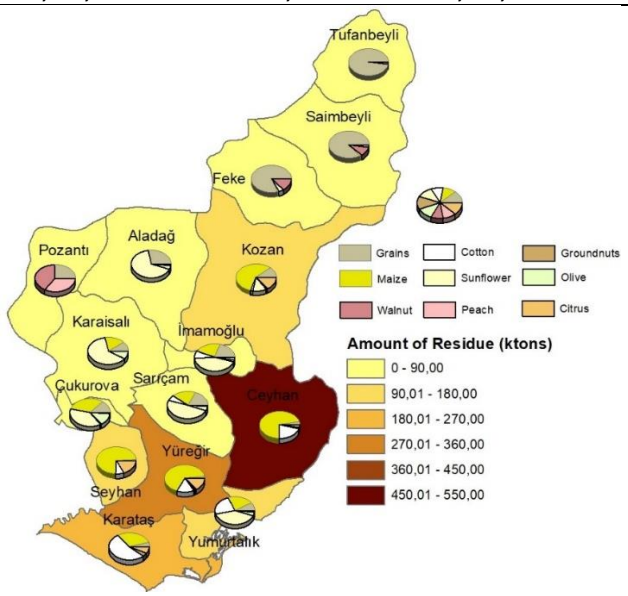

Figure 1. The distribution map of agricultural residues in Adana

30.87% of total residues in Adana were found to originate from the Ceyhan district. Apart from this, also the Yüreğir district is seen to have a high agricultural residue potential (350.4 ktons). It is believed that there will not be a shortage of raw materials for the investment and facilities to be made for obtaining energy from agricultural residues in these two districts.

Table 4. Total heating value of agricultural residues of Adana

Field Crops	Residues	Total Heating Value (*THV*) (GJ)
Wheat	Straw	1,830,915
Barley	Straw	29,130
Maize	Stalks	14,966,299
	Cob	2,791,012
Cotton	Stalks	5,177,488
	Ginning	776,747
Sunflower	Stalks	2,803,911
Groundnut	Shell	559,089
Fruits Crops		
Olive	Cake	254,603
	Pruning	232,045
Walnut	Pruning	14,222
Almond	Pruning	28,564
Peach	Pruning	63,193
Lemon	Pruning	442,281
Orange	Pruning	595,230
Mandarin	Pruning	917,329
TOTAL		**31,482,056**

It was calculated that the total heating value of the agricultural residues was about 31.5 PJ (752 ktoe) for the production period of 2018 in Adana. The heating value of agricultural residues that calculated separately for each product is given in Table 4. The distribution map was given Figure 2.

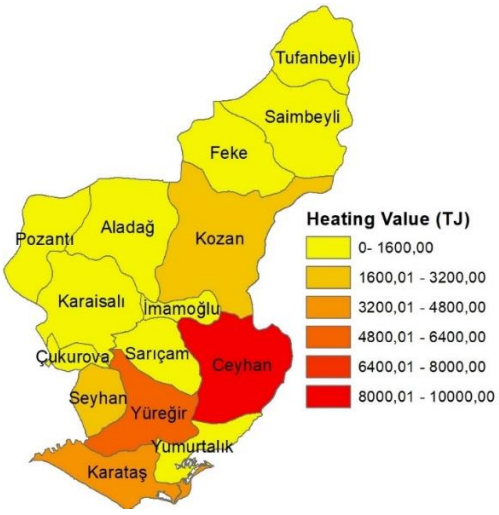

Figure 2. The distribution map of heating value based on agricultural residues in Adana

These maps (Figure1 and 2) showed that the potential of agricultural residues concentrated in the Ceyhan and Yüreğir districts. Especially, it is observed that the type and distribution of residues in Ceyhan district, the distribution of agricultural residues according to heating value is ranked as maize (71.8%), cotton (21.5%) and wheat (2.9%) respectively. In Yüreğir, this ranking consists of maize (65.8%), cotton (16.2%) and citrus pruning (12.7%) respectively. However different crop residues are remarkable in a certain district. Grains (wheat and barley) have a share of 80.3% in Feke, 85.7% Saimbeyli and 95.1% in Tufanbeyli, while in other districts, these distributions are as follows; 51.6% of cotton in Karataş, 55.9% of sunflower in Karaisalı and 75.8% of walnut and almond in Pozantı.

The potential of biomass from agricultural residues was determined in Samsun province. The total biomass potential was determined as 366.6 ktons in the province. (Karaca et. al., 2017).

A study carried out by Karaca and Öztürk (2017) in Osmaniye province indicated that the total biomass potential from agricultural residues was 491 ktons.

Karaca (2018) reported the amount of biomass from agricultural residues was about 380.8 ktons, equivalent to about 6,517.8 TJ of heating value in Balıkesir.

Despite these facts, until now, there has not been any investment in these areas related to agricultural residues, which have a great potential for conversion to energy. However, the results of this study show that such a large potential necessarily has to be evaluated by establishing modern facilities.

4. CONCLUSIONS

This study aimed to determine the distribution of agricultural residues in districts of Adana as given on the map. The importance of this paper is increasing more because Turkey is an energy importing country. Adana is in the second place with a share of 9.1% in Turkey, especially regarding the potential for field crops residues (Karaca, 2015).

The total amount of agricultural residues was approximately 1,768.8 kt. It was found that the total heating value of the agricultural residues was around 31.5 PJ for the production period of 2018. It was determined that this potential concentrate in the Ceyhan, Yüreğir and Karataş districts. It was seen that the majority of agricultural residues originate from field crops. According to the amount of residues of agricultural products, it is listed as, maize (54.3%), cotton (18.9%), sunflower (11.2%), wheat (5.8%) and groundnuts (1.7%).

Although Adana province has a large biomass energy potential, this potential cannot be adequately assessed. In this paper, the produced maps were provided to see more clearly in the differences of data among the districts. The mapping can provide the rise of public awareness, policy-makers' reference and investor's guide about these subjects.

Consequently, agricultural residues are a very attractive choice, since it is economical, sustainable, environmental friendly and a familiar energy source for Adana.

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USE OF MOLECULAR MARKERS IN DISEASE RESISTANT VEGETABLE BREEDING

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ABSTRACT

Today's vegetable breeding studies are primarily aimed at developing resistant varieties. The development of resistant varieties is obtained as a result of long breeding studies. Morphological determinants used in the determination of resistant genotypes in classical breeding studies help to differentiate genotypes but may be affected by environmental conditions. Homozygous and heterozygous individuals cannot be detected if any of these characters are recessive. Therefore, in recent years, advances in the use of molecular markers in the field of biotechnology in disease resistance have rapidly gained importance in the use of plant breeding. Molecular marker assisted selection (MAS) involves selection of plants carrying these genomic regions by means of molecular markers expressing the desired properties. Thus, saving time and space in the selection of disease-resistant varieties, hundreds of plants can be selected simultaneously and reliably and quickly. In this study, types, advantage-disadvantages and application areas of molecular markers used in selection of disease resistant varieties and/or parents in vegetable breeding are discussed.

1. INTRODUCTION

In our country, many chemicals are widely used in the control against disease both in open and greenhouse vegetable growing areas (Kaygusuz & Biçici, 2007; Hwang & Kim, 1995; Çolak & Biçici, 2013; Foster & Hausbeck, 2010). Although some effective chemicals have been developed for many plant diseases, some important diseases are soil-borne diseases such as Fusarium spp, Rhizoctonia spp., Phythium spp. and the disease may develop chemical resistance due to differences in inoculum density in the soil, and no effective chemical control can be achieved economically (Bowers & Mitchell, 1991; Parra & Ristaino, 1998; Walker & Bosland, 1999; Hwang & Kim, 1995). In parallel with the studies in the world, alternative approaches including organic and integrated agricultural systems have come to the fore in order to reduce the negative effects of chemical control in our country (Aksoy, 1999). Among the alternative agricultural systems, cultural measures take the first place in the control against plant diseases. Among these cultural measures, the use of resistant varieties is the most effective, most economical, environmental and sustainable method in the control against disease.

Today's breeding studies are primarily aimed at developing resistant varieties. The development of resistant varieties is obtained as a result of long breeding studies. Resistant varieties are mostly produced as a result of resistant wild species and crosses with existing varieties in order to have quality characteristics such as good taste, shape and color as well as resistance to a certain disease (Scott, 2005). Morphological markers used in classical breeding studies help to differentiate genotypes, but may be affected by environmental conditions. Homozygous and heterozygous individuals cannot be detected if any of these characters are recessive. Therefore, in recent years, advances in the use of molecular markers in the field of biotechnology in disease resistance have rapidly gained importance in the use of plant breeding. Thus, saving time and space in the selection of disease-resistant varieties, hundreds of plants can be selected simultaneously and reliably and quickly (Sambrook et al., 1989; Darling & Brickell, 1994; Summerel et al., 2001; Barone et al., 2005). In this study, types of molecular markers, usage areas in vegetable breeding and some molecular studies on resistance to diseases are mentioned.

2. MATERIAL AND METHODS

Breeding of varieties resistant to one or more vegetable diseases and pests is an alternative approach that limits the environmental and consumer risks of chemical applications. Molecular marker assisted selection (MAS); and selection of plants carrying these genomic regions by means of molecular markers expressing the desired properties. In MAS, DNA-based markers can be used effectively for monitoring the appropriate allele (dominant or recessive), and the selection of the most appropriate individuals for offspring selection is based on the allelic composition throughout a part or the entire genome (Morid et al., 2012). There are basically two different DNA marker techniques. One is RFLP (Restriction Fragment Length Polymorphism) based on DNA hybridization, the other is RAPR (Random Amplified Polymorphic DNA) based on PCR (AFLP), AFLP (Simple Sequence Repeats), SSR (Sequence Related Amplified Polymorphism) techniques. (Staub et al., 1996; Althoff et al., 2007; Zabeau et al., 2007; Williams et al., 1990). Among these techniques, PCR (Polymerase chain reaction) is the most commonly used method (Darling & Brickell, 1994; Kuramae & Souza 2002; Hernandez, 2004). PCR is defined as the enzymatic expression of copies of a specific DNA fragment in in-vitro with short-chain oligonucleotide primers (Mulis, 1990;.Arda, 1995; Gülşen & Mutlu, 2005).

Markers that do not differ between genotypes are defined as monomorphic markers. Markers that differ between individuals of the same or different species are called polymorphic markers. Polymorphic markers are more useful than monomorphic ones because they identify differences. Polymorphic markers show dominant and Co-dominant characteristics, as they can be distinguished between homozygous and heterozygous. Using Co-dominant markers, the difference between heterozygous and homozygous can be clearly seen. However, dominant markers cannot make this distinction. For this reason, Co-dominant markers are preferred in order to know from which parent (mother or father) the disease resistance gene comes from in vegetable breeding (Williams et al., 1990; Staub et al., 1996; Gülşen & Mutlu, 2005; Mutlu et al., 2008).

RFLP (Restriction Fragment Length Polymorphism): It is the first non-PCR based marker system developed. RFLP markers are Co-dominant. With this feature it is possible to identify heterozygous individuals. RFLP is the first molecular marker technique. It is used in phylogenetic studies with RFLP markers, taxonomy and gene mapping studies. RFLP markers, Co-dominated, high polymorphism and high reproducibility, as well as the need for quality DNA, more labor, time and expensive are among the disadvantages of the system (Staub et al., 1996; Bark & Havey, 1995).

RAPD (Random Amplified polymorphic DNA): PCR based, short oligonucleotide primers (6-10 bases) to determine the difference between genotypes. RAPD markers are an advantageous technique in terms of low DNA requirement, high polymorphism rate, and cheap and low labor requirements. However, because RAPD markers are dominant markers, it is difficult to interpret and low reproducibility of the results are among the major disadvantages (Williams et al., 1990).

AFLP (Amplified Fragment Length Polymorphism): AFLP technique is developed by utilizing the principles of RAPD-PCR method. In this method, the DNAs of the genotypes obtained as a result of the breeding are cut with two restriction enzymes (4 and 6 bases) and synthetic DNAs called adapter (ligation) are added to the ends of the DNAs. Ligation products are amplified using primers with selective nucleotide added and the number of selective nucleotides ranges from one to three. AFLP- PCR products are run on polyacrylamide gel and the results are evaluated according to the polymorphism. AFLP technique is between RAPD and RFLP in terms of highly reproducible properties, number of polymorphic bands, cost, labor and reliability. AFLP technique, 30-150 regions can be identified in a single reaction, determination of intra-species and interspecific kinship is an advantageous method in terms of reproducibility. The disadvantage is that the AFLP technique is an expensive and dominant marker (Vos et al., 1995).

SSR (Simple Sequence Repeats): It consists of 2-6 nucleotide sequences that are frequently repeated throughout eukaryotic genomes. The most common in SSR sequencing are dinucleotides, trinucleotides and tetranucleotides. The number of times these sequences are repeated in the genome studied and the location of these sequences differ from species to species. Primers specific to these recurrent regions have been developed in SSR. Thus, different alleles in a locus can be detected by PCR. SSR technique is highly polymorphic, relatively easy, Co-dominate marker and reproducible are important advantages. Especially in plants genetic mapping SSR technique is used successfully. The most important disadvantage of SSR technique is that it requires genome information in new marker development. In the SSR technique, the development of initiator DNAs for the identification and replication of nucleotide sequences is expensive and labor intensive (Guilford, 1997; Weber & May, 1989).

SRAP (Sequence Related Amplified Polymorphism): SRAP is a PCR based marker system targeting open reading zones.The SRAP technique directly amplifies gene regions. The size of the obtained bands can vary between 100-1000 bp. In the RAP technique, the bands are obtained by using forward and reverse primers of 17 or 18 bp length respectively. The SRAP technique is simple, inexpensive, has a high polymorphism rate, is suitable for gene labeling and cDNA fingerprinting studies, has the ease of sequencing the selected bands. SSR technique is used in genetic mapping, gene labeling and genetic diversity studies in different plant species. SRAP markers produce higher consistent results than RAPD markers. Compared to AFLP markers, it is cheaper and requires less labor (Li & Quiros, 2001).

CAPS (Cleaved Amplified Polymorphic Sequence): In the CAPS technique, specific DNA fragments (19-24 mer oligonucleotide primers) specific to the genome of the organism studied are sequenced to form primers specific to them. PCR is performed with these primers. PCR products are cut by cutting enzymes and differences are detected by separating them in agarose gel (Jarvis et al., 1994). CAPS markers can easily distinguish between Co-dominant and homozygous-heterozygous alleles (Konieczny & Ausubel, 1993). The advantages of the CAPS method include the need for very small amounts of DNA, the ability to discriminate from Co-dominant alleles, and simple and inexpensive. However, CAPS is widely used in gene mapping studies and molecular identification studies (Weiland & Yu, 2003).

SCAR (Sequence Characterized Amplified Region**):** In this method, DNA bands obtained from RAPD are cloned and DNA base sequences are determined. Specific primers of 18-24 base length are designed on a portion of this differing DNA fragment and utilized in the PCR study.The SCAR method is being used for screening genome libraries and gene mapping studies (Weising et al., 1995).

2.1. Desired properties of molecular markers

Molecular markers have many advantages over morphological and biochemical markers. Molecular markers; Because they are genome-dependent, they are reliable, reproducible, easy to analyze and simple, suitable for automation, and easily optimized between laboratories. They are also unaffected by environmental and genetic factors. In this context, among the most important features desired in the molecular marker; high polymorphic behavior and different genotypes. It should also show Co-dominant inheritance. Thus, heterozygous individuals and homozygous dominant individuals should be easily distinguished. Molecular markers must be uniform in the genome, reproducible, and require a small amount of DNA or tissue. The application cost should be low and easy to reach, the results should be evaluated easily and quickly (Gülşen & Mutlu, 2005; Helentjaris et al., 1985; Kesawat & Das, 2009; Williams et al., 1990).

2.3. Usage Areas of Molecular Markers

Molecular markers are used to determine the genetic resources of plant and plant diseases and to determine the kinship levels, to protect the varieties genetically and to protect certain varieties at the genome level. Nowadays, in many vegetable species, both greenhouse and field, molecular markers are used in a very short time and reliably to detect diseases and pests that cause economic damage. It is successfully used in breeding programs for the development of new varieties resistant to diseases and pests, genetic mapping, marker assisted selection studies, determination of genetic diversity within and between populations (Khan & Spor, 2001; Gülşen & Mutlu, 2005; Williams et al., 1990).

3. MOLECULAR MARKER ASSISTED SELECTION (MAS) STUDIES IN DISEASE RESISTANCE VEGETABLE BREEDING STUDIES

The main objective of vegetable breeding is to develop high quality and plant disease-pest resistant hybrid varieties. In this context, resistance selection with molecular marker selection (MAS) accelerates vegetable breeding studies, saves time and space in the selection of hybridizations made with the selection of desired genotypes and provides selection of hundreds of plants in one day (Staniaszek et al., 2007, Barone et al., 2005; Gülşen & Mutlu, 2005). It is important for the reliability of the results that the primers used in breeding of disease resistance selection with MAS are preferred to the closest gene. The use of SCAR markers in breeding compared to other SRAP (Budak et al., 2004), RGA (Mutlu et al., 2006), RAPD (Toppino et al., 2004; Boyacı & Abak, 2008) markers; breeding studies in the F2 and F3 populations homozygous or heterozygote in the determination of heredity is very close to the gene is very reliable, accurate and easily detectable in agarose gel quality (Mutlu

et al., 2008). In breeding studies, by selecting genotypes suitable for MAS selection purpose; It contributes to the rapid commercialization of lines, from time to saving, to lower costs in hybridization programs.

Pepper crown blight (*Phytophthora capsici* Leon) is one of the most important diseases causing loss of yield and limiting cultivation in all areas of pepper production in the world. Molecular marker selection provides many advantages in plant breeding studies, particularly in determining polygenic characters such as *Phytophthora capsici* Leon whose resistance is directed by many genes.This quantitative resistance is considered a promising tool for breeding (Thabuis et al. 2004).Quirin et al. (2005) in their study; Using the OpD04.717 primer, they obtained a single band in *Capsicum annuum* and *Capsicum chinense* species resistant to the causative agent. They cloned this band and sequenced it to form a marker.In this study, Study; researchers found that the marker they obtained was very close to the Phyto 5.2. on the 5. chromosome, one of the six QTLs providing resistance. They reported that it can be used to differentiate resistant individuals with Phyto 5.2. The disease resistance is a multiple gene-controlled character. However, important QTLs can be effective in making the control against disease sustainable. In this study; one of the QTLs that are resistant to *Phytophthora capsici* Leon has been mapped and converted to PCR based marker and presented to the use of breeding programs. (Quirin et al., 2005).

They studied the PCR-based RAPD and AFLP markers for resistance to powdery mildew (*Oidium lycopersicum*) expressed by ol-2 gene in tomato. The F2 population was formed by hybridizing with susceptible to powdery mildew Super Marmande variety and resistant *Lycopersicon esculentum* var. *cerasiforme.* At the end of the study, the RAPD marker $OPU3_{1500}$ was detected in susceptible bulk at 1500 bp. The RAPD marker was converted to CAPS and used for molecular marker assisted selection (MAS) (Giovanni et al., 2004). In China; investigated the inheritance analysis of the linkage of Late Blight of tomato (*Phytophthora infestans*) resistance to SSR (simple sequence repeat) markers, an important disease in tomato productionin China. In this study where heredity was defined; 241 F_2 tomato plants were obtained from the hybrid CLN2037E hybridization with 5 precision lines. As a result of genetic mapping and linkage analysis; the disease was controlled by the *Ph*-ROL gene on chromosome 9. The SSR marker TOM236 with the *Ph*-ROL gene has been reported to be at a distance of 5.7 cM (Zhu Shan et al., 2006).

Eggplant (*Solanum melongena*) cultivation; *Fusarium oxysporum* Schlecht. f. sp. *melongenae* Matuo and Ishigami (FOM), which causes wilt disease in plants, has been reported to cause significant yield losses in many countries such as Italy, Israel, Japan and the Netherlands, and damage both in field production and greenhouse cultivation (Kenneth et al., 1970; Capelli et al., 1995; Çolak et al., 2018). Fusarium wilt (*Fusarium oxysporum* f. sp. *melongenae*, FOM) resistance in eggplant in many studies; Fusarium wilt resistant wild species have been reported, including *Solanum indicum, S. integrifolium, S. aethiopicum gr. gilo, S. sisymbriifolium, S. incanum* and *S. torvum (*Mochizuki et al., 1997, Kashyab et al., 2003; Rotino et al., 2004; Toppino et al., 2008). Mutlu et al. (2008) developed that SRAP, SRAP-RGA, RAPD and SCAR markers to determine the resistance to Fusarium wilt (*Fusarium oxysporum* Schlecht . f. sp. *melongenae*) in eggplant. In the study, as a result of 2,316 primer combinations, the three markers were found to be closest to 2.6 cM. Co-dominant SARP marker Me8/Em5 and dominant SRAP-RGA marker Em12 / GLPL2 were found to be linked to the resistance gene by 1.2 cM, but RAPD marker H12 was also associated with 2.6 cM on two alleles. In the study, SRAP marker F2 and back hybrid 3 generations were found to be associated with the endurance gene and converted to two dominant SCAR markers. Two SCAR markers designed with this study may be useful in MAS selection breeding studies to determine Fusarium wilt resistance in eggplant. Çolak et al. (2018) in their study, resistance of 77 different eggplant genotypes against Fusarium wilt (*Fusarium oxysporum* f.sp. *melongenae*-FOM), *Potato Y potyvirus* (PVY) and Root-knot nematode (*Melodiogyne incognita*-RN) were determined with molecular marker assisted selection and classical testing. To determine FOM resistance, 77 eggplant genotypes were screened with the SCAR426 marker, which was identified to be the closest to the gene at 1.2 cM, and it was determined that the four eggplant genotypes, namely P11, P29, P49 and P52 were heterozygous resistant against FOM. FOM-resistant lines were verified by classical testing. As a result of classical testing conducted to determine PVY and RN resistance of eggplant genotypes, it was determined that all lines were PVY-sensitive and P29 and P52 genotypes were resistant to FOM and RN. Disease-resistant genotypes determined in the present study would contribute to the development of the new F1 hybrid eggplant cultivar.

The crown and root rot disease (*Fusarium oxysporum* f. sp. *radicis-lycopersici* / Frl), which is one of the most important soil-borne diseases that limit the production of tomatoes economically, is very difficult because of its soil origin (Çolak & Biçici, 2013). In molecular studies related to resistance to this disease, Truong et al. (2011) developed that the RAPD marker and transformed it into SCAR and presented it to its use in breeding studies. Mutlu et al. (2015) in their study; By transforming the SCAR marker into Co-dominant SCAR, they developed the $SCAR_{frl}$ marker, which can show whether the inheritance is heterozygous or homozygous at a distance of

approximately 0.016 cm at a distance almost above the Frl gene. Çolak et al. (2019) in their study; RAPD primer and SCARFr1 primer were used to determine FRL resistance, CAPS and Co-dominant SCAR primers were used for resistance to *Tomato yellow leaf curling virus* (TYLCV, Israel, Mild, Sardinian strains). In the 418 tomato genotypes; 102 of the FORL, 46 of the TY3 and 35 of the TY1 locus were determined resistance. In this study, 7 tomato genotypes which contain all three targeted gene sources (FORL + TY1 + TY3) were determined as a result of molecular studies and and classical tests.

Molecular marker-based resistance to many vegetable diseases studies; It is emphasized that it is important to conduct validation studies with classical testing at every stage of hybridization programs.Thus, Mutlu et al. (2008) 's Fusarium wilt resistance in eggplant in their study; Although such markers, such as SCAR426 and SCAR347, are very close to the gene and the recombination rate is very low, they report that it is necessary to verify disease resistance by classical testing at regular intervals within the hybridization programs of breeding materials determined to be resistant by markers (Scott et al., 2015).

4. CONCLUSIONS

In today's conditions, resistance to at least 3 and more disease factors is needed depending on the production area and time. As the required number of durability increases, the reclamation time increases and is not even possible. In this context; In recent years, rapid advances in the use of markers in molecular marker assisted selection (MAS) in the field of biotechnology in disease resistance have rapidly gained importance in the use of plant breeding. Thus, saving time and space in the selection of disease resistant varieties can be provided, hundreds of plants at the same time, can be selected safely and quickly (Darling & Brickell, 1994; Barone et al.,2005). Although molecular markers provide great advantages in breeding in terms of speed and cost, conventional validation tests must be performed in disease resistant genotypes (Lee et al., 2015). Because the distance of the developed markers again, taking into account the margins of human and marker origin, it is important to carry out classical validation tests in determining the resistance to MAS selective diseases (Caro et al., 2015; Scott et al., 2015).

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STEVIA: ŞEKERE ALTERNATİF DOĞAL VE SIFIR KALORİLİ TATLANDIRICI

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ABSTRACT

Gıda endüstrisinin en önemli amaçlarından biri, küreselleşen dünyamızda bilinçli tüketici oranını arttırmak ve bu artan bilinçli tüketici taleplerini karşılayabilmektir. Gıda endüstrisi personelleri, tüketicilerin genel eğilimi doğrultusunda gıdalarda bulunan şeker miktarını düşürmeyi (diyabet, obezite, kronik hastalıklar vb. sebeplerden dolayı) amaçlamaktadır. Dolayısı ile daha sağlıklı, doğal ve düşük kaloriye sahip gıda tatlandırıcıları bu amaç kapsamında büyük önem taşımaktadır. Güney Amerika kökenli Stevia (Stevia rebaudiana) bitkisinin ekstraktlarının, Japonya, Çin, Kore ve Brezilya başta olmak üzere birçok ülkede doğal tatlandırıcı olarak kullanımı devam etmektedir.

Stevia Bitkisi ve Steviol Glikozitler

Stevia bitkisinin yüzlerce türü bulunmasına rağmen, tatlı yapraklarıyla bilinen çeşidi *Stevia rebaudiana*'dır. Hem Güney hem de Orta Amerika'da hafif asitli topraklarda yetişebilen Stevia bitkisi Paraguay'ın Guarani yerlilileri tarafından yüzyıllardır içecekleri tatlandırmada kullanılmaktadır (Madan, Ahmad, Singh, Kohli, Kumar ve Garg, 2010; Saulo, 2005).

Yirminci yüzyılın başından itibaren, Stevia dünyanın geri kalanı tarafından da bilinmeye başlamıştır. 1887'de, İtalyan-İsviçreli bir botanikçi olan Dr. Moises Santiago Bertoni bu tatlı yapraklı bitkinin Paraguay'ın yerli halkı tarafından kullanıldığını belirtmiş ve ilk kez Stevianın sınıflandırılmasını sağlamıştır. Bertoni, Stevia bitkisini papatyagiller familyası içerisinde sınıflandırmış, ancak 1905'te yeniden sınıflandırılarak Stevia çeşitleri krizantem familyası (chrysanthemum family) içerisinde yeralmıştır. (Hale, 2001; Madan ve diğerleri, 2010; Soejarto, 2002; Kinghorn, 2002).

Paraguay'daki İngiliz Konsolosluğu, Stevia'nın keşfini Bertoni'ye atfetmiş olsa da diğer araştırmacılar, Stevianın 1500'lerde Paraguay'ın kuzeyinde, İspanyol bir botanikçi Pedro Jaime Esteve tarafından bulunduğunu belirtmektedir (Madan ve diğerleri, 2010; Hale, 2001; Soejarto, 2002; Kinghorn, 2002).

Stevia Bitkisinin Kökeni ve Tarihçesi

Günümüzde şeker ikame maddesi olarak kullanılan birçok kalorili ya da kalorisiz doğal ya da yapay tatlandırıcı bulunmaktadır. Ancak gıda sanayinde gıda güvenliği açısından daha güvenilir gıda maddelerinin üretimini ve tüketicilerin ihtiyaçlarını karşılayabilmek amacıyla duyusal yönden de daha kaliteli ürünlerin üretimine yönelik çalışmalar devam etmektedir (Cardoso & Bolini, 2007).

Doğada, tatlılık özelliğine sahip ve düşük kalorili birçok bileşik yer almaktadır. Bu ürünlerden başlıcaları; Taumatin, Glisirizin, Ksilitol, Filodulsin, Mogrozit ve Steviol glikozitlerdir. Günümüzde obezite sorunu ve aşırı kilo alımı, sağlık açısından önemli risklere neden olan faktörlerin başında yer almaktadır. Bu sebeple, insanlar günlük yaşantılarında, kilo kontrolü ve diyetlerinde kalorisi daha düşük fakat tatlılığı yüksek gıda maddelerine hızlı bir şekilde yönelmektedir. *Stevia rebaudiana* Bertoni bitkisi bu açıdan üzerinde en çok çalışma yapılan bitkilerin başında gelmektedir. Birçok ülkede bu bitkiden elde edilen tatlandırıcıların üretimi ve kullanımı

yaygındır (Lemus-Mondaca, Vega-Gálvez, Zura-Bravo, & Kong, 2012). Ülkemizde ise "Rize Şekeri" ve "Şeker otu" adıyla bilinen *Stevia rebaudiana* Bertoni'nin aslında anavatanı Güney Amerika kıtasıdır. Paraguay ve Brezilya'da uzun bir süreden bu yana tatlandırıcı ve tedavi edici özelliklerinden dolayı kullanılan Stevia bitkisi, Japonya'da da otuz yılı aşan bir süredir birçok insan tarafından tatlandırıcı ve gıda katkı maddesi olarak kullanılmaktadır. Stevianın Kuzey Amerika'da varlığı bilinen 80'den fazla çeşidi, Güney Amerika'da ise 200'den fazla yerli türü bulunmaktadır (Nunes, Ferreira-Machado, Dantas, De Mattos, & Caldeira-de-Araújo, 2007; Tadhani, Patel, & Subhash, 2007). Türkiye'de ise ilk olarak 2009'da Antalya'da üretime geçilmiştir. Daha sonra, Ülkemizde Fethiye, Balıkesir ve Rize gibi yerlerde yetiştiriciliği yapılmaya başlanmıştır. Ülkemizde Steviadan elde edilen tatlandırıcılar üzerine yapılan ilk çalışma ise Karaca tarafından 2010 yılında yapılan "Stevia Rebudiana Yapraklarından Ekstrakte Edilen "Stevioside" ile "Rebaudioside A"nın Meyveli ve Gazlı İçeceklerde Kullanımı" başlıklı çalışma ile gerçekleştirilmiştir (Tadhani ve diğerleri, 2007).

Stevia, nemli ortamlarda kolaylıkla yetişebilen ve 60-90 cm boyuna kadar büyüyebilen Asteraceae familyasına ait olan bir bitki çeşididir (Şekil 1) (Cariño-Cortés, Hernández-Ceruelos, Torres-Valencia, González-Avila, Arriaga-Alba, & Madrigal-Bujaidar, 2007; İnanç & Çınar, 2009). Asteraceae familyasının ismi ise yıldız biçiminde olan çiçekleri bünyesinde barındıran bir cins olan Aster türünden gelmektedir. Genel olarak otsu, çok azı çalı, ağaç vb. biçimindedirler. Yapraklar basit ya da bileşik, stipulsuz, alternat, rozet biçimindedir. Çiçekler baş ya da kapitulum şeklindedir. Bunlarda baş birçok küçük ya da florat olarak adlandırılan çiçekler; konik, küresel veya düzleşmiş bir reseptakulum ya da diskten çıkarlar. Bütün kapitulum fillari olarak nitelendirilen involukral brakteler tarafından sarılmıştır. Bunlar bir ya da birkaç seri şeklinde olabilirler ya da imbrikat dizilmiş olabilirler. Braktenin ikinci şekli de (chaffy) bulunabilir. Bu yapı genel resaptakulum üzerinde bireysel çiçeklerin tabanında yer alır. Brakteler var ise, resaptakulum chaffy'dir; yok ise çıplaktır. Reseptakulum tüyler, dikenler ve oyuklar taşıyabilir. Kapitulumda yer alan çiçekler hermafrodit ya da tek eşeyli, aktinomorf veya zigomorf yalnız bir periyantserisi iyi gelişmiştir. Kalikspappus olarak nitelendirilen tüysü biçimde veya tamamen eksiktir. Korolla5'li vesimpetaldır. Korolla tubular çiçeklerde aktinomorf, ligulat olanlarda zigomorftur. Androkeum 5 stamen'lidir, onların anterleri birleşik yapılı, filamentleri serbest yapılıdır. Ginekeum 2 birleşik karpelli, tek odalı, ovaryumalt halindedir. Meyve akendir. Asteraceae, çiçekli bitkilerin en büyük ailesi olarak nitelendirilir. Dünyada 1100 tür ve 25000 kadar çeşidi bulunurken, Türkiye'de 133 çeşit ve bunlara ait olan 1156'dan fazla çeşidi yer almaktadır (Yıldırım, 2017).

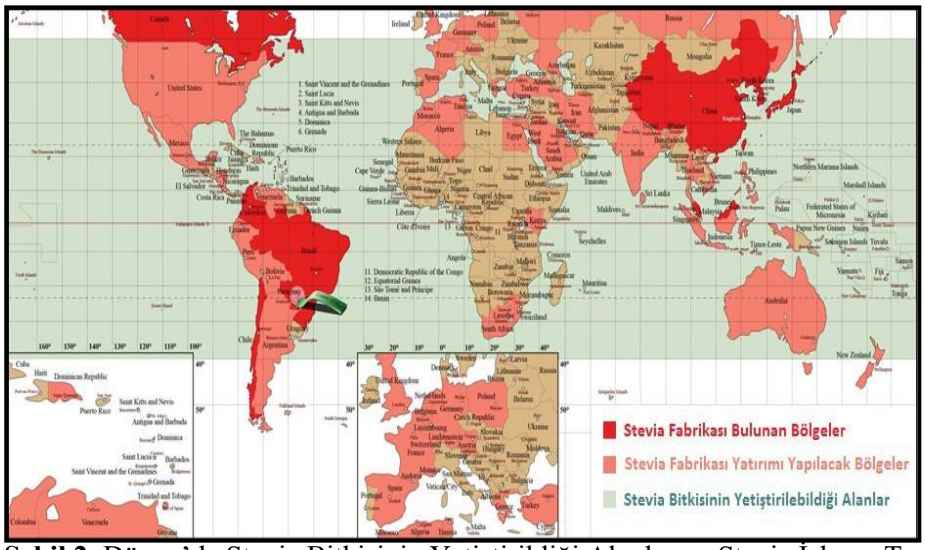
Şekil 1. Stevia bitkisi kısımları ve büyüme aşamaları

Astereceae (Compositae) ailesinde yer alan bitkiler içerisinde yeralan *Stevia rebaudiana* Bertoni bitkisinin yapraklarında bulunan yüksek yoğunluğa sahip tatlandırıcıların tam olarak ne zaman tespit edildiği bilinmese de bilim dünyasında yer almaya başlaması 115 yıl öncesine dayanmaktadır. Paraguay'ın başkenti olan Asunción da İngiliz konsolosu olarak çalışan Cecil Gosling, Stevianın keşfedilmesinde İsviçreli botanikçi Dr Moisés S. Bertoni'ye önemli katkılarda bulunmuştur. Bitki üzerinde çalışmalar gerçekleştiren ve yeni bir tür olduğunu

ortaya koyan Bertoni, daha sonra bitkiye *Stevia rebaudiana* Bertoni adını vermiştir (Gerwig, te Poele, Dijkhuizen, & Kamerling, 2016).

Stevia, Paraguay Kızılderilileri tarafından “tatlı ot" ve “ballı yaprak" gibi değişik isimlerle adlandırılmıştır. Stevia yarı nemli subtropik bölgelerin bitkisi olup (Şekil 2), 60-90 cm boylarında, ortalama 25˚C’de ve bazı türleri 2300-2900 metre yüksekliklerde de yetişebilen tatlılık özelliğine sahip bir bitki türüdür.

*Stevia rebaudiana’*nın anavatanı Güney Amerika’dır. Paraguay, Brezilya, Kolombiya, Meksika, Uruguay, Guatemala, Peru, Japonya, Çin, Güney Kore, Kenya, Bolivya ve Brundi’de yetiştirilmektedir. Ülkemizde daha çok Akdeniz, Ege ve Karadeniz gibi kıyı bölgelerimizde yetiştiriciliği yapılan Stevia bitkisi başta Adana, Antalya, Balıkesir (Burhaniye, Ayvalık), Samsun ve Rize başta olmak üzere birçok ilimizde yetiştirilebilmektedir (Şekil 3). 2017 yılı itibarıyla Ülkemizde yaklaşık 1260 dönüm alanda Stevia yetiştiriciliği yapılmıştır. Ülkemizde şuan için Stevia ve ürünlerini işleyen kurulu bir işletme bulunmazken Çay İşletmeleri Genel Müdürlüğü (ÇAYKUR) tarafından 50 ton/yıl kapasiteli bir işleme tesisinin kurulumu devam etmektedir.

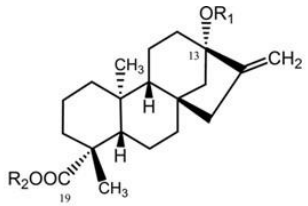


Şekil 2. Dünya’da Stevia Bitkisinin Yetiştirildiği Alanlar ve Stevia İşleme Tesislerinin Bulunduğu Bölgeler

Şekil 3. Türkiye’de 2017 Yılı İtibarıyla Stevia Bitkisinin Yetiştirildiği İller

Anavatanı Paraguay kökenli olan Stevia bitkisi tatlandırıcı özelliği sebebi ile yirminci yüzyılda binden fazla bilimsel çalışmaya ve çeşitli patent başvurularına konu olmuştur. Stevioside, Stevia yapraklarına tatlılık veren ve yapraklarda en fazla bulunan bileşenlerden birisidir (Şekil 4). Tatlılık üzerinde etkisi bulunan Ent-kaurene diterpen glikozitler Steviadan ilk kez yirminci yüzyılın başlarında ekstrakte edilmiştir (Karagöz & Demirdöven, 2018).

Stevia yapraklarında bulunan diğer glikozitler ise daha sonra yapılan çalışmalarla tespit edilmiştir. 1970'lerin başlarında Japon bilim adamları Stevia yapraklarında bulunan ve ent-kaurene diterpen glikozitlerden en önemli ikinci bileşen olan Rebaudioside A'yı (Şekil 4) izole etmeyi başarmışlardır (Kohda, Kasai, Yamasaki ve Murakami, 1976). Stevia yapraklarında bulunan ve tatlılık veren glikozitlerden olan fakat bitki yapraklarında oransal olarak çok daha az olan Dulcosid A, Rebaudioside B- E ve Steviolbioside ise daha sonra yapılan çalışmalarla saptanmıştır (Tanaka, 1982). *Stevia rebaudiana* Bertoni, diğer Stevia çeşitlerine göre yapraklarında daha fazla Stevioside ve Rebaudioside A diterpen glikozitlerini içermektedir. Yaklaşık 230 farklı çeşidi bulunan Stevia bitkisinin hiçbirinde *Stevia rebaudiana* Bertoni'de bulunan kadar yüksek seviyede Stevioside ve Rebaudioside A bulunmamaktadır. Stevia bitkisinin yapraklarında yeralan ancak tatlılık özelliğine sahip olmayan birçok glikozitin de bulunduğu tespit edilmiştir (Soejarto, Kinghorn, & Farnsworth, 1982)



Bileşen Adı	R1 (C-13)	R2 (C-19)	Formülü	Kütlesi
Steviol	H	H	$C_{20}H_{30}O_3$	318.22
Steviol mono-glucoside	β-Glc	H	$C_{26}H_{40}O_8$	480.27
Steviol mono-glucosyl ester	H	β-Glc	$C_{26}H_{40}O_8$	480.27
Rubusoside	β-Glc	β-Glc	$C_{32}H_{50}O_{13}$	642.33
Steviolbioside	β-Glc-(2→1)-β-Glc	H	$C_{32}H_{50}O_{13}$	642.33
Stevioside	β-Glc-(2→1)-β-Glc	β-Glc	$C_{38}H_{60}O_{18}$	804.38
Rebaudioside A	β-Glc-(2→1)-β-Glc \(3→1)-β-Glc	β-Glc	$C_{44}H_{70}O_{23}$	966.43
Rebaudioside B	β-Glc-(2→1)-β-Glc \(3→1)-β-Glc	H	$C_{38}H_{60}O_{18}$	804.38
Rebaudioside C	β-Glc-(2→1)-α-Rha \(3→1)-β-Glc	β-Glc	$C_{44}H_{70}O_{22}$	950.44
Rebaudioside D	β-Glc-(2→1)-β-Glc \(3→1)-β-Glc	β-Glc-(2→1)-β-Glc	$C_{50}H_{80}O_{28}$	1128.48
Rebaudioside F	β-Glc-(2→1)-β-Xyl \(3→1)-β-Glc	β-Glc	$C_{43}H_{68}O_{22}$	936.42
Dulcoside A	β-Glc-(2→1)-α-Rha	β-Glc	$C_{38}H_{60}O_{17}$	788.38

Şekil 4. Steviol glikozitlerin kimyasal yapısı ve bazı özellikleri

Stevia bitkisinden Steviol Glikozitlerin ekstraksiyonu ve saflaştırılması işlemleri ile tatlandırıcı üretimi ve elde edilen bu tatlandırıcıların gıda maddelerinde kullanılmaya başlanması 1970'li yılların başında Japonya'da gerçekleştirilmiştir. O dönemlerde bazı yapay tatlandırıcıların yasaklanmasıyla birlikte Stevianın kullanımı giderek artmıştır. Stevioside'nin keşfinden önce aspartam Japonya'da yüksek yoğunluklu tatlandırıcı sektörünün %41'ini oluşturmuştur (Momtazi-Borojeni, Esmaeili, Abdollahi, & Sahebkar, 2016). Günümüzde Stevialı tatlandırıcılar ve ürünleri açısından Dünya'daki en geniş ürün ağı ve kullanımı ile Japonya bu alanda ilk sıralarda yer almaktadır. Güney Kore'de ise Stevioside ilk kez alkol sektöründe kullanılmış ve zamanla kullanım alanı genişlemiştir (Mathur, Bulchandani, Parihar, & Shekhawat, 2017). Güney Amerika ülkeleri ve Brezilya'da ise Stevioside'in tatlandırıcı olarak kullanımı yaygınken, Kuzey Amerika ülkeleri ve 15 kadar Avrupa Birliği ülkesinde şeker yerine tatlandırıcı olarak kullanılması uzun süre yasaklanmıştır (Ahmed, Hossain, Islam, Saha & Mandal 2011). Ancak günümüzde Amerika Birleşik Devletleri ve Kuzey Avrupa'da birçok sektörde tatlandırıcı olarak kullanılmaktadır (Gardana & Simonetti, 2018). 1991'de Amerika Birleşik Devletleri'nde *Stevia rebaudiana* Bertoni bitkisi yapraklarının ihracatına yasak konulmuş ancak bu yasak 1995 yılında kaldırılmıştır. Bazı ülkelerde ise sağlığa zararlı olup olmadığı hala tartışma konusu olsa da Stevia bitkisinden elde edilen ekstraktların zararlı olduğuna dair gerçekleştirilen bir araştırma bulunmadığı gibi zararlı olmadığı ile ilgili de geniş kapsamlı bir çalışmada literatürde yer almamaktadır (Momtazi-Borojeni ve diğerleri, 2016).

Stevia'nın Kimyasal Bileşimi

Son yıllarda yapılan araştırmalarda *Stevia rebaudiana* Bertoni yapraklarından Steviol Glikozitlerin yanı sıra glikozidik olmayan diterpenler, klorojenik asitler, flavonoidler ve vitaminler gibi daha fazla besleyici değere sahip bileşenlerin de olduğu tespit edilmiştir (Karaköse, Müller ve Kuhnert, 2015; Koubaa, Roselló-Soto, Šic Žlabur, Režek Jambrak, Brnćić, Grimi, Boussetta, & Barba, 2015).

Doğal bir ürün olarak tanımlanan Stevia bitkisi yaprakları, Steviol Glikozitler olarak nitelendirilen farklı tatlılık

değerlerine sahip bileşenlerden oluşmaktadır. Diterpen yapısındaki başlıca Steviol Glikozit bileşenleri; Steviol, Steviolbioside, Stevioside, Rebaudioside A, B, C, D, E, F, M, Rubusoside, Dulcoside A olarak nitelendirilmektedir. Tatlılık özelliğine sahip ve bitkide oransal olarak daha fazla bulunan başlıca Steviol Glikozitler ise Stevioside ve Rebaudioside A'dır (Wallin, 2007). Stevioside'in tatlılık seviyesi, sakkarozdan 110–270 kez, Rebaudioside A'nın ise, 150–320 kez daha fazladır. Ayrıca Rebaudioside C sakkarozdan 40–60 kez, Dulcoside A ise 30 kez daha çok tatlılık oranına sahiptir. Diğer Steviol Glikozitler de düşük oranda tatlılık özelliğini bünyesinde barındırmaktadır. Rebaudioside D ise diğer Steviol Glikozitlere kıyasla tatlılığı daha fazla ve acılığı daha az olan bir glikozittir. Ancak, Rebaudioside E, Rebaudioside D'den daha da fazla tatlılığa sahiptir. Bununla birlikte, Steviada oransal olarak çok daha düşük miktarlarda bulunan Rebaudioside M'in ise çok daha güçlü bir tatlılığa ve yoğunluğa sahip olduğu ve ayrıca diğer Steviol Glikozitlere kıyasla acılığının çok daha düşük olduğu bildirilmiştir. Stevia yapraklarında yer alan (kurumadde esasına göre) Stevioside, Rebaudioside A, Rebaudioside C ve dulcoside A miktarları sıra ile %9.1, %3.8,%0.6 ve % 0.3'dür (Abelyan & Sembilan, 2010). Ayrıca Steviada bulunan diğer önemli besin maddeleri (Tablo 1) yani protein, yağ, karbonhidrat, kül ve lif sırasıyla 100g kuru Stevia yaprağında 9.8, 2.5, 52, 10.5 ve 18.5 gram olarak belirlenmiştir. Başlıca mineral maddeler ise kalsiyum, fosfor, demir, sodyum ve potasyum olup 100g kuru Stevia yaprağında sırası ile 464.6, 11.4, 55.3, 190 ve 1800 mg'dır (Gasmalla, Yang, & Hua, 2014).

Tablo 1. 100g Stevia'nın İçerdiği Besin Değerleri (Gasmalla ve diğerleri, 2014).

Bileşen Adı	Miktarı
Nem (g)	7
Enerji (kcal)	270
Protein (g)	9.8
Yağ (g)	2.5
Karbonhidrat (g)	52
Kül (g)	10.5
Ham lif	18.5
Mineraller	
- **Kalsiyum (mg)**	464.4
- **Fosfor (mg)**	11.4
- **Demir (mg)**	55.3
- **Sodyum (mg)**	190
- **Potasyum (mg)**	1800
Anti Besinsel Faktörler	
- **Okzalik Asit (mg)**	2295
- **Taninler (mg)**	0.01

Stevia rebaudiana Bertoni'nin doğal tatlandırıcı özelliği yapraklarında bulunan bulunan Steviol Glikozitlerden kaynaklanmaktadır. Stevia yaprakları protein, karbonhidrat, yağ ve ham lif içermekte, ikincil metabolit olan Steviol Glikozitler yapraklarda birikmektedir. Bitkinin farklı bölümleri incelendiğinde en yüksek glikozit oranının yapraklarda olduğu bulunmuştur (Çetin ve diğerleri, 2019).

Stevia yapraklarının kimyasal kompozisyonu ve bazı kimyasal özellikleri sırasıyla Tablo 2. ve Tablo 3.'de gösterilmiştir.

Ayrıca; *Stevia rebaudiana* bitkisinin yaprakları fenolik bileşiklerin yanısıra C vitamini, karotenoidler, klorofiller antimikrobiyal ve antioksidan özellikler sahip birçok bileşeni bünyesinde bulundurmaktadır (Abou-Arab, Abou-Arab, & Abu-Salem, 2010; Lemus-Mondaca ve diğerleri, 2012). Bunun dışında; bu bitkinin yaprakları flavonoidler, alkaloidler, suda çözünebilir klorofiller ve ksantofiller, hidroksisinnamik asitler (kafeik, klorojenik, vb.), nötr yapıdaki suda çözünür oligosakaritler, serbest şekerler, amino asitler, lipidler, uçucu yağlar ve eser elementleri de içermektedir. Stevia bitkisi mineral bakımından da değerlendirildiğinde; kobalt, magzenyum, demir, potaysum ve fosfor gibi mineralleri bulundurmaktadır (Dinçel, Alçay, & Badayman, 2018).

Tablo 2. Stevia yapraklarının kimyasal bileşimi (Çetin ve diğerleri, 2019; Lemus-Mondaca ve diğerleri,

2012)

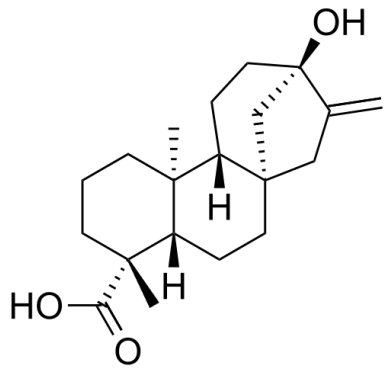
İçerik/Özellik	Miktar (g/100 g kuru yaprak)
Nem	4.65 – 7.7
Protein	9.8 – 20.4
Yağ	1.9 – 5.6
Karbohidrat	35.2 – 61.9
Ham lif	15 – 18.5
Steviol glikozitler	10-15 %

Tablo 3. Stevia yapraklarının kimyasal özellikleri (Çetin ve diğerleri, 2019; Lemus-Mondaca ve diğerleri, 2012)

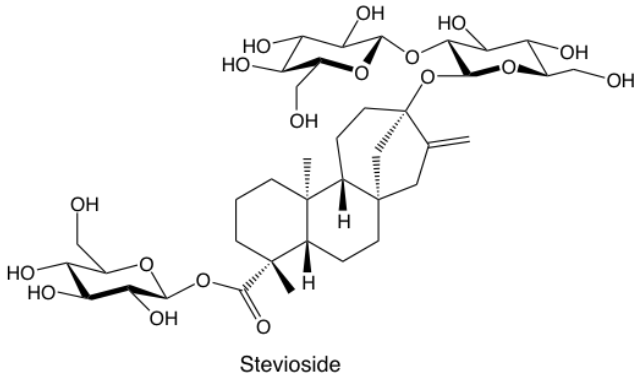
Özellik	Değer
Kitle yoğunluğu	0.443 g/mL
Su tutma kapasitesi	4.7 mL/g
Yağ absorplama kapasitesi	4.5 mL/g
Emülsifikasyon değeri	5.0 mL/g
Şişme endeksi	5.01 g/g
Çözünürlük	0.365 g/g
pH	5.95

Stevia rebaudiana Bertoni bitkisinin yaprağında 30'dan fazla Steviol Glikozit tanımlanmıştır (Wölwer- Rieck, 2012). Glikozitler, karbon hidrat olmayan bir köke (aglikon) bağlanmış karbon hidrat molekülü içeren maddelerdir. Temel olarak bitkilerde bulunur ve hidrolizle şeker ve şeker olmayan bileşiklere parçalanırlar. Stevia'nın tatlılık özelliği bu ent-kaurene diterpenoid glikozitleri olarak adlandırılan glikozitlerden kaynaklanmaktadır. Stevia yaprağında farklı oranlarda bulunan bu glikozitlerden en temel ikisi Stevioside ve Rebaudioside A'dır. Diğer glikozitler 1.0 -2.0 % veya daha düşük oranlarda bulunurlar ve minör glikozitler olarak adlandırılırlar (Çetin ve diğerleri, 2019).

Stevia yapraklarından izole edilen tüm ent-kaurene diterpenoid glikozitlerin kimyasal yapısının temelinde steviol adı verilen aglikon bulunmaktadır (Şekil 5). Glikozitlerin birbirinden farkını steviol'ün 13. ve 19. karbonunun hidroksil bağlanan farklı karbonhidratlar oluşturur. Örneğin Stevioside, steviol'ün 13. karbonundaki hidroksil grubuna 2 glikoz molekülünün 19. karbonun hidroksil grubuna ise 1 glikoz molekülü bağlanması ile oluşur (Şekil 6)(Çetin ve diğerleri, 2019).

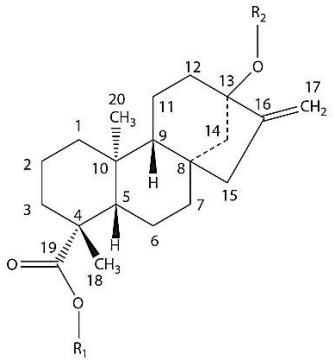


Şekil 5. Steviol (Koyama, Sakai, Ohori, Kitazawa, Izawa, Kakegawa, Fujino, & Ui, 2003)



Şekil 6. Stevioside (Koyama ve diğerleri, 2003)

Steviol kökü, karbonhidrat bağlanan aktif grup bölgeleri (R1 ve R2), Steviol Glikozitler ve bağlanan karbonhidratlar Şekil 4 ve Şekil 7'de gösterilmiştir.



Şekil 7. Steviol glikozitler ve kimyasal yapıları (Geuns, 2003; Prakash ve diğerleri, 2014)

Steviol glikozitlerden Stevioside ve Rebaudioside A nın çözünürlükleri ile ilgili bilimsel çalışmalar da oldukça sınırlı sayıdadır. Steviol glikozitlerin su içerisindeki çözünürlükleri Kinghorn (2002) tarafından derlenmiştir. Stevioside, Rebaudioside A, Rebaudioside B, Rebaudioside C, Rebaudioside D, Rebaudioside D, Rebaudioside E, steviolbioside ve dulcoside A nın su içerisindeki çözünürlükleri sırasıyla % 0.13, 0.80, 0.10, 0.21, 1.00, 1.70, 0.03 ve 0.58'dir. Abou-Arab ve arkadaşları (2010) *Stevia rebaudiana* Bertoni'den su, metanol ve su-metanol karışımı ile Steviol Glikozitleri ekstrakte etmişler ve ekstraktların fiziksel ve kimyasal özelliklerini karakterize etmişler. Elde ettikleri su, metanol ve metanol karışımlarında Stevioside yüzlerini sırasıyla % 15.82, 23.20 ve 18.62 olarak bulmuşlardır. Çalışmalarında elde edilen Stevia tatlandırıcılarının su, metanol, hekzan, aseton, chloroform ve eter içerisindeki

çözünürlüklerine bakmışlardır. Elde ettikleri bulgulara göre Stevia tatlandırıcıları metanolde yüksek çözünürlüğe sahip olarak bulunmuştur. Elde edilen tatlandırıcılar su içerisinde metanole kıyasla daha düşük oranda çözünmüş ve çözünürlük %9.8 bulunmuştur. Tatlandırıcılar hekzan içerisinde çok az oranda çözünürken, aseton, kloroform ve eterde çözünmemişlerdir. Abou-Arab ve arkadaşları (2010) ekstrakte edilen tatlandırıcıların çözünürlüklerini incelemişler fakat yaptıkları çalışma termodinamik çözünürlük değerinin bulunmasından ziyade elde edilen ekstraktın hangi çözgenler içerisinde çözünebildiğini belirlemeye yönelik olmuştur (Çetin ve diğerleri, 2019).

Bir çözünürlük çalışmasında hedef maddenin saflığı mümkün olduğunca çok yüksek olmalı ve çözünürlük değerleri çözünürlük değerlerinin test edildiği sıcaklıklar belirtilerek verilmelidir. Daha ileri aşamalarda sıcaklığa bağlı çözünürlük değerleri çıkartılarak çözünürlük eğrileri elde edilmelidir. Bu bağlamda gerçek termodinamik çözünürlük çalışması Su ve arkadaşları (2013) tarafından gerçekleştirilmiştir. Su ve arkadaşları (2013) Rebaudioside A'nın aseton, etanol, % 95 etanol ve % 90 etanol çözeltilerinde 273.15 -

318.15 K sıcaklıkları arasında çözünürlük değerlerini belirlemiştir. Rebaudioside A'nın çözünürlüğü en yüksek % 90 etanolde bulunmuş, daha sonra sırasıyla % 95 etanol ve etanol çözeltileri takip etmiştir. En düşük çözünürlük ise aseton içerisinde bulunmuştur. Tüm çözgenlerdeki çözünürlük değerleri ise sıcaklığın artması ile artmıştır. Rebaudioside A'nın çözünürlüğü ile ilgili yapılmış diğer bir çalışma ise Zhao ve arkadaşları (2012)

gerçekleştirilmiş, Rebaudioside A'nın metanol-su karışımları içerisindeki çözünürlük değerleri 293.15 – 333.15 K sıcaklıkları aralığında belirlenmiştir. Stevioside ve Rebaudioside A'nın çözünürlük değerleri ile ilgili diğer bir bilgiye Mizutani ve Tanaka (2002)'de ulaşılmıştır. Bu bilgi Yokoyama'nın 1981 yılında yayınladığı çalışmaya atıfta bulunmuş 30 °C de 100 mL su da 2 gram Stevioside'in çözündüğü dolayısıyla su içerisinde çözünürlüğünün düşük olduğu, Rebaudioside A'nın ise kolayca çözündüğü belirtilmiştir (Çetin ve diğerleri, 2019).

Rebaudioside A'nın çözünürlüğü ile ilgili verilere ulaşılan diğer bir kaynak Prakash ve ark. (2008)'dir. Sadece Rebaudioside A içeren, Rebaudioside A içeriği % 97 den fazla olan ve rebiana olarak adlandırılan ürünün su ve etanol içerisindeki çözünürlükleri 15, 25, 40 ve 60 °C'de belirlenmiştir. Etanol içerisinde çözünürlük değerleri 15, 25, 40 ve 60 °C sıcaklıklarda sırasıyla 1.70, 1.69, 1.78 ve 2.15 g/100 g etanol olarak bulunmuştur. Aynı sıcaklıklardaki su içerisindeki çözünürlük değerleri ise 31.10, 33.03, 34.48 ve 39.53 g/100 g su olarak bildirilmiştir. Rebiana'nın su içerisinde 25°C'de termodinamik çözünürlüğünün 0.8 g/100 g su olduğu belirtilerek susuz formda olan Rebaudioside A'nın suda süper doygun çözelti oluşturması sebebiyle su içerisindeki çözünürlük verilerinin yüksek çıktığı bildirilmiştir. Aynı zamanda Rebaudioside A'nın hidrat formunun ise 25 °C'de çözünme hızının çok düşük olduğu belirtilmiştir (5 dakikada <0.2 g/100 g su) (Çetin ve diğerleri, 2019).

Rebaudioside A'nın çözünürlüğü ile ilgili bilimsel çalışmalar incelendiğinde çözünürlükleri üzerine yapılan çalışmaların sınırlı olduğu görülmektedir. Rebaudiosie A'nın çözünürlüğü ile ilgili olarak da 90 % etanol derişimi altındaki derişimlerde etanol içeren su-etanol karışımları içerisinde farklı sıcaklıklarda çözünürlük değerleri belirlenmemiştir. Bu proje ile Rebaudioside A'nın % 0 ila % 100 etanol derişimi aralıklarındaki su-etanol karışımları içerisindeki çözünürlüklerinin farklı sıcaklıklarda belirlenmesi hedeflenmektedir. Elde edilen veriler sonucu bu glikozitin su, etanol ve su-etanol ikili karışımları içerisindeki sıcaklığa bağlı termodinamik çözünürlük değerleri elde edilecektir. Bu çözünürlük verileri söz konusu glikozitin ekstraksiyon ve saflaştırma işlemlerinin geliştirilmesi için temel olacaktır (Çetin ve diğerleri, 2019).

Steviol Glikozitlerle İlgili Yasal Düzenlemeler

1970'li ve 1980'li yıllarda, Kuzey Amerika ve Avrupa'da, Stevia bitkisel ürün olarak kullanılmaya ve piyasaya sürülmeye başlamıştır, 1994 yılında, Stevia ekstraktının ABD'de bir diyet geliştirme olarak kullanılmasına izin verilmiştir (Perrier, Mihalov, & Carlson, 2018). Fakat geçmişte diyet programlarında kullanımına izin verilmesine rağmen 1995 yılında Amerika'da endüstriyel ve gıda alanında kullanımı yasaklanmıştır (Hattori, 1997). Avrupa'da ise uygun raporların veya dokümantasyonun eksikliği nedeniyle marketlerde veya başka bir alanda kullanımına izin verilmemiştir. 11 Kasım 2011 yılında ise Avrupa Birliği Komisyonu Steviol Glikozitleri gıda sektöründe katkı maddesi olarak kabul etmiştir. Alınan bu karar 2011 yılında EFSA'nın (Avrupa Birliği Gıda Otoritesi) Stevia kullanımının güvenliği olduğuna dair yaptığı değerlendirmelere dayanmaktadır. Steviol glikozitlerin kullanımı ise şekerleme, konserve, alkolsüz içecekler gibi belirli alanlarda Avrupa Birliği Komisyonu tarafından onaylanmıştır (Sezgin ve Koç, 2016). Gıda Katkı Maddeleri Ortak Uzman Komitesi (JECFA) Steviol Glikozitlerini sırasıyla 1998, 2004, 2007 ve 2008 yıllarında 51, 58, 63 ve 68 inci toplantılarda incelemiştir. 68. Toplantıda JECFA mevcut Steviol Glikozitlerine 3 tane daha (rubusoside, steviolbioside ve Rebaudioside B) eklemiştir ve %70 Stevioside/ Rebaudioside A şartını kaldırmıştır (FAO/WHO, 2007). Kabul edilebilir günlük tüketim miktarı 69. toplantıda 0-4 mg/ kg vücut ağırlığı olarak belirlenmiştir (JECFA, 2009). Stevioside, Rebaudioside A, Rebaudioside B, Rebaudioside C, Rebaudioside D, Rebaudioside F, dulkosid A, rubusosid ve steviolbiosid gibi bileşenler de dahil olmak üzere % 95'ten az olmayan Steviol Glikozitler içeren Steviol glikozit terkipleri Avrupa'da ve başka yerlerde gıdada tatlandırıcı olarak kullanım için onaylanmış ve saflık kriterleri kabul edilmiştir (EFSA, 2010; JECFA, 2010). Mevcut verilerin gözden geçirilmesine dayanarak, Avrupa Gıda Güvenliği Otoritesi (EFSA) ve FAO / WHO Gıda Katkı Maddeleri Uzman Komitesi, Steviol Glikozitler için kabul edilebilir günlük alımı (ADI) günde 4 mg / kg vücut ağırlığı olarak belirlemiştir (EFSA, 2015). Amerika Birleşik Devletleri'nde, Rebaudioside A ve JECFA şartnamesini karşılayan birkaç Steviol Glikozitler karışımı, çeşitli gıda uygulamaları için genel olarak güvenli (GRAS) kabul edilmiştir. Avrupa Komisyonu, 1131/2011 No'lu Komisyon Tüzüğü uyarınca steviol glikozitlerin tatlandırıcı olarak kullanılmasına izin vermiştir. Steviol glikozitlerin tatlandırıcı muadili olarak kullanımına Avustralya ve Yeni Zelanda'da ise 2008 yılında izin verilmiştir (Sezgin ve Koç, 2016). AB ülkeleri ise kullanım olarak mevzuat kapsamına Avrupa Birliği onayı ile 2009 yılında girmiştir (Sezgin ve Koç, 2016).

Stevia'nın Sağlık Açısından Değerlendirilmesi ve Yapılan Çalışmalar

Dünyada 230 çeşit Stevia türü yer almaktadır. Ancak bu türlerden sadece *Stevia rebaudiana* Bertoni önemli derecede tatlılık özelliğine sahiptir. Stevia yapraklarından birçok doğal ürün izole edilmiştir ve bunlardan en çok bilinen Steviol Glikozitler; Stevioside ve Rebaudioside A olduğu belirtilmiştir (Montoro, Molfetta, Maldini,

Ceccarini, Piancente, Pizza, & Macchia, 2013; Wölwer-Rieck, 2012). Günümüzde tüm Dünya'da, Steviol Glikozitler gıda endüstrisinde yaygın olarak kullanılmaktadır. Ayrıca, yapılan çalışmalarda, Stevioside ve diğer Steviol Glikozitlerin anti-hiperglisemik, anti-inflamatuar, anti-tümör, anti-diare, diüretik ve immünomodülatör gibi sağlığa faydalı etkilerinin olduğu saptanmıştır (Chatsudthipong & Muanprasat, 2009; Gregersen ve diğerleri, 2004; Ruiz-Ruiz, Moguel-Ordoñez, Matus- Basto, & Segura-Campos, 2015).

Stevialı tatlandırıcılar; sakkaroza göre 250-300 kat daha fazla tatlı olması, ısı ve pH stabilitesinin yüksek olması, pişirme ve fırın stabilitesinin olması, alkol içerisinde çözünmesi, ağız içerisinde metalimsi tat bırakmaması gibi özelliklerinin yanısıra en büyük özelliği ise doğal olarak üretiminin gerçekleştirilebilmesidir. Günümüzde bütün sıcak ve soğuk içeceklerde, reçel, komposto, muhallebi gibi kaynatılarak pişirimi yapılan yiyeceklerde, pasta, kek, kurabiye gibi fırında yüksek ısıda yapılan bütün unlu gıdaların içerisinde (İnanç & Çınar, 2009), deniz mahsullerinde, şekerleme endüstrisinde, bazı sebzelerde, çay şekeri yerine (Nunes ve diğerleri, 2007) ve suşi, soya sosu, yoğurt gibi birçok gıda maddesinin üretiminde kullanılmaktadır. ABD'de resmi bir kuruluş olarak bulunan Gıda ve İlaç Organizasyonu (FDA) 23/02/2008 tarihinde Stevia ile ilgili bir uyarı raporu yayınlamıştır. Stevia ile ilgili olarak literatürde yer alan daha önceki bilgilerin yeniden düzenleyen bu rapora göre Stevianın kabul edilebilir bir gıda katkı maddesi olmadığı ve ABD içerisinde "GRAS (güvenli)" olarak kabul edilmediği anlatılmış, gerekçe olarak ise de bir gıda katkı maddesi olarak veya GRAS statüsünde olması için Stevia'da yeterli toksikolojik bilginin bulunmadığı belirtilmiştir. Ancak bir gıda maddesinin bileşimlerinden biri olmasının herhangi bir zararı olmayacağı da rapor bildirilmiştir (FDA). Stevia ekstraktlarının insan sağlığına olumlu etkisi olduğu öngörülmektedir (Tadhani ve diğerleri, 2007). Bazı bilim adamlarına göre antihipertansiyon, antihiperglisemik ve anti-human rotavirus hastalıklarına iyileştirici özelliği sağladığı ortaya konulmuştur (Ritu & Nandini, 2016) ve aynı zamanda Stevia yapraklarının ve Steviadan sağlanılan bir ürünün kuvvetli bir antioksidant özelliğe sahip olduğu ortaya konulmuştur (Tadhani ve diğerleri, 2007).

Stevioside'nin toksikolojisi üzerine gerçekleştirilen çalışmalarda Stevioside'ın mutajenik olmadığı belirlenerek, kanserojenik olabileceği ihtimali ile karşı karşıya gelinmiştir (Panpatil & Polasa, 2014; Toskulkao & Chaturat, 1997). Ancak yapılan başka çalışmalar da ise günde 250 mg/kg vücut ağırlığı olan dozlarda steviol ile beslenen hamster'larda kandaki maksimum steviol konsantrasyonunun toksik olma durumunun olmadığı sonucuna varılmıştır (Ceunen & Geuns, 2013).

Steviol glikozitler yüksek tatlılık özelliklerinin yanında toksik ve mutajenik olmayan bileşiklerdir (Çetin ve diğerleri, 2019). Özellikle Stevioside, Rebaudioside A, steviol ve isosteviol, kandaki yüksek şekeri, yüksek tansiyonu düşürmeye, enflamasyonu, tümör oluşumunu, diyareyi önlemeye, bağışıklığı düzenlemeye yardımcı olmaktadır(Çetin ve diğerleri, 2019; Chatsudthipong & Muanprasat, 2009). Stevioside'ın insan sağlığı üzerine olan olumlu etkileri ile ilgili çalışmalar 2013 yılında De ve arkadaşları tarafından derlenmiştir (Tablo 4). Tablo 4 den de görüldüğü üzere Stevioside Tip 1 ve Tip 2 diyabet hastalarında ve sağlıklı kişilerde sakkaroz yerine doğal tatlandırıcı olarak kullanılmasının yanında, kanseri önlemeye, tümör oluşumunu baskılamaya, mikrobiyel gelişimi durdurmaya yardımcı olup ayrıca antioksidan özellikler de göstermektedir. Sağlık açısından fayda gösteren glikozitler sadece Stevioside ile sınırlı değildir, Rebaudioside A, rebudioside C, dulcoside A glikozitleri hem organoleptik hem de antienflamatuar özellikler göstermektedir(Çetin ve diğerleri, 2019; Koyama ve diğerleri, 2003).

Tablo 2.4 Steviol Glikozit Tüketiminin Farklı Fizyolojik Etkileri (Çetin ve diğerleri, 2019)

Steviol Glikozitlerin Sağlık Üzerine Etkileri
Tip 1 ve Tip 2 Diyabette kan glikoz seviyesini düşürmeye yardımcı olur
Anti-karsinojenik etki (Kanserin tedavisinde kullanılabilir) gösterebilmektedir
Doğal antioksidan
Glikoz metabolizmasını iyileştirmeye yardımcı olur
Anti-diyare terapötik etki gösterebilmektedir
Gastrointestinal sistemde ülser oluşumunu önlemeye yardımcı olur
Kandaki şeker, radyonüklit, kolesterol tri-gliserit, düşük yoğunluklu lipoprotein kolestrolü düşürmeye yardımcı olur
Hücre yenilenmesini ve kanın pıhtılaşmasını iyileştirmeye, neoplastik gelişimi baskılamaya, damarları güçlendirmeye yardımcı olur
Enflamasyonu önlemeye yardımcı olur
Düşük nabzı ve düşük tansiyonu önlemeye yardımcı olur

Anti-mikrobiyal aktivite göstermektedir
Çürük önlemeye yardımcı olur
Diş eti iltihabını önlemeye yardımcı olur
Obezitenin önlenmesinde sakkaroz yerine kullanılabilmektedir ve yüksek tansiyonun önlenmesinde yardımcı olur
İnsan rota virüsüne karşı etkili olabilmektedir
Diüretik etki gösterebilmektedir
Damar genişletici özellik gösterebilmektedir

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DESIGN OF SMALL SCALE INFRARED DRYER

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ABSTRACT

The Drying of agricultural products is vital for sustainable agricultural production systems. In addition to this, it is also crucial to food safety and human health. Drying is the oldest method to preserve food. Moreover today we need to increase the producer's wage by improving the food quality, safety and to effect improvements on new trends foods. For these reasons, we need to design and manufacture the dryer, which could be bought and maintained by small scale producers. Manufacturing of the new type of dryer is vital for improving the larger amount of farmers and producers. Therefore in this study, the idea of small scale dryer design was studied. In the world, lots of dryers are manufactured for the demands of industry and farmers. But for small scale production, the choices are limited. The infrared heating is easily adjustable for small scale applications. In this study, the infrared heat was adjusted to the batch dryer, which has a conveying heater. Within the conveying heat from one side to the other side intermittent drying is almost done, and it improves the food quality. In this study 500 kg capacity of Infrared dryer was designed and manufactured.

1. INTRODUCTION

Drying is known as oldiest method for preserving the food to store secure and protect from spoiling (Naseer et al 2013). Dried foods are tasty, nutritious, lightweight, easy-to- prepare, and easy-to-store and use. From the ancient times natural drying method has been praticed which consists essentially of exposing the threshed products to the air (in sun or shade). Nowadays drying is a conventioanal method and became a important sector for sustainable agricultural production and in food market dried foods play an important role in the food supply chain. There is a demands in the market to consume more dried products. Therefore there is need to dry mass prdoduct to supply the enough dried products in the market. To increase the dried food in the market drying is mostly adapted with artifical drying systems.

Drying method is generally divided into two main groups called artificial and natural drying. However, it is possible to divide these groups into subgroups. According to the transportation method of the heat required to remove the water in the foodstuff to be dried, it is divided into 4 groups as; convection drying, conduction drying, radiation drying and freeze drying.. In addition, the dielectric drying method, which has become widespread in recent years, is a new and increasingly widespread drying method.

Depending on all these methods and special requirements in the industry, more than 400 dryers have been manufactured in the literature and 50 of them have been used commercially (Mujumdar, 2000).

In this study Infrared Drying systems were adapted the smale scale cabinet dryer, to aim the intermittent drying with higher product quality and low energy consumption. Infrared radiation (IR) consists of invisible electromagnetic wavelengths that range between 0.78 and 1000 μm. This type of radiation has the property to transfer thermal energy from a warmer object to a cooler object. Targeted heat is produced by matching the infrared emission spectrum of the heater to the absorption characteristics of the material.

The effect of IR radiation on optical and physical properties of food materials is crucial for the design of an infrared heating system and optimization of a thermal process of food components.

Infrared drying systems also used in different sector for wide range of applicaiton. Its usage in agricultural drying systems is also well known applications. The ınfrared drying systems are more easy to installation and maintainces.

Therefore the designing of infrared dryer as cabinet dryer will help to smale scale farmers by reducing their energy consumption and improving product quality as well.

2. MATERIAL AND METHODS

The electromagnetic spectra within infrared wavelengths can be divided into three parts: long waves (4 m–1 mm), medium waves (2–4 m) and short waves (0.7–2 m, Figure 1). The short waves appear when temperatures are above 1000ºC; the long waves appear below 400ºC and medium waves between these temperatures (Skjöldebrand, 2001.) .

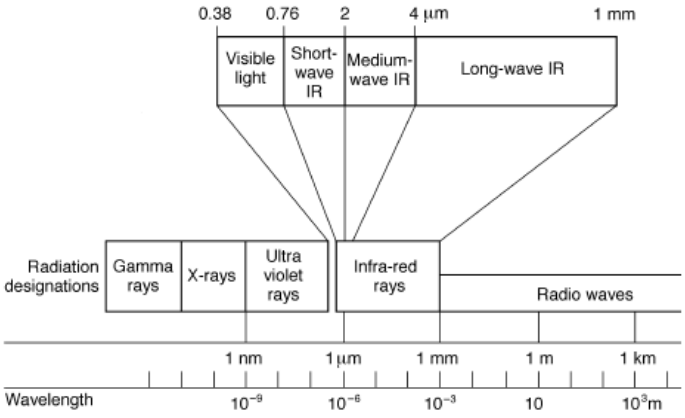

Figure 1. Wavelength Spekterum of Infrared Radiation

The products absorb wavelengths of infrared radiation greater than 2.5 μm, while transmitting a high rate of radiation at wavelengths smaller than this wavelength (Sandu, 1986). Therefore the Infrared heater was selected which is emitted 2.5 μm wavelength (Figure 2). For the intermittent drying, the infrared heater were mounted frame which is moving to one side to other-side.

The trays and carrier (Fig. 3) were made from Stainless stell (316). The carrier could be moveable and reload out of the chamber.

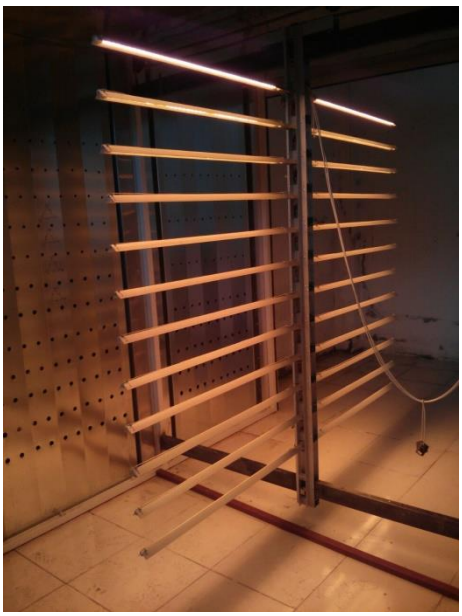

Figure 2. Infrared heater.

Figure 3. Carier and Trays

The drying chamber was constructed with stainless stell 316 L. All the parts which is conducting the products were made from stainless stell. The chamber was designed as 2.5x2.5x2.5 m size (WxLxH).

The drying chamber was designed as closed loop, which leads the product free of oxidaiton (Naseer et al, 2013).

3. RESULTS AND DISCUSSION

The designed and manufactured dryer is a new-developed infrared dryer (ID) as cabinet dryer can be seen as schematic view in Fig. 4. The dryer has 24 infrared heaters (totally 48 kW outpower), which are located in the middle of the cabinet (Erdem 2019). The heaters are moveable and scan the hole tray from one side to the other side. During the movement, every fruit is heated by direct radiation. Therefore it is expected that it could be the shortened the drying times and cause a low electricity consumption (Fig 2). The operation is controlled with PLC (Polly Logical Control, Fig. 5) devices and thermocouple to fix the inlet temperature, air flow rate, moving bar speed and energy.

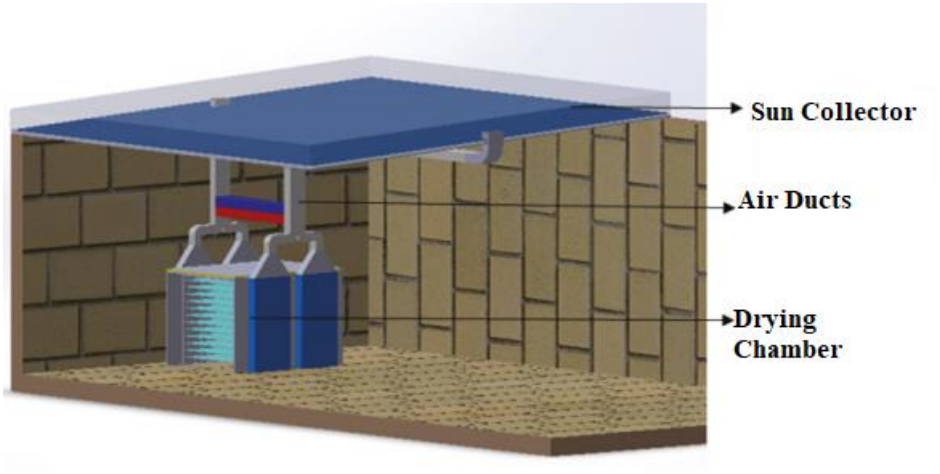

Figure 4. Schematic view of IR DRYER

Figure 5. PLC devices

The moisture exhausting systems consist of two dehumidifier and fans to allow extarnal hot air and fresh air. The drying chamber can be used as closed loop to protect the product from oksidation. The whole wall were coated with isolation material and inside and outside were covered with stainless stell sheet (Figure 6).

Figure 6. IR Dryer

The Dryer were used to dry orange peels, plums and orange slices. During the experiments whole data were collected. The dryer consume low energy with compare to conventional drying.

4. CONCLUSION

Designed and manufactured IR dryer could be used to dry for fruits, vegatables and seeds with higher quality which support to intermittent temperature controlled drying. The smale scale firms and farmers can use the drier for their aims. The installition is easy and can adjust to every plants. The maintaining cost is very cheap.

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