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Experimental and Theoretical Investigation of Drying Pineapple By Natural Means

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ABSTRACT

Drying, used in various sectors, is a process, which needs quite a high amount of energy. Agricultural products can deteriorate quite rapidly as their respiration continues after the harvest. A number of different methods have been used and searched to prevent the products to deteriorate and make them be used for a long time after the harvest. Drying is one of these methods. With basic meaning, drying process is removing the moisture from the agricultural products. Drying the agricultural products under the sun, a conventional drying method, has been used since ancient times. However, when this method is conducted in the open air, hygiene problems with the products emerge. Thus, it leads to serious quality loss in the products. New technologies have been searched to dry the agricultural products with the help of hot air because this method has low energy needs and long drying period. At the end of many investigations carried out, the mostly preferred properties in drying process have been revealed to be short drying period, efficient energy use, providing high quality dried products, small area needed during process; therefore, systems compatible with these properties have been designed. In this study, the drying process of 100g pineapple pieces sliced in the same sizes was performed with the help of a heater at constant temperature of 45oC and at average room temperature of 22.7oC. From the first day until the last day of experiment, measurements of pineapple slices were carried out at regular intervals; and at the end of the fifth day, it was determined that the total weight of 100g pineapple dropped to 12.35gr, which meant that the weight of the product decreased 87.65g in total. In accordance with the data obtained, the moisture rate and moisture content of the dried product were measured at every hour during drying and calculated and shown on the graphs.

Keywords: Pineapple, humidity content, humidity, drying

Dogal Yollar ile Ananasın Kurutulmasının Deneyse ve Teorik Olarak Araştırılması

ÖZ

Kurutma farklı sektörlerde kullanılan enerjisi oldukça yoğun bir işlemdir. Ürünlerin hasat edildikten sonra bile solunumları devam ettiği için çok çabuk bozulabilmektedir. Ürünlerin çürümesini engelleyip daha uzun süre kullanımını sağlamak için farklı yöntemler uygulanmakta ve araştırılmaktadır. Kurutmada bu yöntemlerden biridir. Kurutma işlemi en temel anlamıyla ürünlerden nemin uzaklaştırılmasıdır. Geleneksel kurutma yöntemi olan tarımsal ürünlerin güneşte kurutulması çok eski dönemlerden beri uygulanmaktadır. Ancak kullanılan bu yöntem açık havada olması sebebi ile ürünlerde hijyen sorunu oluşturmaktadır. Dolayısıyla ürün kalitesinde ciddi düşüş yaşanmaktadır. Sıcak hava ile tarım ürünlerinin kurutulması işlemi düşük enerji verimine ve uzun kuruma süresine sahip bir yöntem olduğundan yeni teknolojiler araştırılmaktadır. Yapılan birçok çalışmalar sonucunda kurutma işleminde en çok istenilen özellikler; kuruma süresinin kısa olması, kurutma işlemi boyunca enerjinin daha verimli kullanılması, yüksek kalitede ürün üretimine olanak sağlanması, işlem boyunca ihtiyaç duyulan alanın az olması olarak belirlenmiştir ve bunlara uygun sistemler tasarlanmıştır. Bu çalışmada aynı büyüklüklerde dilimlenen 100gr ananasların 45oC sabit sıcaklıktaki ısıtıcıyla ve ortalama 22.7oC oda sıcaklığında kurutma işlemi gerçekleştirilmiştir. İlk günün sonunda 100gr ananastan düzenli aralıklarla ölçümler yapılmış olup 5 günün sonunda kurutulan cismin ağırlığının 12.35gr'a düştüğü, toplamda 87.65gr azaldığı yapılan deneylerle belirlenmiştir. Veriler doğrultusunda kurutma süresi boyunca kurutulan cismin Nem Oranı ve nem içeriği ölçümün yapıldığı her bir saat için ayrı ayrı hesaplanıp grafiğe dökülmüştür.

Anahtar Kelimeler: Ananas, nem içeriği, nem oranı, kurutma

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1. INTRODUCTION

Drying is a highly intensive process that needs a lot of energy and is used in various sectors. Since the agricultural products continue to respire after they are harvested, they may deteriorate quite quickly. Hence, various methods have been applied and searched for in order to make the crops stop deteriorating and be used for longer periods of time. Drying is one of these methods. With its basic meaning, drying is to remove the moisture present in the crops. Drying the crops under the sun, which is a conventional way of drying, has been utilized since ancient times. However, this method leads to the problem of hygiene with the crops since it is carried out in the open air. Therefore, loss of crop quality is observed in this method. New technologies have been sought to dry the agricultural products to be dried via hot air, which has low energy needs and a long drying period. As the results of a number of studies performed till now, the most wanted properties in the drying process have been determined as; short drying period, efficient use of energy during drying, providing an opportunity for products, and small area needed during the process; and systems compatible with these properties have been designed.

The process of drying is directly related to the structure of the crops to be dried. The fact that the crops have a hygroscopic structure or not is a factor affecting the drying process. Among the products with hygroscopic structure, there take place agricultural products. For that reason, the drying process will be slower compared to products with different structures. One of the factors having an effect on the drying process is the inner structure of the products to be dried. While drying can comprise more than one stage, sometimes these stages may not be observed during the whole process. The stage in which water covers the outer surface and in which the drying process occurs on the outer surface is defined as the constant drying rate stage. After this stage, drying starts on the outer surface of the product to be dried. It is widely known that one of the most significant economic sources of Turkey is agriculture. Constant technological development has been observed in the sectors related to agriculture. The developing technology finds various application fields in the field of agriculture. Especially, this technology has started to be used in agricultural fields together with an increasing number of the systems where solar energy is used in drying agricultural products. Up until today, many different methods related to with fruits and vegetables drying process have been tried; and the parameters were determined about not only the methods but about the experimental procedures as well. Drying fruits and vegetables is a process that has great contributions to the environment. On the one hand, reducing the high amount of water in the product requires a significant amount of energy, on the other hand, it consists of a number of complex procedures. The stages of drying process are as follows: The preparation of the agricultural products before being dried, their sensitivity levels to heat and their structures. Therefore, the drying technologies made up of properties, which will not pose any harm to the environment, develop very slowly. One of the reasons for this is the effort to make a great profit in a short time. The economic concern of the consumers should be considered while creating various drying technologies [1].

Drying, in its most general definition, is the process of removing the fluid in a product and all kinds of foodstuff with the help of heating. In industry, it is used as the final process, and in agriculture, it is used for drying vegetables and fruits. The fundamental purpose of drying is to decrease fluid/water amount in products to the lowest level so that bacteria and viruses will be prevented to proliferate. In other words, by reducing the fluid/water amount in the products to be dried to the lowest level, the products will have a longer consuming life. Every agricultural product has a different amount of water in them [2]. Thanks to the drying process, we can consume many agricultural products such as fruits, vegetables grains grown in the world out of season. For this reason, the importance of drying is increasing day by day. When the amount of fluid in the products decreases to the desired amount with drying, the consumption time of the products increases. Therefore, the drying process is the most important step after the harvesting of agricultural products. Thanks to drying, losses in agricultural products have decreased significantly [3].

Due to the following reasons, it is possible to earn more income from the products through the drying process:

- It decreases the fall of the ripe products.
- It makes possible to harvest agricultural products such as tea, cotton maize easier.
- It maintains longer germination times of seeds.
- It makes it possible to store the dried products longer time without being deteriorated.

1.1 Factors Effecting Drying

The factors effecting drying are generally divided into two parts as internal and external factors. Internal factors are generally about the properties of the agricultural products, and they are related with the products being cut or made smaller and humidity at the start of drying process and the physical and chemical properties and forms of the products. On the other hand, external factors are about the velocity, humidity, temperature and motion of the air.

1.2 The dried Products

Turkey is a Mediterranean country. In this country, there are nearly all kinds of plentiful fruits and vegetables. Growing these agricultural products takes a long time.

Unfortunately, the time for their staying fresh is rather short. In order to extend this time and make these products be used for four seasons, drying process is applied. In Table 1. drying some agricultural products and the requirements needed for this process are given. When the products are examined, it can be seen that energy need

Table 1. Drying Conditions of Some Products [4]

Name of the product	Humidity		Maximum Drying Temperature (°C)	Evaporated Water (kg/t)	Energy Requirement (kJ/tx10⁶)
	Before %	After %			
Apple	80	24	70	736,8	1,502
Apricot	85	18	65	817,1	1,666
Banana	80	15	70	823,5	1,679
Cabbage	80	4	55	791,7	1,614
Carrot	70	5	75	684,2	1,365
Manyok (Cassava)	62	17	-	542,2	1,105
Cauliflower	80	6	65	787,2	1,605
Red Pepper	80	5	65	789,5	1,610
Cocoa Bean	50	7	-	462,4	0,943
Coffee Bean	55	12	-	488,6	0,996
Coffee	50	11	-	438,6	0,695
Conifer	30-40	10-15	50	222,2-294,1	0,453-0,60
Corn	24	14	50	116,3	0,237
Figs	80	24		736,8	1,502
Fish	75	15	30	705,9	1,439
Leafy Greens	25-35	17-20	50	96,4-187,5	0,197-0,382
Garlic	80	4	55	791,7	1,674
Grapes	80	15-20	70	750-623,5	1,529-1,679
Green Beans	70	5	75	664,2	1,395
Green Peas	80	5	65	789,5	1,610
Peanuts	40	9	50	340,6	0,694
Guava (Hintarmudu)	80	7	65	784,9	1,600

Onion	80	4	55	791,7	1,614
Peach	85	18	65	817,1	1,666
Pineapple	80	10	65	777,8	1,586
Potato	75	13	75	712,6	1,453
Plum	85	15	55	823,5	1,769
Paddy	24	11	50	146,1	0,298
Spinach	80	10	-	777,8	1,566
Sweet Potato	75	7	75	731,2	1,491
Wheat	20	16	45	47,6	0,097

of each product is different. However, the products with high level of liquid requires more energy.

1.3 Pineapple

Pineapple is a kind of fruit, which consists of flowers. The outer part of the fruit is covered with pines, and the top has large green leaves. The leaves are gathered at the bottom of the fruit, and they are long and hard having edges with pines. The outer surface of the fruit is covered with a thick layer with pores. Once the pineapple fruit is cut from its branch, it does not exhibit any ripeness. It is used as sweetener in a lot of foodstuff such as salads, cocktails, yoghurt, jam and ice cream. A person who consumes a glass of pineapple juice every day meets 6% of his manganese, and 42% of his C vitamin and 10% of his B1, B5, B6 vitamin need. The pineapple fruit is quite rich in calcium and potassium. In 100g pineapple, there is 14g sugar, 50 calories, 1.7 g oil, 1g protein and 21.6g protein. The fruit, which is quite rich in fibre, approximately consists of 86% water [5]. The European travellers called this fruit as “pine apple” in English and as piña in Spanish etc. since the fruit was similar to the reproductive organs of cone-bearing pine trees in shape. Later, in order that pine cone-bearing could keep its original meaning, a name used in Tupi-Guarani Languages was chosen. The word ananas, adopted in Turkish as well, was registered into the dictionaries for the first time in 1938 [6].

1.4 Pineapple Production in the World and Turkey

Pineapple, quite well known around the world, is a perennial, fruity and tropical plant. This fruit belongs to the Bromeliaceae family. There are more than 2500 varieties of the pineapple plant. Originally grown in South America, the plant was later discovered and spread all over the world by travellers and historians who visited there.

Currently, approximately 25 million tons of pineapples are produced worldwide. This data makes it the third most consumed fruit after bananas and citrus fruits. Pineapple contributes greatly to the economy of the countries where it is produced. Its good taste and use in many recipes make it invaluable in the food industry [7]. Pineapple, whose native land is South America, is grown in warm countries. The fruit is large and smells nice. It was first discovered by Jean de Léry in 1555, and then grown in England and France, from where it spread all over the world. According to data obtained in 2009, Brazil is at the first rank in annual pineapple production with 2.206.492 tonnes. The Philippines follow Brazil with 2.198,497 tonnes of annual pineapple production. According to FAOSTAT data, the total pineapple production throughout the world in a year in 2009 is 19.488,240 tonnes. Costa Rika was at the first rank with fresh pineapple importing country in 2001 with 322.000 tonnes. The most common pineapple generally found in the USA and Europe supermarkets was started to be grown in Hawaii at the beginning of 1970s. In commercial agriculture, it is possible to apply pineapple blossoms artificially, which enables the farmer to harvest the main fruit earlier. This method also makes it possible for the plant to produce a second but smaller fruit [6]. Pineapple is grown in the western and southern parts of Turkey. The regions, which especially exhibit Mediterranean climate properties, are quite suitable for growing pineapple. Pineapple cultivation is carried out in the provinces of Antalya, Mersin and Adana in Turkey. However, the fruit is generally traded from foreign countries since the fruit grown in Turkey is not enough. In order to grow pineapple, a moisture and humus rich soil is needed. Once the fruit starts to form, irrigation is increased; and the plant is especially watered more in summer months.

1.5 A Brief Comparison of Drying Methods

Drying under the sun naturally, known as a conventional method, is a simple system and does not need any finance since the method is performed in the open air. Despite these advantages, there may be some quality losses in the products. Dust, fungus and insect dirt can occur on the surface of the products as the drying process lasts long in conventional method. Since different drying methods have been utilized in developed countries, it has been observed that the losses occurring in the products have decreased and the quality of the products have increased seriously compared to conventional drying methods [8,9]. Various methods such as solar energy, ultraviolet, hot air, heat pump, microwave, vacuuming, freezing and electro hydro-dynamics are used in drying vegetables and fruits.

It is necessary to choose the right drying method for reducing the losses concerning with health issues possible to occur in the products to minimum. The mostly used method to dehydrate the products is drying them by means of air as the drying process is quite easy and it is the common way for the product to be used for a long time

[10]. Although this drying method has a lot of advantages, it needs great amount of energy; and thus it may result in high cost [11]. One of the most negative aspect of drying the products with hot air is that the drying process takes a long time even at high temperatures. And, this can lead to great deal of lose in the quality properties of the product such as texture, colour and nutrient content [12]. In the products dried by means of air-drying systems, some problems like dust and biological contamination emerge [13,14]. One of the recommended methods to minimize the disadvantages of air-drying method is the application of hybrid drying methods using different energy sources such as freezing, ultrasound and microwave [15,16].

In their study, Lenaerts et al. (2018) determined that drying the products by means of microwave method provides the producers with quality products, nicer smell, higher nutrient potential and more alive colours compared to conventional drying method, which is conducted via hot air [17]. Orikasa et al. 2014, in their work, investigated the changes in sliced kiwi such as colour change, moisture content and antioxidant activity by utilizing hot air and vacuuming drying methods [18]. In sliced kiwi examples, they determined that vacuuming method was more convenient in preventing L-ascorbic-acid than hot air drying method. In addition, they found that different quality parameters such as hardness, total colour change and antioxidant activity were not important.

Drying the products through microwave method has been a method, which attracts attention recently. The most significant advantage of this method is that it reduces the long duration for drying the biological product used by conventional drying method and decreases the quality losses the least [12]. Microwave drying system depends on the system of drying the product by electromagnetic waves not only to heat the surface of it but also all the product in volume as in air-drying method. The difference in water vapour pressure that will occur in and around the product to be dried is used as the driving force to remove the moisture in the product. The heat transfer direction of the drying process carried out by means of micro-wave is just opposite of the conventional drying system [17]. The temperature inside of the product that is in the centre is generally higher than the surface temperature in microwave drying method [19]. The temperature increase in the product contains thermos diffusion and pressure gradient causing pumping the moisture towards upper part of the product [20]. In drying system carried out by means of microwave under proper conditions, it has been proved that the drying period has decreased a great deal, and the product quality depending on the physical features of the product such as colour and texture has improved [21]. This process has also been generally used as a pre-process in drying [22]. In their study, Monteiro et al. (2015) found that vegetables and fruit maintained their characteristic properties as in freezing method in microwave drying method; and that drying time in products decreased as well [23]. Tian et al. (2016), in the study they carried out, applied different drying methods to shiitake mushrooms [24]. These methods are microwave, hot air, vacuuming and microwave. At the end of the study, they observed that the most effective method is vacuum-microwave method. It was observed that the colour properties give better results in the vacuum microwave drying process and there is less collapsed structure in the products dried in this way. Lv et al. (2018) applied a vacuum microwave drying process at 80 ºC for approximately 150 minutes to reduce the moisture content of round bamboos by 10%. As a result, the surface of the bamboos had smooth, shiny form and golden colour [25]. This process showed a good mechanical performance, although it owned a few visible defects. In similar conditions, to dry the bamboos with conventional drying methods, it should be dried for approximately 900 minutes. In their study, Cuccurullo et al. (2018) dried sliced apple pieces by microwave method and evaluated the humidity rate, temperature level and drying speed of the drying process [21]. As a result, they obtained better results in product quality at constant temperatures of 70 and 80 ºC. One of the drying methods used to keep the products at the desired temperature is freeze-drying [26]. The freeze-drying method is one of the leading drying methods that prevents heat damage in the products, minimizes the shrinkage on the surface of the products and provides excellent protection [27]. Freeze-drying enables the formation of products with advantageous quality and porous structures that are not particularly suitable for ordinary drying methods [28]. The most basic element of this drying method is the applied pressure. The system pressure is kept very low and the boiling point is adjusted below 0ºC. Thus, the water in the product freezes and moves away from the dry solid [22]. However, freeze-drying is a process, which requires quite high-energy. Therefore, it is used in high-cost products [29].

2. MATERIAL AND METHODS

Pineapple was used as the product in the drying experiment. Pineapple was purchased from a supermarket in Diyarbakır province, where it was sold. The purchased fruit was kept in the refrigerator at +30C overnight. The next day, the drying process was started. A heater providing a constant temperature of 45 ºC was used throughout the drying period.

2.1 Preparation of Experimental Setup

First of all, the pineapples were peeled. Then, they were thoroughly washed and cleaned; and then they were sliced into equal size (thickness 7 cm). The sliced pineapples were placed on a rectangular paper assembly. The equipment consisted of a heater, a sensitive scale and a humidity meter and thermometer. The humidity meter was placed in the environment where the drying experiment was carried out in order to measure the humidity of the environment during the process. A precision scale, kept in fixed

Table 2. Devices Used in the Experiment Set

Technical details	
Weighing units: (g / ct / dwt / ozt / oz / gn).	Working temperature: 10-30 degrees Celsius
Capacity / accuracy : 500g /0.01g	Power supply: 2 * AAA batteries
Small tray size: 10.5 * 10.5 * 0.8cm	Weight: 265g
Large tray size: 11 * 13.1 * 2.2 cm	Overload and low - power indication
Scale size : 10.6 * 12.7 * 1.8cm	Sensitivity: 0.01 g

positon, and which could weigh within the range of 500 g, was used to measure the weight of the product to be dried in regular intervals (Table.2). A heater was used to realize the drying process. The temperature of the heater was kept at 45 ºC. The temperature of the environment in which the experiment was conducted changed between 22.1 ºC and 22.8 ºC.

2.2 Drying Pineapple

For drying process, 100 g pineapple was used in total. In regular intervals, the total weight of the sliced and placed on the heater pineapples and the humidity and temperature of the room were measured. All data are shown in Table 3.

On the first day of the experiment, after all equipment was prepared for the experiment, the product to be dried was placed on the heater at 19:30. At that time, the room temperature and humidity were 22,5 ºC and 42%, respectively; and the total weight of the product was measured as 100g. On the fifth day (last day) of the experiment, according to the measurements carried out, the room temperature and humidity were 22,6 ºC and 32%, respectively; and the dried product was weighed to be 12,35g. To ensure that the drying process is complete, on the 5th day of the experiment, after 13.30, the last measurement time shown in Table 1. measurements were carried out at three different times; meanwhile, it was observed that there was no change in the weight of the dried product.

2.3 Evaluation of Experimental Data

During drying process of pineapple, some changes occurred both in the weight and on the surface of the product. As the days passed while drying, quite high shrinkage and contraction on the outer surface of pineapple slices occurred. These shrinkages and contractions were photographed and reported day by day. When the experiment time finished and drying process was completed, the Moisture Content and Moisture Rate (mr) of pineapple were determined and with the help of the data obtained, these values were transferred into a table. The data found through calculations are shown in Table 4.

Table 3. Drying Values of Pineapple in Regular Intervals

DAY	HOUR	ROOM TEMPERATURE (ºC)	HEATER TEMPERATURE (ºC)	HUMIDITY RATE (%)	TOTAL WEIGHT (g)
1. DAY	19.30	22.5	45	42	100
1. DAY	21.30	22.8	45	39	80.36
1. DAY	23.30	22.6	45	36	75.90
2. DAY	01.30	22.3	45	34	67.16
2. DAY	12.30	22.9	45	33	34.04
2. DAY	14.30	22.6	45	33	30.86
2. DAY	16.30	22.5	45	33	27.87
2. DAY	18.30	22.5	45	34	24.87
2. DAY	20.30	22.6	45	35	23.02
2. DAY	22.30	22.7	45	35	20.95
3. DAY	00.30	22.7	45	35	19.47
3. DAY	02.30	22.6	45	35	18.20
3. DAY	12.30	22.8	45	35	14.58
3. DAY	14.30	22.7	45	35	14.26
3. DAY	16.30	22.7	45	37	13.91
3. DAY	18.30	22.6	45	38	13.64
3. DAY	21.30	22.6	45	41	13.35
3. DAY	23.30	22.5	45	41	13.20
4. DAY	01.30	22.7	45	40	13.02
4. DAY	10.30	22.1	45	36	12.74
4. DAY	13.30	22.3	45	37	12.63
4. DAY	16.30	22.6	45	37	12.53
4. DAY	21.00	22.6	45	35	12.49
5. DAY	13.30	22.6	45	32	12.35

Table 4. Moisture Content and Rate Calculated through Drying Process

DAY	HOUR	ROOM TEMPERATURE (°C)	TOTAL WEİGHT (g)	MOISTURE CONTENT	HUMIDITY RATE (MR)
1. Day	19.30	22.5	100	7.097	1
1. Day	21.30	22.8	80.36	5.5068	0.7759
1. Day	23.30	22.6	75.90	5.1457	0.7250
2. Day	01.30	22.3	67.16	4.4380	0.6253
2. Day	12.30	22.9	34.04	1.7562	0.2474
2. Day	14.30	22.6	30.86	1.4987	0.2111
2. Day	16.30	22.5	27.87	1.2566	0.1770
2. Day	18.30	22.5	24.87	1.0137	0.1428
2. Day	20.30	22.6	23.02	0.8639	0.1217
2. Day	22.30	22.7	20.95	0.6963	0.0981
3. Day	00.30	22.7	19.47	0.5765	0.0812
3. Day	02.30	22.6	18.20	0.4736	0.0667
3. Day	12.30	22.8	14.58	0.1805	0.0254
3. Day	14.30	22.7	14.26	0.1546	0.0217
3. Day	16.30	22.7	13.90	0.1255	0.0176
3. Day	18.30	22.6	13.64	0.1044	0.0147
3. Day	21.30	22.6	13.35	0.0809	0.0113
3. Day	23.30	22.5	13.20	0.0688	0.0096
4. Day	01.30	22.7	13.02	0.0542	0.0076
4. Day	10.30	22.1	12.74	0.0315	0.0044
4. Day	13.30	22.3	12.63	0.0226	0.0031
4. Day	16.30	22.6	12.53	0.0145	0.0020
4. Day	21.00	22.6	12.49	0.0113	0.0015
5. Day	13.30	22.6	12.35	0	0

The equations used to determine the Moisture Content and Moisture Rate are as follows:

Moisture Content(gwater/gthick): (Ü*TK*-Ü*TKM)/(*Ü*TKM*) (1)

ÜTK: Total Mass of the Product

ÜTKM: The Total Amount of Dry Matter in the Product

Moisture Ratio (MR): (M-Me)/(Mo-Me) (2)

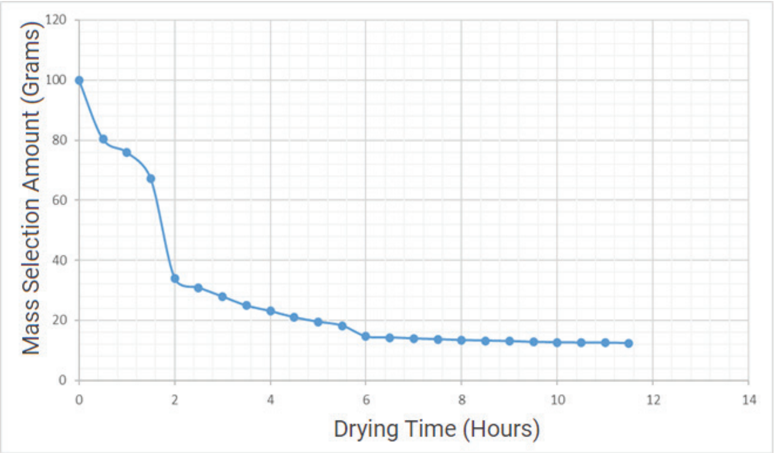
M = Moisture Content at Any Timet

M_0 = First Moisture Content

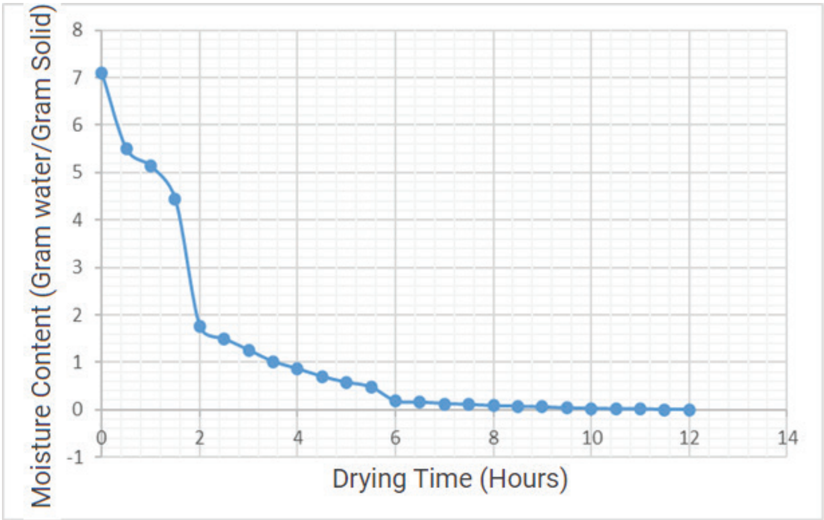
M_e = Balance Moisture Content (equilibrium moisture content of the product)

Since it loses the fluid in its structure at certain intervals during the drying period, some changes occur in the mass of the dried materials. As time progresses, its mass decreases. In Graph 1, the amount of mass change occurring day by day during the experiment is given. It is seen that as the drying time increased, the amount of mass change in the fruit decreased. This indicates that the amount of mass change and the drying time are inversely proportional.

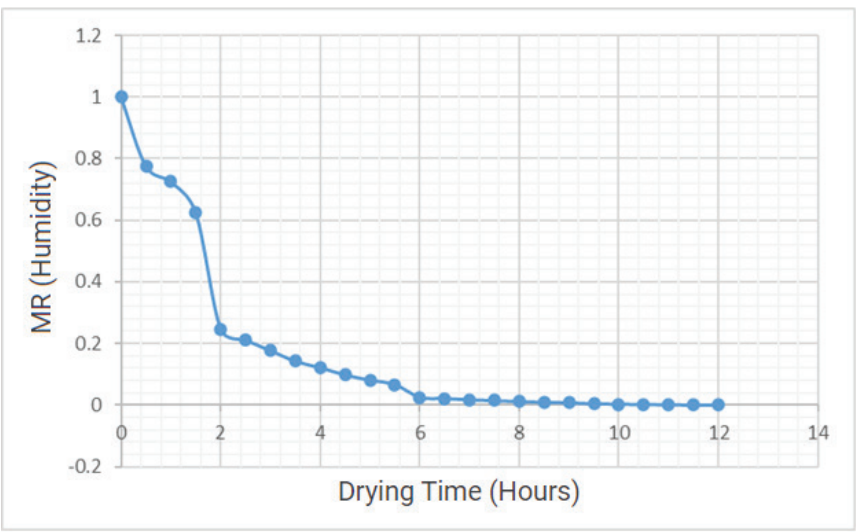
The moisture content of the product to be dried is known as a percentage of the original weight of the product to be dried. When the Transaction 1. given above is applied, Graph 2. emerges. As can be seen from the graph, the moisture content decreases as the drying time increases. However, after a certain period of time, the amount of change in moisture content decreases.



Graph 1. Drying Time of Pineapple - Mass Change Amount Graph



Graph 2. Moist Content According to Drying Time of Pineapple



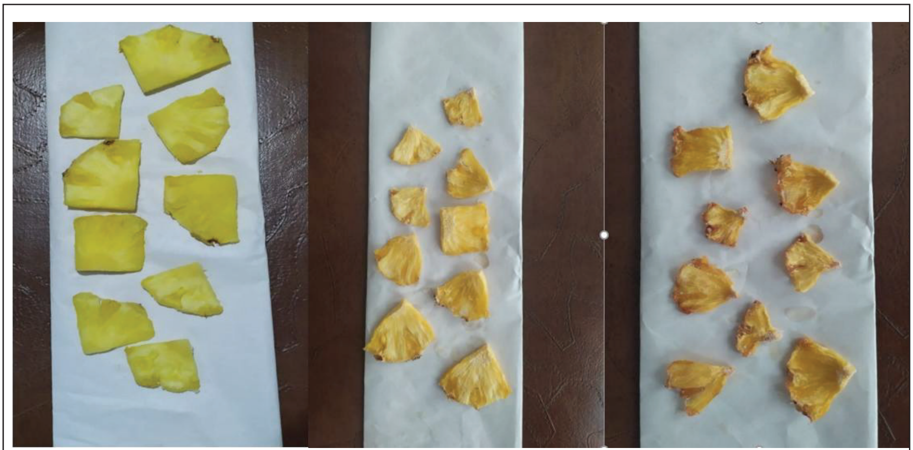
Graph 3. Moisture Rate (mr) According to Drying Time

Throughout the experiment, the moisture rate was observed and calculated at certain intervals. Briefly, moisture rate is the capacity usage ratio of the product to be dried. The weight and quality of the products to be dried are directly affected by the moisture rate change of the environment where the drying process is carried out. While Graph 3. was being formed, the equations in Transaction 2. were used. As can be understood from the emerging graph, the amount of moisture rate decreased as the drying time elapsed like moisture content.

3. RESULTS AND DISCUSSION

One of the most important features of agricultural products is to harvest them at certain times of the year. Very little of the products produced during this period can be consumed fresh. For this reason, products must be stored until they reach consumers. The water and some organic substances in the structure of vegetables and fruits cause chemical deterioration in the products. Major problems are encountered in storing the products after the harvesting process and keeping them intact. For this reason, it is inevitable that the extra products will deteriorate and be thrown away. The production of vegetables and fruits in our country is increasing day by day. Different methods such as freezing, drying and canning are applied to preserve the products produced. Thanks to these methods, quality losses are minimized after the harvesting of the products, so that the desired amount and high quality product can be offered to the consumers.

In the study of Murat Sarı and Sevil Karaaslan on "Microwave Drying of Pineapple and Determining the Appropriate Drying Model" in the Journal of the Faculty of Agriculture of Süleyman Demirel University in 2014, different microwave powers were



a) First Day b) Second Day c) Third Day

Figure 1. The First Three days of Drying Process

used and examined in drying of pineapple fruit by microwave method. The effect of 5 different powers used on the drying of pineapple fruit was studied and the relationship of these powers with each other was examined. In the drying process made by microwave method, 180W, 360W, 540W, 720W and 900W as power and durations of 129, 34, 31, 27 and 22 minutes were used, respectively. As a result of the study, it was determined that the drying time was shortened with the increase of microwave power.

In Figure 1. above, there is the image of cleaned and sliced pineapples for drying process. As can be understood from the figure, the drying process of pineapples has not been started. The pineapple slices are placed on the surface of the heater as shown in the figure of experimental setup above, and then drying process has been started. In Figure 1. b, there are some images taken on the second day of the drying process. As can be seen from the figure, some visible changes on the surfaces of the pineapple slices were observed. The weight of pineapple, which was 100g at the beginning of the experiment, was measured as 20.95 g at the end of the second day. In Figure 1.c, the pineapple slices are seen in their third day of drying process. It can be seen that the amount of drying and contraction on their surfaces increased compared to second day. Since the product lost the fluid in its structure, contraction and shrinkage have been established in the sizes of pineapple slices compared to first two days.

The pineapple slices, whose total weight was 20.95 g at the beginning of the third day, were determined to have 13.01g as can be seen in Figure 2. In the first measurement of the fourth day, the weight of the pineapples was 13.02 g. In the last measurement made on the same day, the total weight of pineapples was determined as 12.49 g as shown in Figure 2.b. It was observed that the contraction and darkening of the colour tone increased on the outer surface compared to the previous day. On the day the ex-

a) Third Day Weight b) Fourth Day Weigh c) Fourth Day Weight evening

Figure 2. Total Weight Values of Drying Process on the Third and Fourth Days

Figure 3. The Fourth Day of Drying Process

periment was completed, the total weight was measured as 12.35 g. On the last day, there was a total loss of 0.14 g compared to the previous day. The measurement of the fifth day shows that the amount of drying fluid in the product decreased as it approached to the end of the experiment and the drying process was completed. The drying experiment, which started with a total of 100 g pineapple slices, ended with 12.35 g.

In Figure 3. above, there are the images of the pineapple slices on the fourth day of drying process. When Figure 3. and Figure 1. are compared, at first sight, the surface changes of pineapple slices attract attention. Compared to the first day of the experiment, there occurred shrinkages, contractions and cracks on the surface of pineapple slices. On the last day when drying process was completed, the pineapple slices lost all fluid in their structure, thus achieved a hard structure.

4. CONCLUSION

In this study, the experiment started with 100g sliced Pineapples. Measurements were made at regular intervals every day with the precision scale provided. The heater temperature was kept constant throughout the experiment at 45□C. During the drying process, which lasted for five days in total, the humidity of the environment was measured with the help of a humidity meter and the room temperature with the help of a thermometer. In the experiment we started with 100g pineapple on the first day, the total weight was determined as 20.95g at the end of the second day, 13.20g at the end of the third day, 12.49g at the end of the fourth day and 12.35g on the last day. It was observed that the most fluid loss occurred at the end of the first day. As a result of the experiment, moisture content and moisture content were calculated depending on the drying time of the pineapple. The data obtained as a result of the calculations were graphed. During the drying period of pineapples, there was a decrease in moisture content and moisture rate. During the experiment, the moisture content, ambient temperature and product weight in the drying environment were measured at certain intervals. As a result of these measurements, various calculations were made to determine the moisture content of the product. In future studies to be done, in addition to these, values such as Equilibrium Moisture Content (Me), Moisture Diffusion Coefficient (Deff) should be measured. In this experimental study, we dried the pineapple and examined the experimental data. However, since the natural methods we apply have negative effects on product quality, quality losses in products can be reduced to a minimum with new systems to be developed. It has been observed that the experiment we carried out in the open air caused a hygiene problem in the dried product. Determining different methods, such as designing the experimental setup as closed, will eliminate this problem. The change in the amount of reduction decreased as the drying time increased. As a result, it was determined that moisture content and moisture ratio were inversely proportional to the drying time.

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