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DETERMINATION OF THE EFFECTS OF DIFFERENT PACKAGING METHODS AND MATERIALS ON STORAGE TIME OF DRIED APPLE

Recep KULCU

Isparta University of Applied Science, Faculty of Agriculture Sciences and Technologies, Department of Agricultural Machinery and Technologies Engineering, Turkey

recepkulcu@sdu.edu.tr

Abstract

The aim of this study was to determine the effects of different packaging materials and packaging methods on changes in product characteristics during the storage period of dry products. In the experiments dried apples were used which were cut into cubes as dry product. In the packaging of dried apples, transparent doypack, metallized doypack, aluminum doypack, transparent plastic and paper materials are used. Dried products are placed in packing materials using special dosing machines to be 200 g each in each case. While atmospheric and vacuum packaging applications were used as packaging methods, only atmospheric packaging method was used in transparent plastic and pouch paper packages in terms of material properties. A total of 30 samples were prepared from each application. The packaged products were stored in the cabins in the SDU Agricultural Machinery and Technology Engineering Department laboratory. The temperature and humidity values in the cabin are recorded in the storage case. The products were stored for one year and one sample was opened and analyzed every fifteen day during the preservation process. The result of the study showed that the vacuum packaging is more successful and the aluminum layer material as the packaging material provides the highest protection.

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Keywords

Packing Material, Packaging Methods, Dried Apple, Storage Time

1. Introduction

Drying; the removal of the water contained in a substance. The Technical Drying process ensures that the product remains intact over long periods of storage by lowering the product moisture to a level sufficient to limit microbial growth or other reactions. In addition to this, it is also possible to preserve quality properties such as aroma and nutritional value by reducing the amount of moisture. The other aim of the drying process is to improve efficiency in transporting and storing important components of food by reducing volume (Ceylan et al., 2005). Packaging is the covering, wrapping, covering or assembling of the product with its material and environment, which can be partially or completely disposed of or recycled, which facilitates the transport, storage and sale of the product (Alagöz and Ekici, 2009). From packaging methods; packaging techniques such as vacuum packaging, modified atmosphere packaging (MAP), sous vide, active packaging and intelligent packaging are among the most applied techniques (Alagöz and Ekici, 2009). In vacuum packaging, food is placed in a low oxygen permeability packaging to prevent aerobic microorganisms and oxygen-induced deterioration caused by aerial deterioration, and shelf life of the product is increased. In this process, the air in the package is vacuumed and the package is closed. In vacuum packaging, there is a small amount of O_2 remaining in the package. However, O_2 in the lower portion of the pouch is used for a short time in aerobic microorganisms and CO_2 is produced. In the vacuum packaging, the oxygen in the package is removed and the problem of aerobic microorganism development and oxidation is minimized. The principle of the modifying atmospheric packing method is to ensure that the gas given in the desired composition to the unopened package has its place by sweeping the present atmosphere or to remove the air of the package by vacuum and then inject the gas into it. Oxygen, carbon dioxide and nitrogen are widely used in the modified atmosphere packaging. The choice of gas to be used varies depending on the food to be packed (Hecer, 2012).

Paper-based packaging is still advantageous, despite the technological advances in packaging and new packaging materials that are constantly being developed (Erdal, 2009). Paper and cardboard packaging forms, paper bags and small bags made of wrapping paper and wrapping paper, large heavy duty bags, foldable or non-foldable carton or cardboard boxes, labels, support and filling materials and other additives (Engin, 2013). However, paper packaging materials are not very suitable for packaging dry products due to their high moisture permeability. Glass packaging is a kind preferred by consumers in terms of naturalness and hygiene in packaging. In addition, glass, as a packaging material, is a preferred material especially in food, medicine, alcoholic and/or carbonated beverages sectors (Erdal, 2009). Especially in the field of glass packaging, the growing importance of packaging in the food and cosmetics sectors and the distribution channels are making this sector more active (TMS, 2012). Types of glass packaging; bottles, jars, cups, bottles and light bulbs. Packaging materials of plastic origin are becoming widespread nowadays. Plastic is one of the important group of substances in the petrochemical industry which is obtained by using petroleum-based products or by-products and natural gas as raw materials and obtained by their chemical transformations. There are different types of plastic packaging. The main types of these species are; PET (Polyethylene Terephthalate), PVC (Polyvinylchloride), PP (Polypropylene), PS (Polystyrene) and PE (Polyethylene). Plastic packages are made from different layers such as aluminum and metallized and have a development potential and are suitable for packaging dry products.

2 600 000 tons of apple production in Turkey is ranked third in the world, China 33 265 186 tons the first US 4.2 million tons are located in second (TSI, 2015). The most apple production in Turkey is carried out in the Mediterranean region, production in this region is about 34.9% of the apple production in Turkey 's meets. The apple production in Turkey when you look at some of the provinces of Isparta province makes up annual apple production. Isparta province covers approximately 21.9% of the annual apple production of our country.

There are many studies on packaging in the literature. The literature survey was carried out to find out how to store the apple in the cold storage rooms and the packaging of the appliances without drying them. However, there was no study on the packaging and preservation of dryed apple.

Granny Smith (GS) and Golden Delicious (GD) appliances, stored in the cold by Batu and Demirdöven (2010) modified atmosphere packaging, packed in the atmosphere at 1ºC and stored for 6 months for sensory quality values. TAQ values were determined with titration acidity (TA), total water soluble dry matter (SCC) and SCCM: TA values as chemical quality values and sweetness, sourness, apple flavor, crispness and hardness values as sensory quality values. In the packaging of the apples, they used PE30 (packed with 30µ polyethylene), PP40 (packaged with 40µ polypropylene), HF30 (packed with 30µ polypropylene stretched on both sides). As a result, they determined that the acidity content of different packaging materials did not differ on the same kind of apples. When comparing the quality criteria obtained from the packaged varieties of apples, they found that the GS apples were stiffer than the GD apples and the acidity and sourness values were higher. They also observed that the GS apples also caused thickening of the shell color. The packaging determined that filminin GS had no effect on the SCF: acid ratio in the range of GS but this difference was significantly different in the HF30 packaged GD apple variety.

Cakmak et al. (2007) conducted a study to determine the effect of packaging characteristics on quality losses during fresh fig migration at Ege University. In this study; intended to determine the product quality losses that can occur depending on the highest vibration values determined in transport vehicles inspected during transport, fig types, average transport time, transport containers of different characteristics, and shapes of the fruits placed in the containers. They carried out their experiments in two different fig types, Sarılop and Bursa Siyah. They used containers made of cardboard boxes, thin and thick polystyrene materials as the transport container. They have taken into account the maximum value (16 Hz-2.5 ms^{-2}) measured in the road conditions examined as vibration values. They were placed on the carrying vessels so that the fruit would be above the neck (ostiol down) and below the neck (ostiol up). At the end of the research, it was found that the highest quality loss occurred in the carrying neck (above the ostiol below), which is the carrying type applied today, and the widely used carrying material, in the cardboard box. The container made from fine polystyrene material has been identified as the most suitable carrying vessel.

Despite the fact that during the preparation phase of the study, studies on preservation of the elvan in the cold air depot were made in the literature review, scientific studies on preserving the elvan as a dry product were not reached. Dry apples produced in our country are packed and kept by companies using different packaging methods and materials. However, companies do not have information on the effects of different methods and materials on dry apple during storage. In interviews with companies producing dry apples in Isparta province, it became clear that the most important factor in determining the packaging method and material was the cost. Some companies have reported that the dry apples they pack are dehydrated during storage and the degradation accelerates. Determination of the dry turkey and Isparta apple important product storage conditions is of great importance for scientific and commercial purposes.

The aim of this study is to identify the most suitable packaging methods and materials for dry apples by determining the changes in the quality of different packaging methods and materials during the storage period of the dry apples.

2. Materials and Methods

The aim of the study is to determine the effects of packaging of dry appliances on different packaging materials and different methods on shelf life. In this context, dried apples obtained from Isparta under experimental conditions; transparent doypack, aluminum doypack and metallized doypack packing materials. In addition to the packaging materials, packaging methods were also evaluated. Packages for this purpose; It is packed with packing machine and vacuum packing machine working under normal atmospheric conditions. Each variation was created in 30 trials. The packaged dry apples were then placed in the waiting rooms and analyzed by analyzing samples taken every fifteen days during each shelf life. The types and characteristics of the packaging used in the experiments are as follows.

• ***Aluminum DoYpack packaging:*** Aluminum packaging structure ensures that products are kept fresh for a longer time as they are not exposed to light or air from outside. Aluminum DoYpack packaging; aluminum, polyethylene and pet (polyethylene terephthalate) materials. The product protects the product from dust and moisture as it prevents contact with the external environment.

• ***Metallized DoYpack:*** It is made of metal and cpp doypack (material that is not stretched in the production process of polypropylene which is a plastic raw material) materials. The front side is transparent and the rear side is metallic. Due to the transparentness of the front side, the product inside can be seen from the front of the packaging. Like aluminum doypack, it preserves the freshness of product for a long time and keeps the product from dust and moisture.

• ***Transparent DoYpack:*** Used to pack products such as spices, sugar, salt. Since both sides are transparent, the product can be easily seen from the outside. It can not protect the product against long-term nausea. It passes through the product as if it were a light. Polyethylene and polyethylenetaphthalate are manufactured from structural raw materials

Figure 1: Packaging materials

The L *, a * and b * values of the dried apple samples used in the experiments were determined by the PCE-CSM brand colorimeter shown in Figure 2.

Figure 2: Colorimeter used in the experiment

In the moisture analyzes of the dried apples used in the experiments, the sample weights were measured with the help of the delicate sensitive scale of Neck brand FLY-3000 model shown in Figure 3. The precision scale has a maximum weight of 3000 grams and a minimum weigh of 2 grams and a sensitivity of 0.01 grams.

Figure 3: The precision scale used in the experiment

The Nükleon Nst-120 brand drying oven used in the experiments is shown in Figure 4. The drying oven (oven) is sensitive and PID controlled and thanks to the fan circulation system, it ensures the constant drying temperatures. Drying oven with digital control panel can reach 120 L volume and + 5 / + 250 C temperature. The installed power of the oven is 1500W, the voltage and frequency is 230V-50Hz, the internal measurement values are 49 × 49 × 50 cm and the external measurement values are 60 × 70 × 76 cm.

Figure 4: Drying oven used in the experiments

The experiments were carried out using shredded and dried apples in cubes of about 0.5 cm on each side. The moisture content of the dried apples is at the level of 17.13 ± 2.81% on an wet basis.

Figure 5: Dry apples used in the experiment

After the dried apples were packed, they were kept in the cabins located in the laboratory of SDÜ Agricultural Machinery and Technology Engineering Department. Images of packaged dry appliances placed in the cabinet are shown in Fig.

Figure 6: Packaged and preserved dry apples

2.1 Analysis Methods

The moisture content of the dried apple samples used in the experiments was determined in terms of age (y.b.) to determine the change in water content over time. In the moisture analysis, the products were dried in the oven at 105 ºC and the moisture content was calculated using the following equation (Yağcıoğlu, 1999).

$$\%\boldsymbol{Moisture} = \frac{W_y - W_k}{W_y} \boldsymbol{x100} \qquad (1)$$

W_y: Product pre-oven weight (g)

W_k: Weight of product after oven (g)

L *, a *, b *, Hue angle, croma value, total color deviation and browning index values were determined in the color analysis of dried apple samples. Color measurements were measured before packaging and after 1 year storage period to examine the change of color values.

Color measurements According to the CIE (International Commission on Illumination) color system shown in Figure 7.

• Brightness value (L) ranges from 0 to 100, with 0 value (black) and 100 value (white)

• Red (a) and green (-a) values range from -90 to +90, with -90 values (green) and +90 values (red)

• Jaundice (b) and blue (-b) values range from -90 to +90, expressed as -90 value (blue) and +90 value (yellow) (Anonymous, 1996).

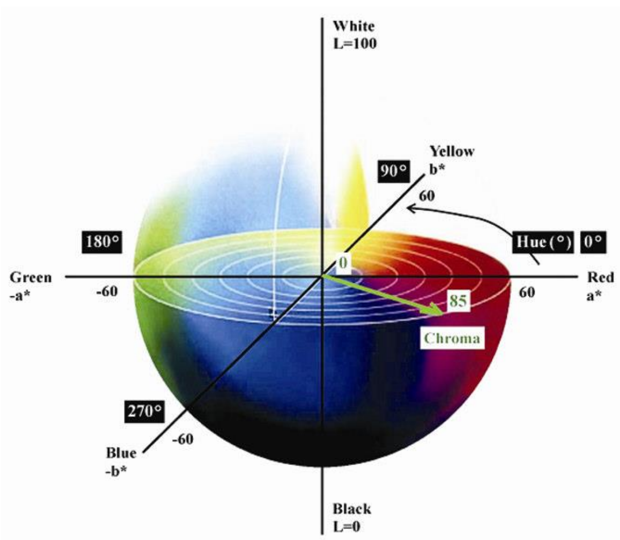

Figure 7: CIE Lab L *, a * and b * color space

The total color deviation calculation is performed to determine the color change of the products kept for one year according to the products before storage. If the calculated values take a negative or positive value;

- Positive ΔL * the color shine of the dried product is higher than the color shine of the fresh (standard) product. If the value is negative, it indicates that the color brightness of the product is reduced,
- Positive Δa * the green color of the dried product is lower than the green color of the fresh (standard) product. If the value is negative, the product shows an increase in green color,
- Positive Δb * the yellow color of the dried product is higher than the yellow color of the fresh (standard) product. If the value is negative, the product shows a decrease in yellow color.

• Total color change is calculated by the following equation;

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2} \qquad (2)$$

$$\Delta \mathbf{L} = \mathbf{L}_{\mathbf{sample}} - \mathbf{L}_{\mathbf{standard}}$$

$$\Delta \mathbf{a} = \mathbf{a}_{\mathbf{sample}} - \mathbf{a}_{\mathbf{standard}}$$

$$\Delta \mathbf{b} = \mathbf{b}_{\mathbf{sample}} - \mathbf{b}_{\mathbf{standard}}$$

Δa: Red color deviation

Δb: Yellow color deviation

ΔL: Color brightness deviation

ΔE: Total color deviation

During the comparison of apple colors, the L *, a *, b * coordinates as well as the color intensity C (chroma) values derived from these values were calculated. The C value is a dimensionless value ranging from 0 to 60 (McGuire, 1992).

The C (Croma) values and equations used in obtaining the deviations are given below (Soysal,2000).

$$C = \sqrt{a^{*2} + b^{*2}} \qquad (3)$$

Hue (H °) is the name of the colors in the color space and examples of green, yellow, blue and red colors can be given. The Hue angle is defined as a reddish purple at 0 ° and 360 °, a yellow at 90 ° angle, a green at 180 ° angle and a blue at 270 ° angle, as shown in Figure 7. In the experiments, Hue (H °) values were calculated using the following equations, depending on whether the a * and b * values are negative or positive (Guine ve Barroca, 2012). Equation 4 is used because the a * and b * values used in the calculations of Hue (H °) values in the experiments provide conditions a *> 0 and b *> 0 respectively. Equation 4 is used because the a * and b * values used in the calculations of Hue (H °) values in the experiments provide conditions a *> 0 and b *> 0 respectively. Equation 4 is used because the a * and b * values used in the calculations of Hue (H °) values in the experiments provide conditions a *> 0 and b *> 0 respectively. 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Table 1: Equations used to find the hue of color

Equation	Value range	Equation No
$H = arctg\left(\frac{b*}{a*}\right)$	a* >0 and b* >0	(4)
$H = 180 + arctg\left(\frac{b*}{a*}\right)$	a* <0 and b* >0	(5)
$H = 270 + arctg\left(\frac{b*}{a*}\right)$	a* <0 and b* <0	(6)
$H = 360 + arctg\left(\frac{b*}{a*}\right)$	a* >0 and b* >0	(7)

H: Color angle (Hue)

C: Kroma

The browning index represents the purity of the brown color and is an important parameter for describing some of the changes that browning reactions bring about in the product color (Palou vd., 1999).

The browning index (BI) of the samples was calculated by the following equation (Buera vd., 1986);

$$BI = \frac{[100(x - 0.31)]}{(0.17)} \quad (8)$$

The x in the formula is the chromaticity coordinate and XYZ is calculated from the tristimulus values. According to the following form;

$$x = \frac{(a^* + 1.75L^*)}{(5.645L^* + a^* - 3.012b^*)} \quad (9)$$

BI: Browning index

x: value of chromaticity

3. Results and Dıscussıon

The changes in temperature of the air in the cabins were shown in Figure 8. When the laboratory where the storage cabinets are located is located within the faculty building, the heating system of the facade does not allow the temperatures to fall below 19 ºC. Temperatures rose to 32 ºC in the summer months, while temperatures during the winter months decreased to 19 ºC, especially on weekends.

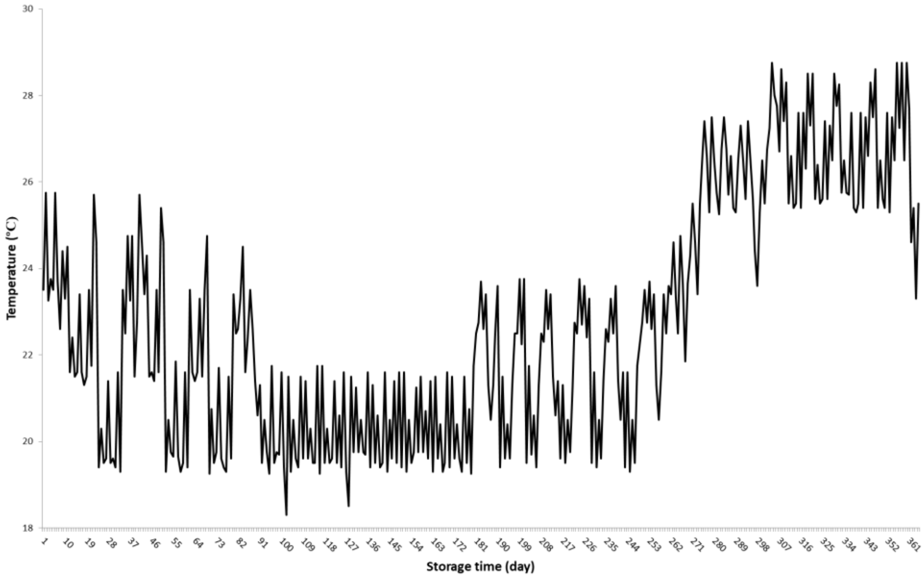

Figure 8: Changes of temperature of the air in the storage cabin

The changes in the moisture content of the air in the cabin during the storage operation are shown in Figure 9. During the tests, the moisture content of the air in the cabin varied between 26-45%. Moisture values decreased in the summer months, while moisture values increased in the spring and winter months. However, since the laboratory has a heating system and is located in a closed building, it has been observed that the humidity values do not change suddenly and reach levels that cause serious effects on the products.

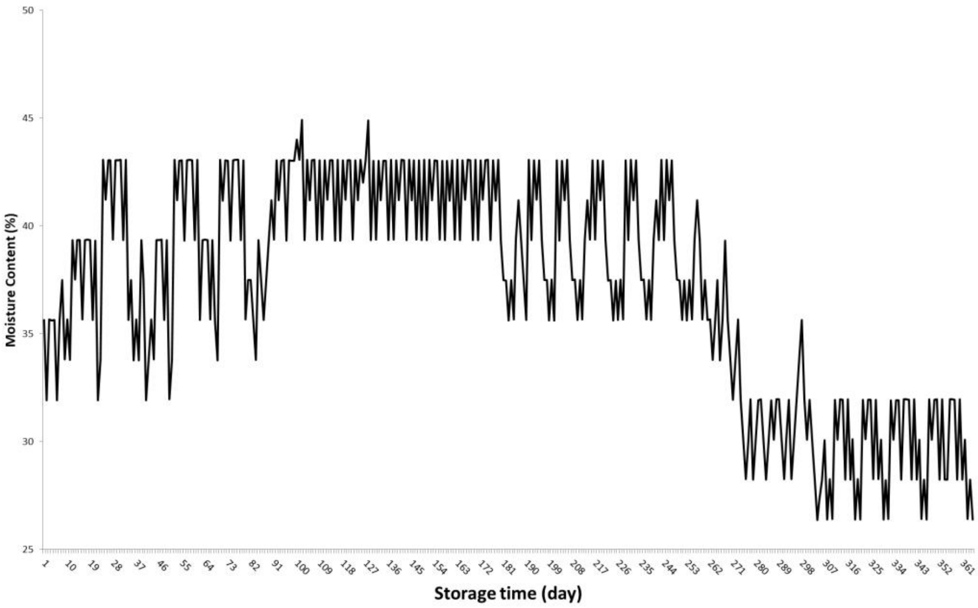

Figure 9: Variations in the moisture content of the air in the cabinet on the enclosure

Every fifteen days during the storage process, one of the packages prepared for the applications was opened and the analysis of the samples from the packages was carried out. The coding used for the applications in the analysis process are shown in Table 2.

Table 2: *Codings used in the experiment and their counterparts*

Cod	Method and material	Packing Closure Method
AAD	Packed in atomospheric conditions, aluminum doypack	Heat shut-off
AMD	Packed in atomospheric conditions, the metalized doypack	Heat shut-off
ASD	Packed in atomospheric conditions, the transparent doypack	Heat shut-off
VAD	Packaged in vacuum conditions, aluminum doypack	Heat shut-off
VMD	Packaged in vacuum conditions, metalized doypack	Heat shut-off
VSD	Packaged in vacuum conditions, transparent doypack	Heat shut-off
SN	Transparent nylon packaged in atmospheric conditions	Connecting with rope
KK	Packed in atmospheric conditions, pouch paper	Stapling
K	Unpackaged control example	Open

Figure 10 shows the changes in moisture content of the samples opened every 15 days from packages stored for one year. The moisture content of 17,13% prior to packaging is maintained after one year of preservation; 34,71% for unpackaged sample, 31,54% for KK, 29,25% for SN, 27,29% for ASD, 24,53% for AMD, 21,42% for AAD, 20,92% for VSD, VMD to 19.52% and for VAD to 18.38%. In all samples moisture levels were found to be lower than the moisture levels of the dry appliances packed in a vacuum and the aluminum packages were found to be more successful.

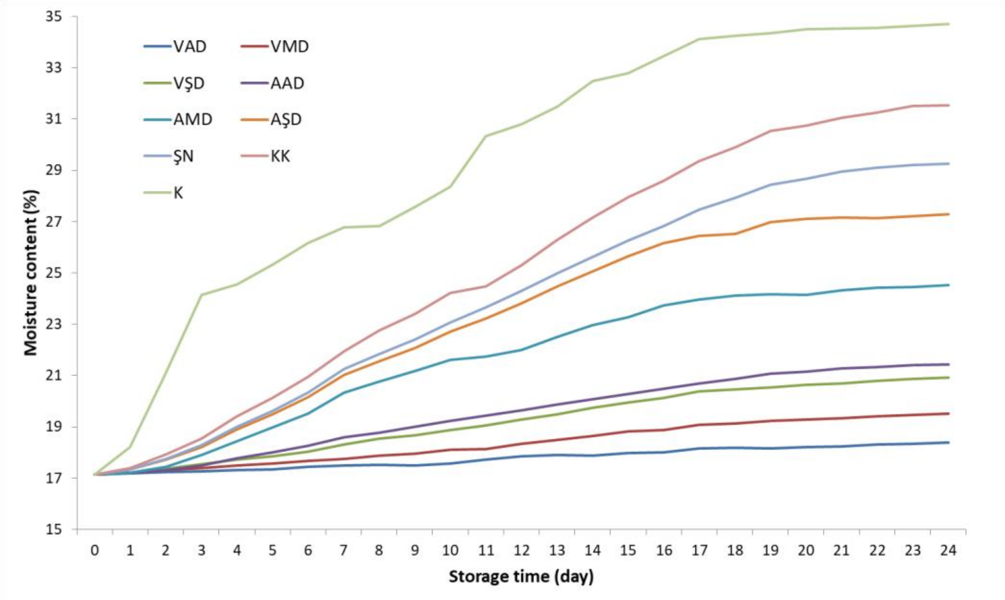

Figure 10: Changes in moisture content of the products in the packaging during the storage operation

The changes in color properties of the products before and after one year of storage with different methods and materials are shown in Table 3.

Table 3: Color values of packaged dry apple samples before packaging

Code	L	a	b	C	H°	BI	ΔE
AAD	71,89	7,01	37,01	37,66	79,26	76,90	1,37
AMD	70,14	7,89	37,56	38,37	78,14	81,98	3,31
ASD	69,78	8,01	38,01	38,84	78,86	83,95	3,83
VAD	72,25	6,89	36,89	37,52	79,41	75,94	1,05
VMD	70,69	7,23	37,12	37,81	78,96	79,20	2,39
VSD	70,45	8,02	37,56	38,40	77,93	81,64	3,16
ŞN	70,12	8,23	38,11	38,98	77,81	83,91	3,76
KK	68,25	8,56	38,21	39,15	77,36	87,76	5,37
K	67,78	8,94	38,66	39,68	76,96	90,37	6,10
Pre-Stored Dried Apple	72,64	6,14	36,26	36,77	80,38	73,00	-

The L value refers to the brightness of the products and the decrease in this value indicates that the product brightness is reduced. In all applications, the shine of the product decreased, but in the case of aluminum-added packages this reduction was found to be at a very low level.

It is seen that the Croma (C) values of the products are increased a little in all the applications which are wrapped and left for one year. While there was no significant deviation in the C values of the packaged products, it was determined that the C value in the chipping paper and control sample was higher.

In the measurements made, it was determined that all samples were decreased in angle of H ° according to the samples before packing. However, it was observed that this decrease was lower in the cases using aluminum packaging. In all applications it can be said that the H ° angle is in the band 76-80, so it is in the yellow zone.

The biomass index (BI) values represent a change that is evolved as a result of biochemical reactions in products. The value of smearing index increased by about 17.37 units in the products packed with the pouch paper and unpacked, which decreased to 2.94 in the vacuum aluminum die-pack packaging.

The color deviation (ΔE) value of dry appliances kept without packaging is 6.10, 5,37 for KK, 3,76 for SN, 3,16 for VSD, 2,39 for VMD, 3,83 for ASD, 3,31 for AMD and 1,37 for AAD. It has been determined that color deviation of aluminum doypack packages is lower than other packages.

4. Conclusıons

When the changes in the moisture values of the products were evaluated as a result of a one year preservation process, the following results were obtained;

- Increases in the moisture content of the products, even if a little in all packaging materials and methods,
- Doypack packaging materials have been found to have a higher moisture protection than pouch paper and transparent nylon packaging,
- Vacuum packaging method provides more successful protection than atmospheric packaging method,
- Aluminum layered DyoPack packaging material provides maximum protection.

When the changes in the color values of the products are evaluated in an integrity, the following results have been achieved;

- The packaging process reduces the color changes of the products,
- The protection of pouch paper and transparent nylon packaging is low,
- Aluminum packages have been observed to better protect color values as they provide light moisture insulation.
- The deviations in the color values of the samples taken from the packages made by vacuuming are lower than the atmospheric method,

- The lowest deviation values in terms of color values were determined in samples taken from vacuum aluminum doypack packaging.

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