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Solar Drying of Traditional Herzegovinian Fruit Sweet Ćupter

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Declaration

I hereby declare that I have done this thesis entitled Solar Drying of Traditional Herzegovinian Fruit Sweet Ćupter independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague, 2.5.2020

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Betül Elibol

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Abstract

Ćupter was a traditional fruit sweet in Bosnia and Herzegovina made from boiled grape juice mixed with flour or wheat semolina. Ćupter was traditionally produced in rural areas of Herzegovina in the grape harvesting season and mostly serve for Cristmas Eve. This type of sweet was popular for its favourable taste and nutrition value. Ćupter was a strong candidate to become a novel food for healthy diet lifestyle in modern times. No additives were needed for preparation of ćupter. One of the traditional processing steps was drying of ćupter under sun on open air. This thesis mainly focused on using solar drying method for grape product. Traditional open air sun drying, solar drying and freeze drying were used in a comparison to determine the drying kinetics in terms of moisture content, drying time, colour change etc. In this way, it was tried to reveal the effects of drying process on final quality of the product by experiments and sensory analysis. The colour values of ćupter samples were measured in CIE (L^* a^* b^*) colour and overall combined colour (ΔE) was calculated. Significant differences ($p<0.05$) were found.

Key words: Solar drying, open sun drying, freeze drying, lyophilizer, grape ćupter

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1. Introduction and Literature Review

1.1 Role of Grapes in Human Diet

Viticulture has been one of the most important agriculture activities for many civilizations. Grapes (*Vitis* spp.) are the world's most common produced fruit crops (FAO-OIV 2016). Grapes, one of the most valuable products in the world, are mostly used in winemaking. *Vitis* also includes more than 60 inter-fertile species. The most common grape cultivar belongs to *Vitis vinifera* species (Migicovsky et al. 2016).

The primary origin of grape is seen as the Mediterranean side of Mesopotamia and around Caspian Sea in Southwestern Asia. It can be said that the first viticulture in history was generally found in Anatolian land (Minor Asia) which is within the current borders of Turkey (Söylemezoğlu et al. 2016). Viticulture had started around 5500 - 5000 BP in Mesopotamia by the main civilizations such as Assyrians, Phoenicians etc. The Romans were the first civilization who gave names to cultivars (This et al. 2006). Viticulture is extended to all Europe after it is reached to Rome, South France and Greece in ancient times. In any form of grape has an important role in the human diet from archaic times to modern times. Some ancient Greek philosophers mentioned about healing power of grape. Later, Europeans used grape juice as cure for eye and skin diseases and throat problems and they used dried grapes for healing thrist and constipation (Badet 2011).

Approximately 75 million tonnes of grapes are produced annually. Almost half of it around 41 % is grown in Europe and 29 % in Asia, and 21 % in the United States of America. Grapes can be produced in temperate areas. Warm summers and temperate winters have been seen in the temperate climate zone as grape crops require (FAO-OIV 2016). Approximately half of grapes are used to produce wine, one third is used as fresh table fruit, and the rest are refined to produce foods such as jam, juice, grape seed extract and oil, jelly, dried grapes (raisins etc.), and vinegar (FAO-OIV 2016).

For the winemaking process Cabernet Sauvignon, Garnacha, Graciano, Mencia, Merlot, and Tempranillo are the most commonly used in Spain (Revilla et al. 2001). Moscato d'Amburgo, Italia, Sultana, Bicane, Regina are some of the very common table grape cultivars. Table grape cultivars generally cannot be used for winemaking process.

That is why the cultivars are widely changed for the purpose of producer (Crespan et al. 1999). For example Sultana (Sultani) cultivar is a very common table grapes in Turkey for exporting as fresh table grapes and mostly as raisins (Akdeniz 2011). Sultana variety is preferable for its seedless structure and it constitutes 98 % of all production in Turkey (Uysal 2007).

Table grapes are the richest in carbohydrates (17 g / 100 g) in all fruits in general. Grapes have a high caloric content (65 kcal / 100 g) thanks to its high sugar content. But grapes have a relatively low glycemic index. It causes grapes are beneficial for healthy diet. It is rich in minerals such as manganese, potassium, sodium and iron and also rich in vitamins as A, B1, B2, B6, C (Gülcü et al.2008). Nutritional value can be changed in the form of grape for all purpose of usage but it is highly beneficial for health. Red wines contain polyphenolic antioxidants. Consumption of antioxidants has great effects on human health. It can protect from cardiovascular diseases and cancer (Lopez-Velez et al. 2003).

Consumption of grape and wine as an alcoholic fermented form of grape is very important in the Mediterranean diet by the reason of its health benefits. Amino acids in wine partly satisfy daily needs of human amino acid requirements. Moderate wine consumption contribute to reaching a healthier life (Gamboa et al. 2019). Grapes and products of grapes are famous for claiming beneficial health effects such as antioxidant, anti-inflammatory, anti-allergic, anti-cancer, immune-stimulating, anti-viral, cardio-protective and antithrombotic features. It has protective effects on the human body against many diseases (Martinez et al. 2012). Consumption of grape seed extract and other grape related products in the human diet helps to have an active healthy lifestyle and reduces the possibility of cancer in general population (Kaur, 2009). Nowadays researhers focus on the chemical structure of grape, and grape-based products in industrial production. For example the topical use of grapeseed oil is both safe and effective on human skin (Spiers & Cleaves 1999).

1.2. Grapes Cultivation in Bosnia and Herzegovina

Bosnia and Herzegovina is one of the few countries does not have a ministry responsible for agriculture, food and rural development in the state-level. There is only the Ministry of Foreign Trade and Economic Relations and its Department of Agriculture. There were some difficulties within foreign trade in Soviet times. Bosnia and Herzegovina has a decentralized political and administrative structure. The Federation has 10 cantons, each of them has control of policy in areas. Bosnia and Herzegovina has almost no institutions which can regulate and govern the areas of production of wine and control of labelling and analysis (Gaeta et al. 2012). Under these conditions, Bosnia and Herzegovinian wine is not very known internationally. Nevertheless, viticulture has an important role in the economy of Bosnia and Herzegovina. Its share in the national income is quite small. It is around 1.7 % but this participation will be expected to rise by increased plantation vineyards (Woods 2009).

It can be said that wine production has an important role in Bosnia Herzegovina culture. In the southern part of Bosnia and Herzegovina, viticulture and wine production developed mainly on small farms. According to the Federal Bureau of Statistics, there is a total of 13,493,000 grape crops in Bosnia and Herzegovina. The manuel harvest of grapes is 22.973 t (Beljo 2017). Especially the vineyards of the Mediterranean Herzegovina employ about 250 workers per 1 hectare, annually. It is quite important number of people for Bosnia and Herzegovinian national economy. It helps to decrease the unemployment level of the country (Nurković 2017).

It is difficult to produce volumes of grapes in specific wine-growing regions because of the administrative structure of the country. But 99.14 % of production of grapes in the Federation of Bosnia and Herzegovina is achieved in the Herzegovina zone. That is why viticulture as an economic activity is almost exclusively related to Herzegovina thanks to the Mediterranean climate zone (Beljo 2017).

There are autochthonous varieties Zilavka and Blatina are mostly grown in the wine-growing zone of Herzegovina. These are white wines Krkosija, Bena and Dobrogostina and red wines Alicant Bouschet and Trnjak. Those cultivares cover more than 80% of total areas. There are also other foreign origin cultuvars such as Vranac, Trebinje, Smederovka, Merlot, Skadarka, Cabernet Sauvignon, Chardonnay, Syrah, Grasevina. But of course Zilavka and Blatina dominant as the brand of Herzegovina (Beljo 2017).

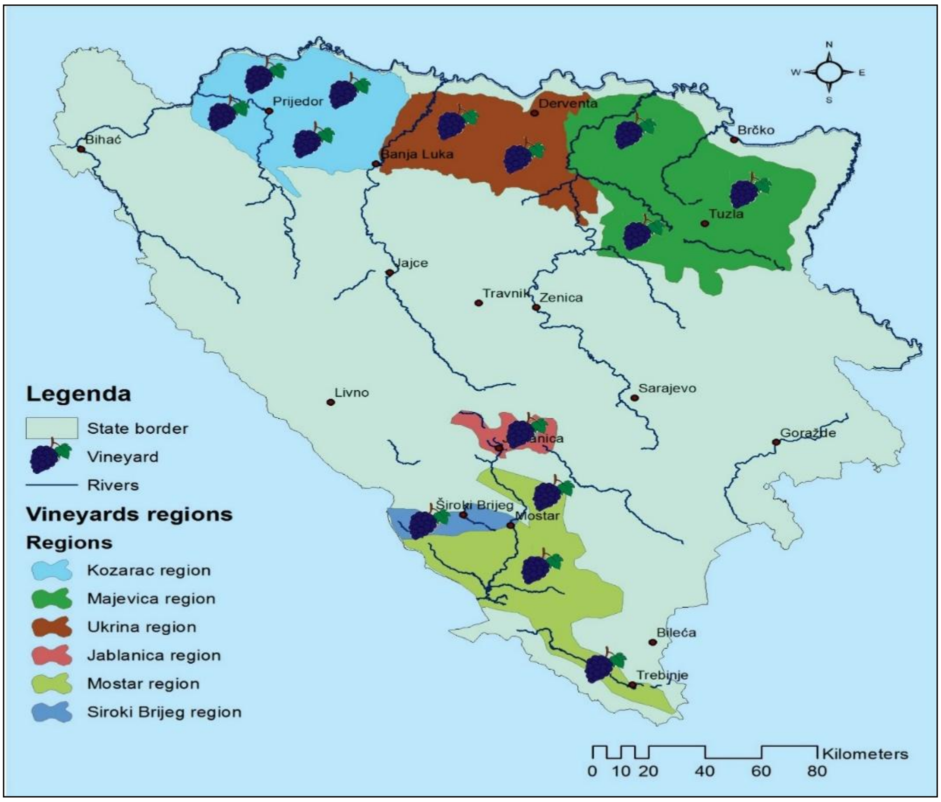

Figure 2. Wine growing areas in Bosnia and Herzegovina (Nurković 2017)

Herzegovina has intensely sun heat six months in a year. There is a vegetation that contains plants such as thorn, oak, ash, field maple, spruce and pine. Bosnia and Herzegovina's heritage of viticulture and winemaking culture is started in the Illyrian times. The first grape activities is started with the Thracians introduced to Balkans. Today, wine production is placed around the rivers Neretva and Trebišnjica in Herzegovinian wine region with Mostar, Lištica and Jablanica vineyards (Nurković 2017).

Potential growth in viticulture will have not only direct but also indirect positive effects on economy as wine tourism (Nurković 2017). Local authorities may have a chance to organise wine festivals, hiking trails, bike routes as local, national and international levels. Many examples can be given from all around the world. For example, vintage festivities as called 'Bağbozumu Şenlikleri' in Bozcaada, Cappadocia, and Şirince, Urla in Turkey (Diken & Tepeci 2017).

1.2.1. Role of Ćupter in Bosnia Herzegovina Culture

Viticulture has a great role in Bosnia and Herzegovina. Not only for wine making but also grapes are used as other forms such as table grapes, concentrated juice, vinegar, raisins and another type of dried grape sweets. In one part of Herzegovina, grape must is used for the preparation of very tasty jelly, the so-called ćupter. From stewed must-semolina mixture, they made ćupter, a kind of grape jelly. Ćupter has been a very pleasant sweetish taste and used to be consumed usually as a dessert together with almonds, walnuts and dried figs. It has no additives, chemicals nor refined sugar in it. It is interesting that preparation of ćupter survived as tradition only in Brotnjo (the municipality of Čitluk), while in other areas it can hardly be found. There is only one brand to purchase found in the city of Mostar in the market as industrial production. Other than this, preparation of ćupter is only home made by grandparents. It is prepared after harvesting season and mostly serve for Christmas Eve gatherings. One of the traditional processing steps is drying of ćupter under sun on open air (Beljo 2017).

Figure 2. Ćupter (Sajin 2015)

The European Union (EU) has implemented food labelling policies such as Protected Designation of Origin (PDO), Protected Geographical Indication (PGI) and Traditional Guaranteed Speciality (TSG) (Resano et al. 2012). Ćupter as a potential candidate to be labelled by EU Quality Schemes for Agricultural Products is locally produced food from locally-grown products. It might be a local brand of Čitluk or Bosnia and Herzegovaina national product. Local produced foods can be accepted healthier and alternative to foods from mass products. It might help to development of the local economy and new valuable market. Regional cultures feeds gastronomic tourism. PDO, PGI, TSG products are accepted as safe, authenic, high quality and natural. Labelling the product with these etiquettes contributes to its social prestige and gives an opportunity for marketing of product easily. Labelling has impact on consumer preferences (Erraach et al. 2014).

Ćupter has the potential to become a brand product. Standardisation is required for this. If the studies on nutritional value information, how it is produced, how it can be marketed are carried out, ćupter would have a great impact on the economic and social status of the people of Bosnia and Herzegovina. For example lokum (Turkish delight) is well known sweet as national product of Turkey (Batu et al. 2006). A study on the role of traditional ćupter in regional development and innovative tecnology for traditional food ćupter can be prepared by the autorities. Turkish delight gives a competition chance in global trade market. Its effects on economy and social acceptance in the local and global level are great (Kuşat 2012). There are other banch of studies on Protected Geographic Indicators (PGI) and Product Differentiation of Origination (PDO) products such as Diyarbakır watermelon, Antep pistachios, roasted chickpeas Corum, Malatya apricots, Afyon kaymak (milk cream) from Turkey (Oraman 2015) and Bordeaux wine, Camembert cheese for France (Hassan & Monier-Dilhan 2016) and Wisconsin cheddar from the United States and parmigiano reggiano from Italy (House 2009).

1.3. Fruit Drying

Agriculture, which Yuval Noah Harari called the greatest fraud in the history, has started approxmately 9500 - 8500 BC in the location that southeast Turkey, western Iran and the Levant. Wheat and goats were domesticated around 9000 BC, then some of the legumes and cereal, olive trees and horses slowly by the centuries. Grapevines were domesticated around 3500 BC (Harari 2011).

Starting with agriculture, man has been preserving food to save more than needed in that moment and use for later all year long. It seems like food preservation were started with drying food for later use (Hugo 1991). Food preservation is important for food safety and security. Fresh fruits, cereals, legumes, meat, fish would be safely used any season of the year.

Decision of which preservation would be choosen is also quite important. Unsuitable prevention and storage methods causes food looses around 50-70 % of fruits. The majority of loss in developing countries arise after harvest stage to the consumer (Yaldız & Ertekin 2001). Food spoilage occurs with any sensory changes such as tactile, visual, odour or flavour. Food preservation method should be choosen wisely and maintain carefully to avoid undesirable results like food spoilage. The main cause of food spoilage is spreading microorganisms such as moulds, yeast and bacteria (Rawat 2015). Freezing drying, curing, conserving, fermenting or otherwise acidifying, the addition of preservatives, heat-pasteurisation and sterilisation are well-known food preserving tecniques (Gould 2012).

Food drying is one of archaic food preserving methods. It is easy, unexpensive and very common way of food preserving applied to various fruits, vegetables, meats, cereals etc. Basically, it is dehydration by water evaporation. It can be done by air drying, sun drying, wind drying, smoking, vacuum-microwave finish drying or and freeze drying can be used for food drying method (Turkiewicz 2019).

Fruit drying is very common method for many different cultures in the history. Because of the short harvesting season, difficulties of storage and short self-life of fresh fruits, it should be preserved in some form with preserving methods such as drying. For drying fruit, traditional method is open sun drying. Human being has been drying fruits on rocks, leafs, textile to reduce the spoiling speed. Because foods tend to spoil right after harvesting. Proccess of drying fruits needs pretreatment before drying step. Once harvesting is done; washing, purifying can be the next steps (Verghese 2013). In this point, cooking as a pretreatment could be used if desarable final product needs. Here the aim of prevention is extend the shelf life with decresing the possibilty of bacteria, yeast or mold (Rawat 2015).

Dried products are very popular in worldwide regarding the extention of self-life. It has many benefits for storage and transportation stages. Especially when the most suitable drying method is choosed, the nutritonal value mostly can be kept for all year long (Verghese 2013).

1.3.1. Grape Drying

Grape drying is a complex process. Because it requires pretreatment operation and post-drying process (Esmaiili 2007). Drying grapes is a great industrial activity for the economy of the the country where grapes are grown. Drying methods are varied. For instance open sun drying, shade drying, mechanical drying and solar drying. Drying with solar energy is cost-effctive for the places with good sunshine in harvesting season and post- harvesting process (Sharma 2013).

1.3.2. Dried Grape Products

1.3.2.1. Raisins

Raisins are the most known dried grapes. Chile, Greece, Iran, South Africa, Turkey, and The United States are the most competing countries in terms of volume of export. The European Union is the largest importer of dried grapes in the world. More than 50 % of the world's imports reach to the European Union. Dried grapes are the most important dried fruits with 40 % of all dried fruit imports (Sharma & Somkuwar 2019).

There are various methods of process grapes into raisins. It is preferable for extand the shelf-life. It is mostly consume as snacks. Solution of ethyl oleate and potassium carbonate accelerates can be used for faster loss of moisture from berries as pretreatment. Variety of grapes, canopy, the amount of water and pesticides usage, berry size and skin tickness are important vineyard factors for quality of raisins (Sharma & Somkuwar 2019).

Figure 3. Different Colours of Raisins (Gıdatarım 2015)

Figure 4. Raisins Drying (Manisahaberleri 2018)

The safe level of moisture content should be 12 to 18 % (Bolin 1980). In this level of moisture content, raisins are safe to transport and storage all year long in case of proper process and material are used for packaking, transportation and storage. The best range of moisture content would be 14 to 16 % for the most favorable taste. Less then 14 % will me too dry for consumer desires (Sharma & Somkuwar 2019).

1.3.2.2. Pestil

Pestil, a well known grape sweet in Turkey, is prepared from boiled grape juice and starch mixture by using traditional technique. There are types, mostly with walnuts, of pestils and different serving shapes of pestil are exist. It is a fruit leather basically. It can be made from grape, apple, mulberry, apricot generally. The most common one is grape pestils with walnuts (Kaya et al. 2002). It is a quite dry product available in the market. The commercial moisture content of pestil is 12 % (Maskan et al. 2002).

Generally it is dried in 0.5 and 2.0 mm thickness and drying takes approximately two days. The shelf-life can be one year if the moisture content would be controlled. It is easy to store with a proper packaging (Kaya et al. 2002).

Figure 5. Pestil (Gumushaneden 2019)

Figure 6. Pestil Drying (Diatek 2015)

Figure 7. Hommade Pestil Drying (Diatek 2015)

1.3.2.3. Köme -Cevizli Sucuk - Churchkhela

Where pestil is accepted as an edible film in the general literature, köme is considered as mulberry/grape pulp coated walnuts (Yıldız 2013; Kaya & Maskan 2003). It is quite known in some countries as Georgia and Turkey. It is named as sucuk (sudjuk or sujuk in Bosnia and Herzegovina) thanks to the its shape of local type of sausage. Churchkhela is the Georgian name of it and it is called as köme only in northen Turkey and as Cevizli Sucuk in all over Turkey (Bayram 2018). It is used to prepared only in rural areas, hommade by small scale farmers. But nowadays, it is produced for lager scales as mass production. It can be found in organic shops, spice shops or supermarkets all over the countries which it is known. Moreover, it is even exported to the abroad. Cevizli sucuk has different types according to production process differs. In some regions, it is produced from the white foam of the grape pekmez (a local type of molasses) mixed with wheat flour (Kaya et al. 2002). It might contain different tpyes of nuts as well. For instance hazelnuts, walnut, pistachio, peanut. The moisture content of the available köme in the market is around 19 - 21 % according to a master thesis about köme and pestil (Bayram 2018).

Figure 8. Köme Drying (Knec 2019)

Figure 9. Köme- White Sucuk with Pistacio (Marasmarket 2019)

1.4. Quality of Dried Products

What makes a dried product quality is choosing a suitable drying method and maintain the process. The final product should preserve the nutritional value as fresh product alike. It should look like disarable for consumers preferance in the market. Possiblity of any contaminations should be decreased (Rawat 2015).

During the process of drying there can be many challenges to standardisation of quality. High instrumentation cost in develpoing countries, food looses, unreliable power supply, training the people who deal with drying are some of those challenges (Zambrano et al. 2019). With EU laws, International Organisation for Standardisation (ISO) and Codex Alimentarius Commission, it has been tried to ensure standardization in dried fruits, cereals, spicies etc. The definition of residues of pesticides certain mycotoxins, heavy metals, persistent organic pollutants are revealed (Schaarschmidt 2016). But of course there are national standards institues which have been tried the ensure standardization of dried products in different countries. National standards institutions' regulations are quite important not only for that country but also for the countries which trade with them. If Iran's high rank among dry fruits in the world will be considered, the legal limitations of the Institute of Standards and Industrial Research of Iran (ISIRI) are seen as important as EU legislations. There are many exporting dried products of Iran to EU such as raisins, dried cherries, prunes and dried apricots (Reazai et al. 2014).

Post-harvesting process has an important role on the quality of dried product. In this process many conditions such as relative humidity, temperature, duration, transportation, waiting time for drying, drying method should be secured (Gloria 2011; Fani et al. 2013). In order for raisins to maintain their quality during storage, the targeted moisture content and water activity range in the drying stage should be determined. The water activity range of raisins shall be between 0.51 - 0.62 and level of moisture content should be 12 to 18 % (Bolin 1980; Seçkin & Taşeri 2015). Over 18 % of moisture content is not safe. There will be contaminations such as mould. Raisinis with less than 11 % of moisture content has also not desirable flavor and and gives hard mouth feeling. The best range of moisture content would be 14 to 16 % (Sharma & Somkuwar 2019). Of course raisins and ćupters are not the exactly same product but they are both dried grape products. It was decided to reaching under 0.60 water activity to store the ćupters safely from any contaminations in the research of drying ćupters. As it is decided that at the point of 0.6 water activity ćupters were safe from bacteria, mold or fungi (Farakos et al. 2014).

Ambient temperature, wind velocity, the time under sun, humidity determines the quality of the dried grapes. Berry size and variety of grapes are also quite important facotrs for quality of final product of grape drying process. Smaller berries lose water faster than larger berries thanks to larger area of skin of grape (Sharma 2013). Quality parameters of dried grapes are colour, texture and microbial stability. Moisture content, water activity, skin damage determines the microbial stability. Sulfur dioxide (SO_2) can be used for microbial stability. It works as antioxidant and preserves from microorganismic reactions. It also effects the colour by bleaching. Since the colour of dried grapes is quite important factor for marketing SO_2 is commonly used (Sharma 2013).

The colour of the raisins determines the quality of the final product as well. If it is too dark for consumer desires, it is a highly possible problem for marketingof the product. It should not be over dried and too dark. When it is dried directly under the sunlights, it gets quite dark. The colour of raisins should light and all the berries should have uniform colour. The drying location should be chosen away from water sources and direct sunlight. Also it should be protected during the transport. In this way it is possible to avoid from food looses and undesirable colour changes (Sharma & Somkuwar 2019).

Size of berries and the stage of getting rape of the grapes are also quite important quality parameters. The grapes should be rape enough and size should be uniform. The drying time of the different size grape berries can be different. It effects the quality of the final product. Some will be dried and some will be not yet with different size of grape berries. Small size grapes gives small-sized raisins with shrinkage during drying process (Sharma & Somkuwar 2019). Another quality parameters of final product are cleanliness from dust during transportation and softness of the raisins. Soft texture raisins are more desirable. Hard texture gives an undesirable chewing feeling. Softness is more or less related with the variety of the crop, drying method and moisture content of the final product (Sharma & Somkuwar 2019).

1.5. Solar Drying

Usage of solar radiation for drying is one of the oldest method of solar energy. According to findings, the first installation for drying by solar energy was in South France in about 8000 BC (Belessiotis & Delyannis 2011). Taking advantage of solar radiation for drying is very common. This drying method is used by families or small scale farmers in rural areas for preserving purpose. It is used mostly for domestic up to small scale commercial producers. Nowadays there are industrial solar drying applications also. But it is not still discovered widely. Solar dryers have small capacity but they are more controlled than open sun (Sharma et al. 2009).

Although open sun drying is very common and cost effective method, it causes losses of quatitiy of product by birds, insects etc. It is open the possibilities of dust and dirt from environment. It might be spoiled by rain or lost completely by wind. Regarding to these facts, the quality of dried fruit is most probably decresed by usage of open sun drying (Yaldız & Ertekin 2011).

At the same time solar dryer has advantages of controlling the process of drying. By help of well designed solar dryer, energy efficiency can be increased and controlled all the mandatory requirements for quality. Drying technology should be selected according to the needs of individual farming area. It should be low cost, easy to operate and more effective drying kinetics (Chua & Chou 2003). For instance if the drying time will be shorter with solar dryer, producers would have motivation to install and use this solar dryer. Because shorter drying time means faster result and quikly reach to the consumer in the market. Producer would get benefit from short storage time and avoid any difficulties that would face during the long drying process. Being dependent on the weather is a big disadvantage. As it is mention before, most of the food looses occur post-harvesting stage (Yaldız & Ertekin 2001).

There are many factors in pre-harvesting stage also have effects on drying time and quality of final product. Grapevine producers use the leafs of the grape crop for producing pickled leafs for traditional dish '*sarma/dolma*' in Turkey. Excessive leaf intake, excessive nitrogen in the late period, fertilizer use, irrigation after phenological period, excessive use of hormones, improper agricultural practices have effect on wet and dry crop quality and yield, as well as prolonged the harvest and drying time (Akdeniz 2011).

Solar dryers have more advantages than traditional open sun drying method regarding to control of process with time and energy efficiency and decrease the possibility of contaminations. Although less solar dryer depands on phsical and weather conditions such solar radiation, air velosity, humidity still choosing of proper location and knowlage of practitioner quite important for success. And power supply is stil sun. It still depands on natural solar energy (Eissen 2010; Tiwari 2016). Compared with sun drying, solar dryers can be prefrable. Because solar dryers can produce higher conductive air temperatures and low relative humidity. It would improve the drying rates of dried products and lower final moisture content (Brenndorfer et al. 1985).

1.5.1. Drying Fundamentals

There are two processes take place in a row during the drying of wet solid product. The first one is transfer of heat to change the temperature of wet solid and evaporate the moisture of surface. The second one is moisture transfer from solid to the surface and from surface to the surrounding athmosphere. Drying process leads to physical, chemical and biochemical transformations Some are desirable and some are not (Mujumdar & Devahastin 1997). It is aimed to ensuring keeping the nutritional value at the same level as the fresh food and the appearance of the food is still desirable by consumers. Lastly but not the least, it is aimed that ensuring the safety of storage by evaporation of water and avoid from any contaminations (Rawat 2015).

Transfer of moisture within the solid and mechanism of mass transfer can be explained as:

- Liquid diffusion, when wet solid temperature is under the boiling point of the liquid
- Vapor diffusion, wheather the liquid evaporate
- Knudsen diffusion, if drying happens in the very low temperatures and pressures (in freeze drying)
- Surface diffusion (possible even though not proven)
- Hydrostatic pressure differences, when the internal evaporation rates exceed the transport rate of the steam carried from the solid to the environment

• Combinations of the above mechanisms (Mujumdar& Devahastin 1997)

When there is equal situation between vapor pressure of moisture of the product and vapor pressure the surrending ambient air, it is called the equilibrium moisture content. It means there is an equilibirum between absorption of environmental air moisture contain and moisture desorptation from the product. Actually absorption and adsorption considered as a single process. Relative humidity is called as 'equilibrium relative humidity'. It is defined with moisture content curves against moisture equilibrium isotherms. But this describtion of sorption phenomena is not accepted universally (Belessiotis & Delyannis 2011).

1.5.2. Drying Kinetics

In the drying process, moisture content is the key point in terms of shelf-life time. Formulation of moisture content in wet solid basis is used (Mujumdar & Devahastin 1997) for calculation of moisture content of the dried product. Moisture content is the ration of the difference measured weight in that moment and weight after drying in percentage. Many agricultural products such as vegetables, fruits etc. do not have constant rate. Because the internal heat and mass transfer rates determine how and when the water is ready to evaporate in surface. As long as there is a free water film on the surface, the drying tare will remain within a fixed time (Mujumdar & Devahastin 1997). Equation of moisture content for wet basis is given below (Belessiotis & Delyannis, 2011):

$$MC_{wb} = water(kg)/(\,water(kg) + dry\ product(kg))$$

1.5.3. Direct/Forced Solar Dryer

Basically, there are as generic and sub-groups in total as shortly four types of solar dryers; direct solar dryers, indirect solar dryers, mixed-mode dryers and hybrid solar dryers (Ekechukwu & Norton 1999; Fudholi et al. 2010). It is decided to use direct and forced solar dryer with fans and solar panel in this research.

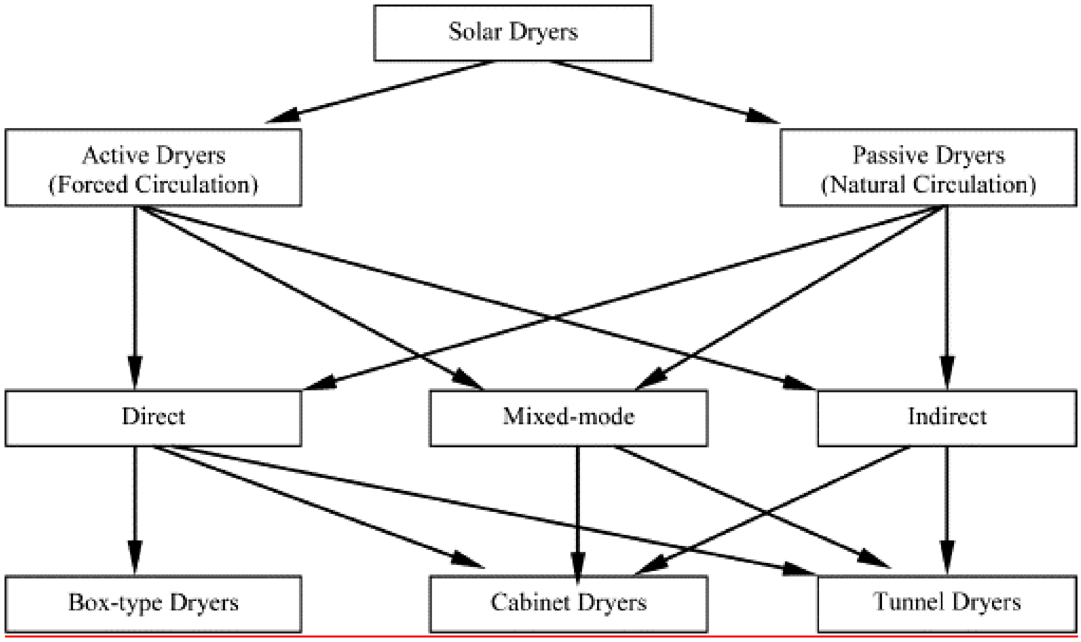

Figure 10. Classification of solar dryers (Augustus Leon et al. 2002)

Active solar drying installations depend on mostly only solar energy. Dehedration by evaporation of water particules occurs with solar energy usage. Fossil fuel based heating system would be used as well. This energy is used for pumps air circulation by helps of fan sor pumps installed (Ekechukwu & Nortan, 1999).

1.6. Frezee Drying

Lyophilization is known a common freeze drying method in the last century. Lyophilization or freeze drying is a procecess can be seen in two steps such as primary drying and secondary drying. Firstly the water in the product will be frozen then it will be sublimed from the product. The main working principle is about sublimation. Water in the product becomes ice by freezing. Then that ice passes directly from solid state to vapor state. It never passing through the liquid state of the product. Once the first fozen process is done from the water of product, this frozen particules are leaving the product by sublimation (Nireesha et al. 2013).

Freeze drying has advantages as minimal chemical decomposition and controlled heating for removal of water only as needed. But it is not easy to apply in developing countires for drying purpose of small scale farmers. It is quite high cost technology and increased handling and processing time is a great disadvantages. Another disadvantages of the lyophilzation is complexity of the process and its consequences on the final product quality and performance of process (Nireesha et al. 2013).

2. Objectives of the Thesis

Main Objective

The main objective of this work was to investigate drying behaviour and sensory properties of Ćupter – the traditional grape sweet from Bosnia and Herzegovina.

Specific Objectives

1. Investigation of three different drying methods open sun drying, solar drying, lyophilisation.
2. Evaluation of drying behaviour of ćupter with respect to used drying method.
3. Comparison of final sensorial properties such as colour, texture, taste and flavor of Ćupter.

3. Materials and Methods

3.1. Grape Samples

In this research Žilavka, Bena and Krkošija species of grapes were used. They were quite common and typical Bosnia and Herzegovinian grape species as mentioned in the introduction part. The grapes were harvested manually on the 25th of September 2019 from the vineyard which belongs to University of Mostar in Bosnia Herzegovina. Immediately after harvesting, stems of grapes were removed and grape berries were pressed and filtred to obtain clear grape juice. Total 10 liters of juice were obtained. Sugar content of the juice was as follows: fructose 8.51 g /100 mL, glucose 5.194 g/mL. The freshly prepared juice was cooked shortly (30 min) to stop the fermentation process. During the cooking process the foam of the grape juice and the natural yeast was cleaned by a spoon for purifying. After that, it was stored into the fridge overnight. Half amount of juice (5 liters) was placed in the freezer for -20 °C for later use (experiment 2), while other half (5 liters) was placed into the fridge overnight for sample preparation in the next day (experiment 1).

Figure 11. Harvested Grapes in the vineyard of University of Mostar

Figure 12. Seperating of Grape Berries from Steams

Figure 13. Phisical Filtering of Grape Juice

3.2. Ćupter Preparation

Ćupter was prepared from the following ingredients:

- 5 litres of clear grape juice
- 500 grams of semolina
- 233 grams almonds (optional)

First of all, 4 litres of grape juice was cooked in a medium heat. Stirring was necessary while cooking. Meanwhile grape juice was almost boiled, the rest of the 1 litre of grape juice was mixed with semolina in another bowl. At this point, it was important to save just a little bit of grape juice only for covering the bottom of the plastic plates where the cupter was later formed. This little amount of grape juice prevents unwanted adhesive/sticky condition. It surved as a middle layer in between ćupter and modules to avoid sticky situation. Mixture of 1litre of grape juice with semolina was mixed into the boiling grape juice and cooked for 5 minutes. After that, ćupter was ready to divide to the plastic plates.

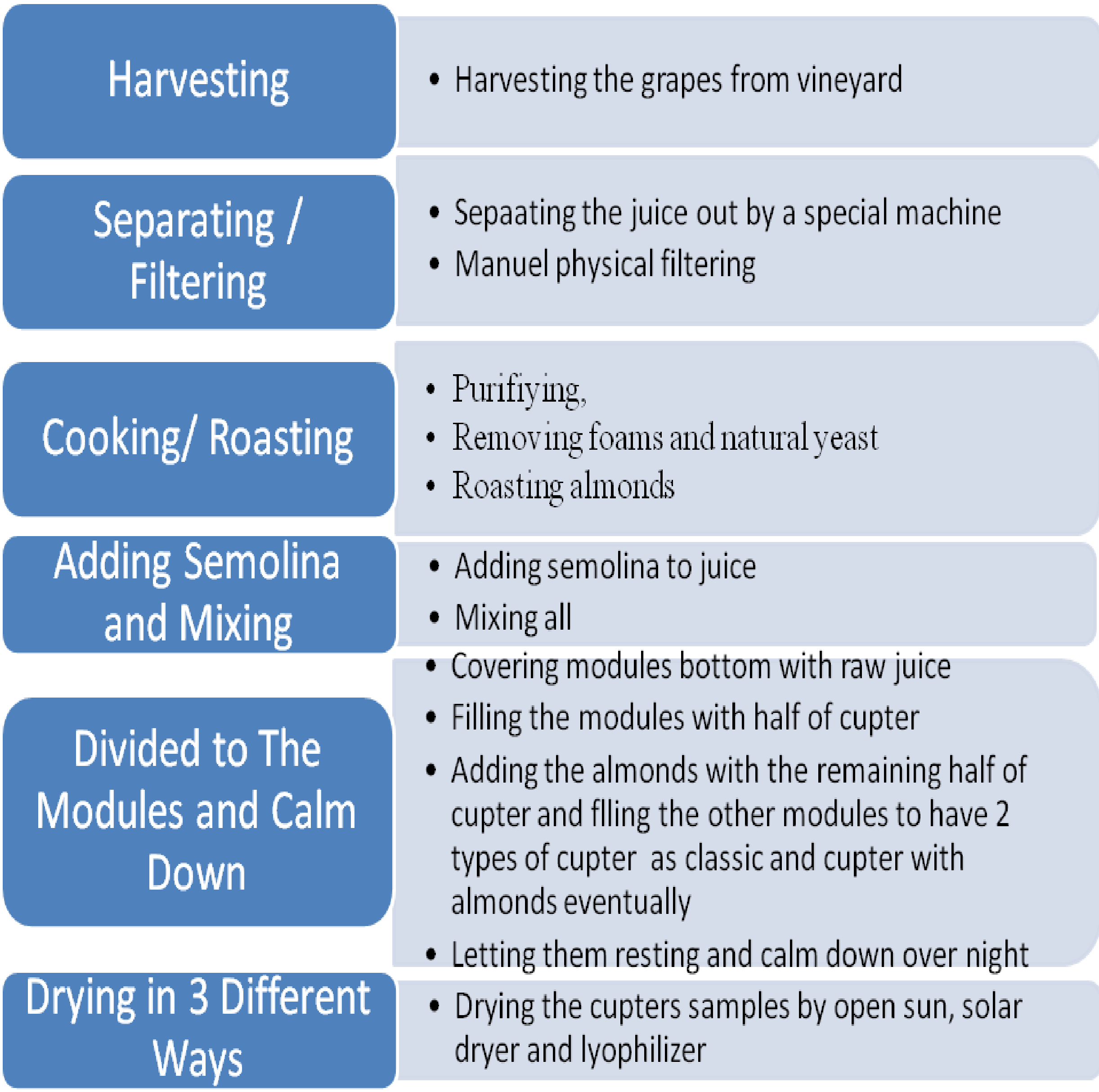

Figure 14. Preparation Steps of Ćupter Drying

Half amount of cooked ćupter was placed in the plastic plates covered by a small amount of grape juice (classic ćupter). Other half of the ćupter was mixed with roasted and chopped almonds (almond ćupter). And again the remaining mixture of ćupter with almonds was put in the plastic plates. The plastic plates were classic medium size plastic one-use plates which were 21 cm diameter. The ćupter rounds were 20cm diameter when the frame of the modules calculated. Totally 8 classic plain ćupter, 10 plates of almond and 5 extra plates of thicker ćupter with almonds (finally not used in rest of the research because of different size) were prepared. Ćupters divided equally in terms of weight but since the almonds increased the volume of the ćupters, we had more ćupters with almonds than classic plain ćupters in the end. The plates were kept under the sun for 30 minutes to shape them quickly then moved back to indoor for overnight to dry them next day.

Next day in the morning, the ćupters were cut into the samples. For instance, one round of sample divided by half to use measuring water availability and colour. And the other half is divided by 3 for measuring the weight. Finally, the samples were labeled as 1, 2 and 3, classic (without almonds) and 1, 2 and 3 samples with almonds, same for open sun, solar dryer, lyophilizer and also as Experiment 1-2. For example; experiment 1- open sun - classic – sample 1.

At least 6 ćupters (classic) + 6 ćupter (almond) were necessary for drying in each experiment. Ćupters divided into 2 classic ćupters + 2 ćupters with almonds for open air sun drying, 2 classic ćupters + 2 ćupters with almonds for solar dryig and 2 classic ćupters + 2 ćupters with almonds for lyophilisation.

3.3. Ćupter Drying

Totally two experiments were carried out at Faculty of Agriculture and Food Technology, University of Mostar. Drying experiments were completed in a row. The first experiment started on 28/09/2019 at 9.00 am and ended 30/09/2019 at 14.00 pm. The second experiment started on 30/09/2019 at 15.00 pm and ended on 4/10/2019 at

15.00 pm. Three drying methods were used for the each experiment. These were sun drying, solar drying and lyophilisation.

Drying of ćupters was carried out in the solar dryer, see Figure 15, designed at the Faculty of Tropical AgriSciences, Czech University of Life Sciences Prague. The dryer is classified as cabinet type forced solar dryer. The dimensions of the dryer were as follows (width x depth x height): 1500 x 500 x 700 mm. The body of the solar dryer was wooden contruction and walls were made from sandwich thermal insulation panels. There was a transparent polycarbonate (4 mm thickness) surface on the top to see sunlight directly. One side was equipped with doors enabling access into the drying chamber. Dryer had a connected solar panel to collect the sunlight for working fan. Air flow is provided by this fan. The calculated power of the fan in proper conditions:1.6 W. Totally two fans were incorporated into the solar dryer. There was no power bank to save energy for later use. It worked only when there was a sunlight. That is the reason why the panel was moved by controller due to the position of the sun during the day. There were two layers of tray made from wood and a plastic, which had temperature resistanciy. It is eligible for food drying process safely.

Figure 15. Solar dryer at University of Mostar

Figure 16. Ćupter inside the solar dryer

Open sun drying as the traditional way of drying ćupter was carried out simultaneously to compare with the solar dryer. Classroom desk was used for this purposes, see Figure 17.

Figure 17. Open sun drying on a desk at University of Mostar

Freeze drying was done in the lyophilizer. Martin Christ Alpha 1-4 LSC basic (Martin Christ Gefriertrocknungsanlagen GmbH, DE). According to pilot research, it was estimated that after 11 hours of freeze drying, water activity of the ćupter samples was 0.6, thus the freeze drying for the research was set up for 11 hours. Due to the specific features of this device, it was not possible to measure the parameters every hour as in the case of solar or open sun drying. Parameters such as weight of 3 reference samples and colour was measured in the beginning and in the end of the freeze drying.

Figure 18. Lyophilizer

Following parameters were measured every hour during solar drying and open sun drying experiments:

- drying air temperature (°C) and drying air relative humidity (RH) (%)- Temperature- Humidity Logger S3121 (Comet System, Czech Republic)

- drying air velocity (m/s) Anemometer Testo 425 (Lenzkirch, Germany)

- weight loss of 3 reference samples of classic ćupter and 3 reference samples of almond ćupter (g)- Balance Kern 572-30(Kern&Sohn GmbH)

- ambient air temperature (°C) and ambient air RH (%)-Temperature- Humidity Logger S3121 (Comet System, Czech Republic)

- global solar radiation (W/m^2)- Solarimeter SL 100 (KIMO instruments, France)

- water activity of 3 reference samples of classic cupter and 3 reference samples of almond cupter- Pawkit (Decagon Devices Inc, USA)

Figure 19. Measurement desk

Once the ćupter samples were reached water activity 0.6, ćupters were ready to serve or store. It was the safe level of water activity to avoid any contaminants such as bacteria, mould, fungi etc.

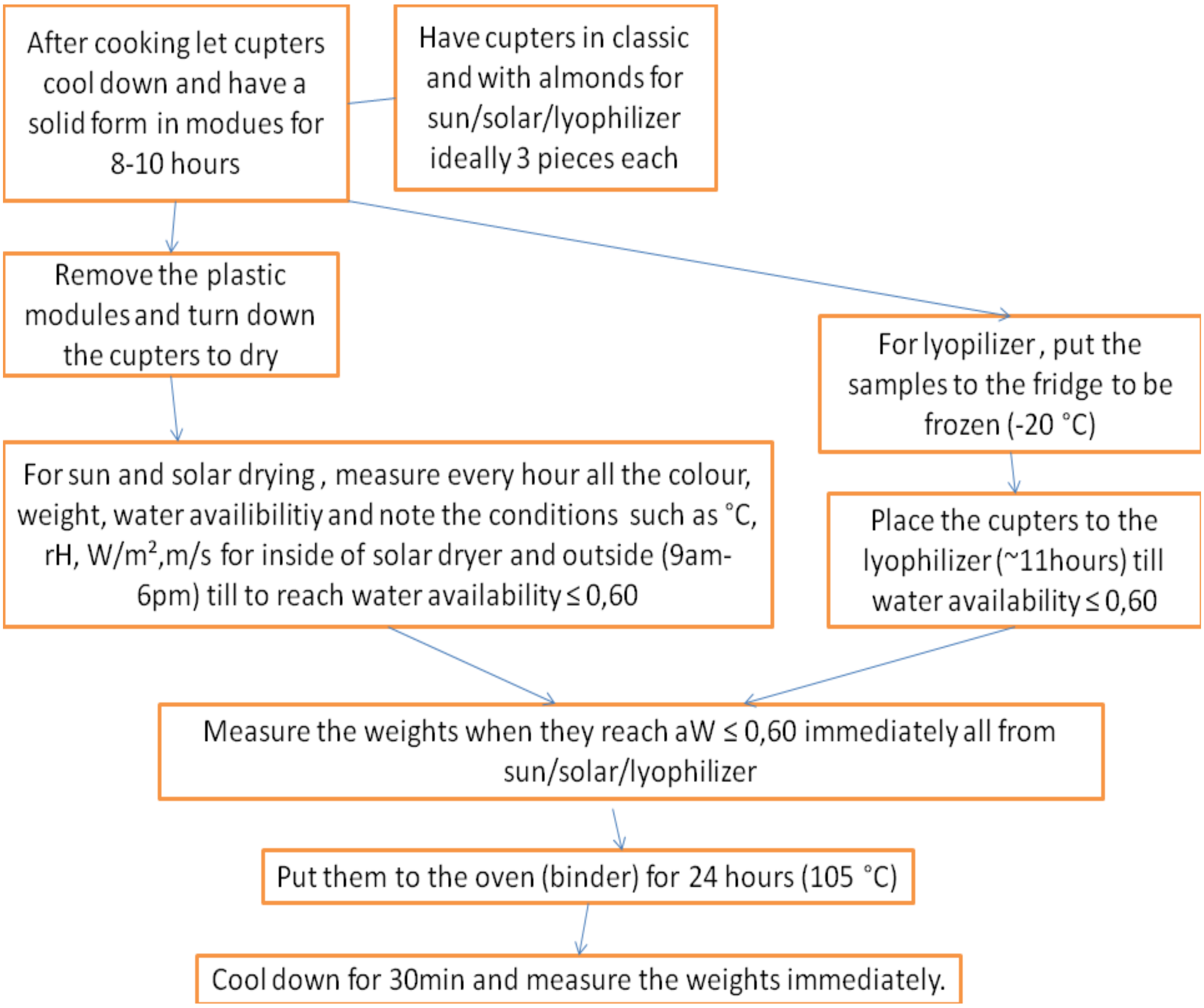

Figure 20. Action Flowchart of Ćupter Drying

3.3.1. Moisture Content

The most important indicator of qualified drying process calculating was the moisture content. At the end of each drying test in the solar dryer, open sun and lyophilizer the reference samples were collected in triplicates and dry matter content was estimated by the oven method 105°C for 24 h (Memmert UFE 500 GmbH + Co. KG, Germany). Following equation was used to estimate dry matter content on a wet basis (Belassiotis & Delyannis 2011).

$$MC_{wb} = \frac{water\ (g)}{water\ (g) + dry\ \acute{c}upter\ (g)}$$

It can be only calculeted by the end of the whole process of drying experiment. To determine how long it needs to be dried, it was decided to reach acceptable level of water acticity as a guide parameter. It was decided to reach 0.6 of water activity which is safe from bacteria, mold or fungi by research supervisiors. Since there was not published any ariticle about ćupter drying, decision was given by comparing with closest dried grape sweet products such as raisins, pestil.

The water activity range of raisins shall be between 0.51 - 0.62 and level range of moisture content should be % 12 to 18 (Bolin 1980). Raisins and ćupters are not the exactly same product but anyways they are both dried grape products. It was decided to store the ćupters safely from any contaminations at that point about 0.6 water activity to avoid from bacteria, mold or fungi.

Once the ćupter samples were reached 0.60 water activity in the end of the process, the measurents were checked couple times to be sure that all the parts of ćupter had similar results. All the types of ćupters were controlled with double checking because not every single part of sample can be exactly same in terms of moisture. The edges were more dry then the middle part naturally. Eventually each samples of ćupters had reached the 0.60 water activity after 23 hours of drying for the first experiment and 36 hours of drying for the second experiment.

In addition to water activity, there were also solar raditon, ambient temperature, temperature of inside the solar panel, relative humidity, air velocity, weights, colour of the samples measured every hour from 9 am till 6 pm. Measurements were noted on the paper protocol of the ćupter drying experiment. All the measurements were also typed on Microsoft Office Excel 2007 with respect to the paper protocol. This raw data has been used to create the graphs and tables and later on statistical analysis as mentioned in the results chapter.

3.5. Sensory Analysis

Two independent panels, first of 20 assessors from Faculty of Agrobiology and Faculty of Tropical AgriSciences, CZU in Prague and second of 20 assessors from

Faculty of Agriculture and Food Technology, University of Mostar, were organized in October 2019. Assessors were trained and evaluated the samples of ćupters submitted on a Petri dishes labelled by 3-digit code. Profile method with unstructured graphic scale was used. Following parameters for evaluation were used: general look, general taste, intensity of taste, sweetness, sourness, smell, colour intensity, colour likableness, hardness, chewiness, juiciness and description of off taste or after taste. Form for sensory analysis see in Annex. Assessors in University of Mostar had the translated version in their local language with the same form of questionnaire. All assessors rated the samples in a scale from 1(extremely dislike) to 9 (extremely like) on the evaluation form given.

3.5.1 Colour

The colour of both classic and almond ćupter samples were measured with a spectrophotometer CM-2600d (MINOLTA) in the CIE L* a* b* color space. L * a * b * are used to symbolised colours; L * lightness, a * red / green value and b * yellow / blue shows the value (Krokida et al. 2008). The colour were measured 3 times in case of classic ćupter and 5 times in case of almond ćupter. To evaluate the effect of different drying procedure on the overall combined colour of ćupter, colour change ΔE is given by the formula (Chua et al. 2000).

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

where $\Delta L = L - L_{base}$

$\Delta a = a - a_{base}$

$\Delta b = b - b_{base}$

L, *a* and *b*= colours coordinates of the sample

L_{base}, a_{base} and b_{base} = color coordinates of the ćupter sample before drying

3.6. Statistical Analysis

Data were statistically analysed with IBM SPSS Software. One-way Anova test with post hoc Tukey test was used for analysing results. Microsoft Office Excel 2007 was used for T-test.

4. Results and Discussion

4.1.Drying Performance Comparison of Ćupters with Open Sun Drying, Solar Drying and Lyophilizer

As it is clear from the Table 1. There is a difference between climatic conditions of experiment 1 and 2. The values of mean ambient temperature, RH and solar radiation during the first experiment were 27.4 °C, 46.46 % and 435.78 W/m², respectively. The values of mean ambient temperature, relative humidity and solar radiation during the second experiment were 24.67 °C, 52.16 % and 244.63 W/m², respectively. Further the values of mean drying air temperature, drying air relative humidity and mean drying air velocity during the first solar experiment were 31.96 °C, 36.26 % and 2.08 m/s, respectively. And last but not least the values of mean drying air temperature, drying air relative humidity and mean drying air velocity during the second solar experiment were 26.88 °C, 46.97 % and 1.39 m/s, respectively.

Table. 1. Overall climatic and drying conditions during experiments

Experiment 1								Experiment 2							
Ambient Temperature (°C)				Drying Chamber Air Temperature (°C)				Ambient Temperature (°C)				Drying Chamber Air Temperature (°C)			
Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
27.4	4.19	33.9	19.8	31.96	6.83	49.5	19.4	24.67	5.21	39.9	15.4	26.88	5.99	41.3	19
Ambient Relative Humidity (%)				Drying Chamber Relative Humidity (%)				Ambient Relative Humidity (%)				Drying Chamber Relative Humidity (%)			
Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
46.46	11.17	69.5	21.7	36.26	13.7	66.2	15	52.16	13.08	78.2	31.5	46.97	16.45	71.8	20.6
Ambient Air Velocity (m/s)				Air Velocity Inside Chamber (m/S)				Ambient Air Velocity (m/S)				Air Velocity Inside Chamber (m/S)			
Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
0.39	0.22	0.96	0.14	2.08	1.58	4.05	0.13	0.36	0.31	1.13	0.05	1.39	1.95	9.37	0.05
Solar Radiation (W/m^2)								Solar Radiation (W/m^2)							
Mean	SD	Max	Min					Mean	SD	Max	Min				
435.78	276.92	780	25					244.63	282.49	753	1				

The ambient temperature, ambient relative humidity and solar radiation curves are presented in Figure 21 for solar drying experiment 1 and in Figure 23 for experiment 2. The daily mean values of the drying chamber temperature, drying chamber relative humidity and drying air velocity are presented in Figure 22 and 24 respectively for experiment 1 and 2. From these figures, it is evident that high solar radiation corresponds to high drying temperature and low relative humidity of the drying air.

The maximum values of solar radiaton for both of the experiments were quite close to each other. They were 780 W/m², and 753 W/m² respectively. But the means of the solar radiaton for experiment 1 and 2 were 435.78 W/m² and 244.6 W/m² respectively. This difference caused different drying times and effected to performance of solar dryer. The first experiment took 20 hours long and the second experiment took 36 hours long.

The daily mean values of ambient air velocity were quite close to each other. They were 0.39 m/s for the first experiment and 0.36 m/s for the second experiment. But there was relatively large difference between the mean values of drying air velocity of experiment 1 and 2 because of the weather conditions. The mean values of the drying air velocity were 2.08 m/s and 1.39 m/s respectively. The fans which created the air flow inside of the solar dryer were connected to the solar panel. There was no regulatory system which would regulates the air flow itself due to the position of the sun during the day neither another energy resources would work when there is no enough sunlight.

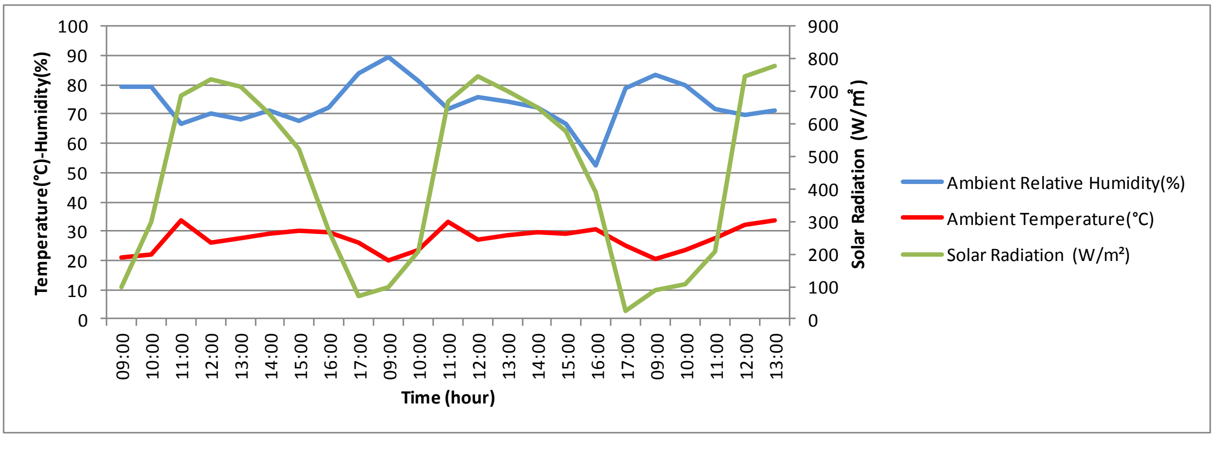

Figure 21. Ambient temperature, ambient relative humidity and solar radiation, experiment 1

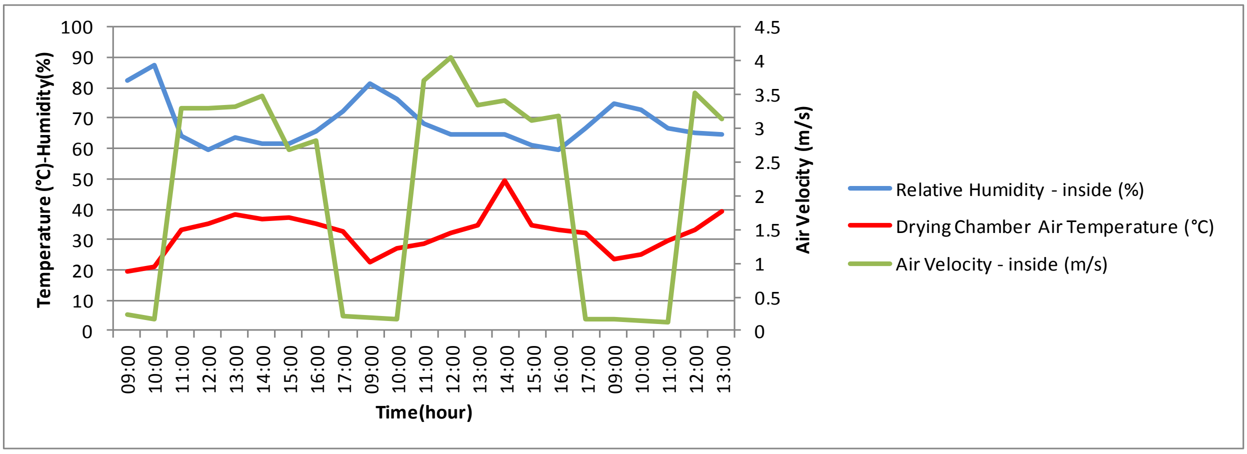

Figure 22. Drying chamber air temperature, relative humidity and air velocity, experiment 1

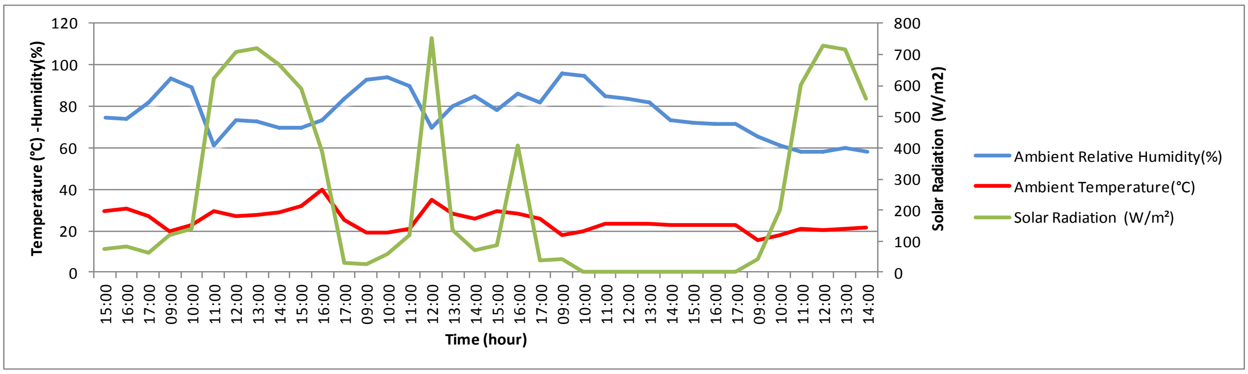

Figure 23. Ambient temperature, ambient relative humidity and solar radiation, experiment 2

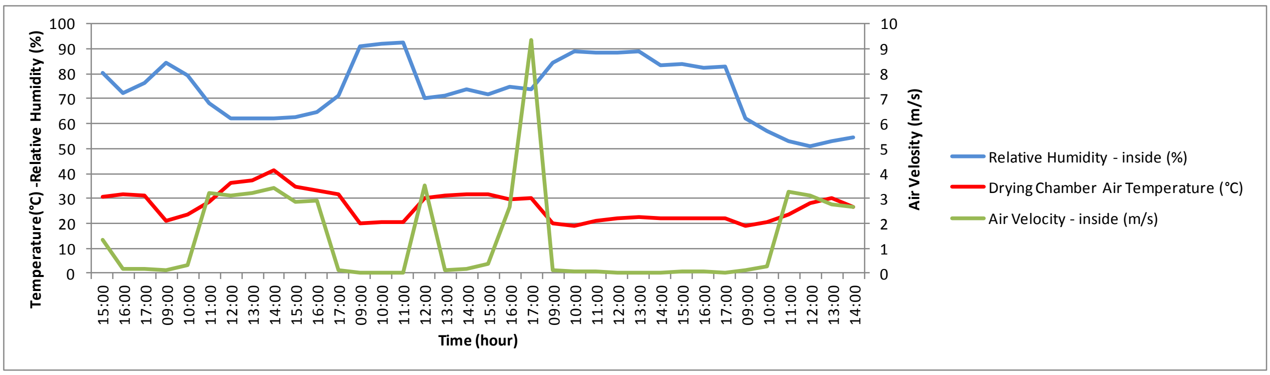

Figure 24. Drying chamber air temperature, relative humidity and air velocity, experiment 2

It is clear from the Figure 22 and 24 that drying air velocity of the first experiment was better than the second experiment. Beacuse there was better ambient air velocity during the first experiment. But as opposite to this, the relative humidity curve of the first experiment seems alike to the relative humidity curve of the second experiment. Because of the heavy rain, thunderstroms it was a must to move all the drying equipments to indoor. The fans of the solar drying did not work at all for some times in the second experiment. It is also visible in the solar radiation comparison. In general if the fans would work properly the drying time of the solar dryer would be much shorter (Yaldız et al. 2001).

But there are some other researches proved there would be no significant difference in the different weather conditions. The weather conditions such as the sushine hours, daytime temperature and relative humidity did not have significant difference on drying of cassava chips in humid zone (Olufayo & Ogunkunle 1996). It might be no significant difference because it was a humid zone. The location that drying ćupter experiment carried is a Mediterranean climate zone. There was heavy rain and thunderstroms. The difference of the climatic conditions were quite different.

For avoiding the negative effects of the weather conditions, a hybrid system would be a solution to the solar dryer work during the nights and cloudy rainy days (Thanaraj et al. 2004). It would have extra cost to the producing. It should be decided wisely with benefits of the final quality of the product and effects on the access to the market. Some simple good designs with using unexpensive and locally available materials would be benefiticial to the final product quality and make the process easier for the producers. In small scale farmers it would be preferable (Sharma et al. 1995). The cost of the designed solar dryer and the effects on the final product should be calculated well according to needs of the producer and the available conditions. The type of solar drying method to be used should be decided with some points taken into account. Some of them are quantitiy of the product, drying time available to operate and availablity of researces included technical skills, unexpensive materials, the source of power and durabilty of the design (Sharma et al. 1995).

4.2. Moisture Content and Drying Curves

Moisture content of the ćupter samples was calculated with given equation. There were information of what shall be the moisture content of raisins, pestils and köme in the literature. Raisins 12-18 % and pestil 12 % and köme 19-21 % (Bolin 1980; Maskan et al. 2002; Bayram 2018). Ćupter, as it is mention detailed in the literature reviews, is different product than the other dried grape products. Ćupter is a jelly and it has a softer texture than a pestil or köme. But there is no scientific information found about what the safe moisture content for ćupter. That is why it is decided to reach similar moisture content. It is decided to stop drying experiments when samples reached below 0.6 water activity. In this way it is calculeted the moisture content of ćupter in wet basis.

Final moisture content was higher than as expected. It might cause some contaminatons in this range of mositure content. Dryin process could continue to dry the ćupters, but the water activity had reached the agreed level. In addition, the local society, which knows the ćupter, stated that the grapes seem dried enough, and that they are normally served as it was. On the other hand, if the dried grape product –raisins, ćupter etc.- is too dried, then it is not desirable neither. That is why experiments has been stopped in the lights of these findings.

Every different product has different drying process. The thickness of a product has a great impact on drying time to reach moisture content to the desired level (Olufaya & Ogunkunle 1996). For instance because of the drying shape of product pestil would have shorter drying time. Because it has thinner drying and serving shape. Thinner samples of pestil have shorter time of drying and higher drying rates (Maskan et al. 2002). Solar drying is more preferable than natural sun drying for grape drying process in other researchs too. Concerning the final moisture attained for grape samples, solar drying is more efficient (Gallali et al. 2000).

Drying curves (time versus moisture content) of sun drying and solar drying methods in the type of classic and with almonds samples are presented in Figure 25 and 26 for experiment 1 and 2. Values of moisture content of ćupter samples were analyzed using ttest on Microsoft Office Excel 2007. There is statistically significant difference in between sun drying method and solar drying method for both of the experiments. Results of the moisture content calculations has also significant different between the types of ćupters mostly (Table 2). It means from statistical point of view, it is possible to conclude that the drying behaviors of ćupters with sun drying and solar drying differce. Also adding almonds to the ćupter has effects on the drying process. In the first experiment there is not significant difference between classic ćupter and ćupter with almonds with sun drying method. But the rest of the results shows us, there is statistically significant difference.

From Figure 25 and Table 2 it is evident that solar drying method has better drying behavior than sun drying even though the results seemed slightly different from the drying curves. It means that solar dryer method is more efficient than open sun drying due to drying behavior (Chua & Chou 2003) Solar dryer has more advantages than traditional open sun drying method regarding to control of process with time and energy efficiency. Although less solar dryer depands on phsical and weather conditions such solar radiation, air velosity, humidity still choosing of proper location and knowlage of practitioner quite important for success. But of course its power supply is still sun. It still depands on natural solar energy (Eissen et al. 2010; Tiwari 2016). For example the drying curves in the second experiment have more flat due to weather conditions. It would be even faster drying time if there would be enough sunlight to run fans. (Figure 26) Drying rates at the earlier stages are higher and then drying rates are decreased at the later stages of drying. It might be about initial stages of drying process and then falling rate period of typical resulting in difficult movement of water from the interior part of the drying product (Mujumdar & Devahastin 1997; Nathakaranakule *et al.* 2007). It is slightly visible in the Figure 25 and 26. Focusing on the overall progress of the drying curves, these results would proved this argument.

Table 2. All pairwise comparison of moisture content between drying methods and types of ćupters used (p<0.05)

Experiment 1		
sun classic	solar classic	**significant**
sun almond	solar almond	**significant**
sun classic	sun almond	**not significant**
solar classic	solar almond	**significant**
Experiment 2		
sun classic	solar classic	**significant**
sun almond	solar almond	**significant**
sun classic	sun almond	**significant**
solar classic	solar almond	**significant**

The average initial and final moisture contents of ćupter samples are 51.86 %, 49.47 %, 53.28 %, 49.81 % and 16.35 %, 20.97 %, 17.93 %, 18.35 % for the first experiment of sun classic, sun almonds, solar classic and solar almonds respectively. the mean values of initial and final moisture content of ćupter samples are 67.27%, 60.37 %, 65.42 %, 59.99 % and 26.32 %, 21.61 %, 20.69 %, 18.92 % for the second experiment of sun classic, sun almonds, solar classic and solar almonds respectively. From these results it is clear that drying rate was higher in the solar drying method than open sun drying method. It is quite visible in the second experiment and sligtly but still visible in the first experiment. This fact was confirmed by a comparison procedure, which was used to analyze the influence of drying methods on the moisture content of dried ćupter types classic and with almonds. Data were tested with the t-test as the pairwise comparison procedure. The results are summarized in Table 2. From this table is evident that there are a statistically significant differences in moisture content between the open sun drying and solar drying. These findings correspond to the results of similar studies where the effects of different methods of drying used drying behavior (Eissen et al. 2010; Tiwari 2016).

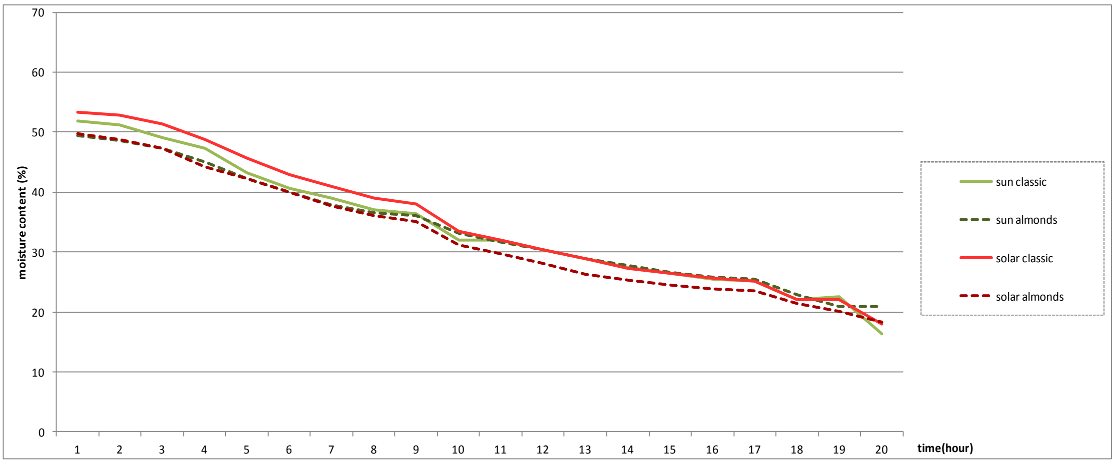

Figure 25. Drying Curves, Experiment 1

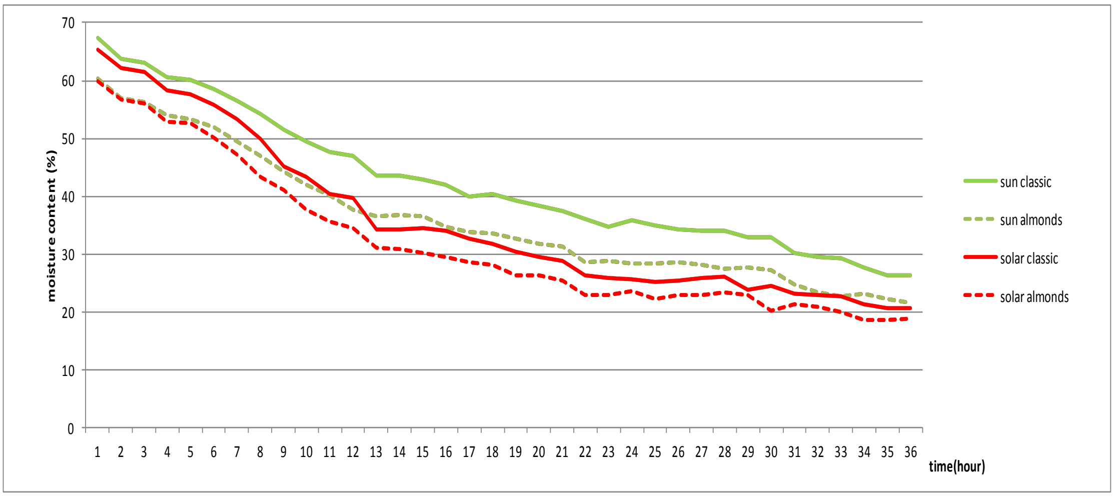

Figure 26. Drying Curves, Experiment 2

The drying from the surface of the product intermitted during the night times when there is no sunlight till the next day. The surface moisture content decreased during the day. The heat transfer and the mass-transfer rates at the surface controls the drying during the day and night times (Baini & Langrish 2007). İncreasing the surface moisture content or getting dry slower in this time of the drying process is connected with the internal diffusion. It is the moisture moves from iner wet region of the ćupters to the surface. When the fans of the solar dryer off, humidity of the surranding atmoshere increased. It has great impact on the drying rate and as a result effected to the drying curves.

4.3. Sensory Analysis and Colour Change

The results of the sensory panels for Mostar and Prague are shown in Figure 27. and 28. It was important to have sensory analysis in Mostar as the city ćupters are respectively known and Prague where ćupter is not known. This sensory panel aimed to investigate if different drying methods (sun drying and solar drying and lyophilizer) and different kind of ćupter (with and without almonds) can influence the results of sensory profile analysis. In Mostar, there was no samples from lyophilizer only sun drying and solar drying samples were there.

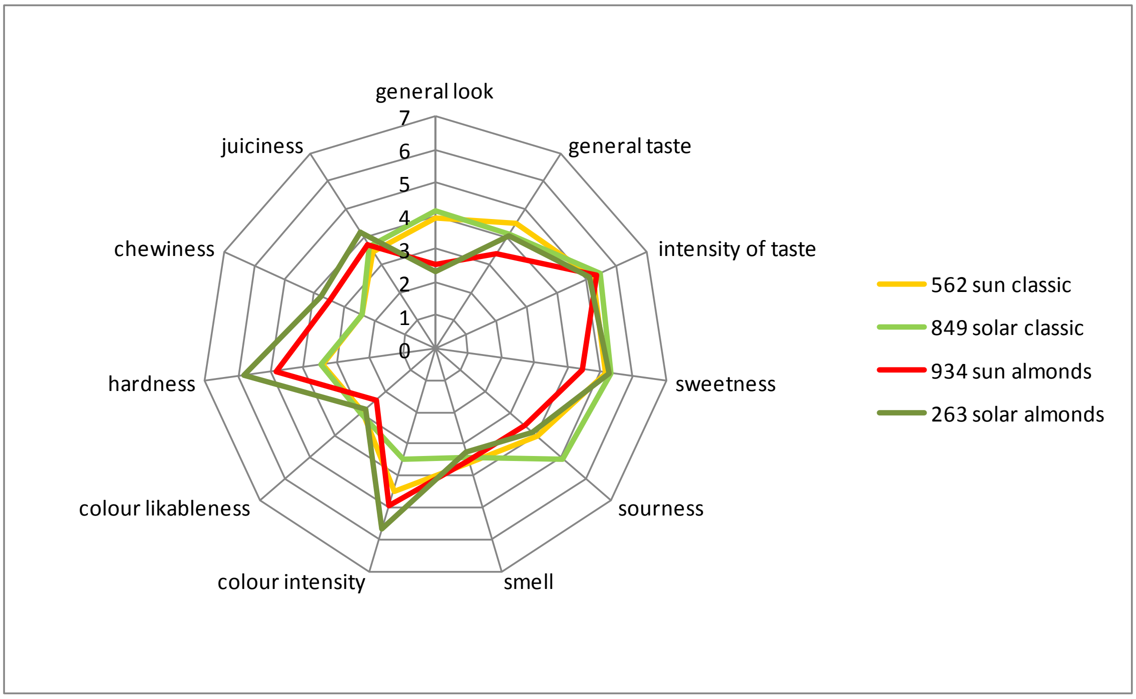

Figure 27. Spider diagram of sensory profiling of ćupter samples in Mostar

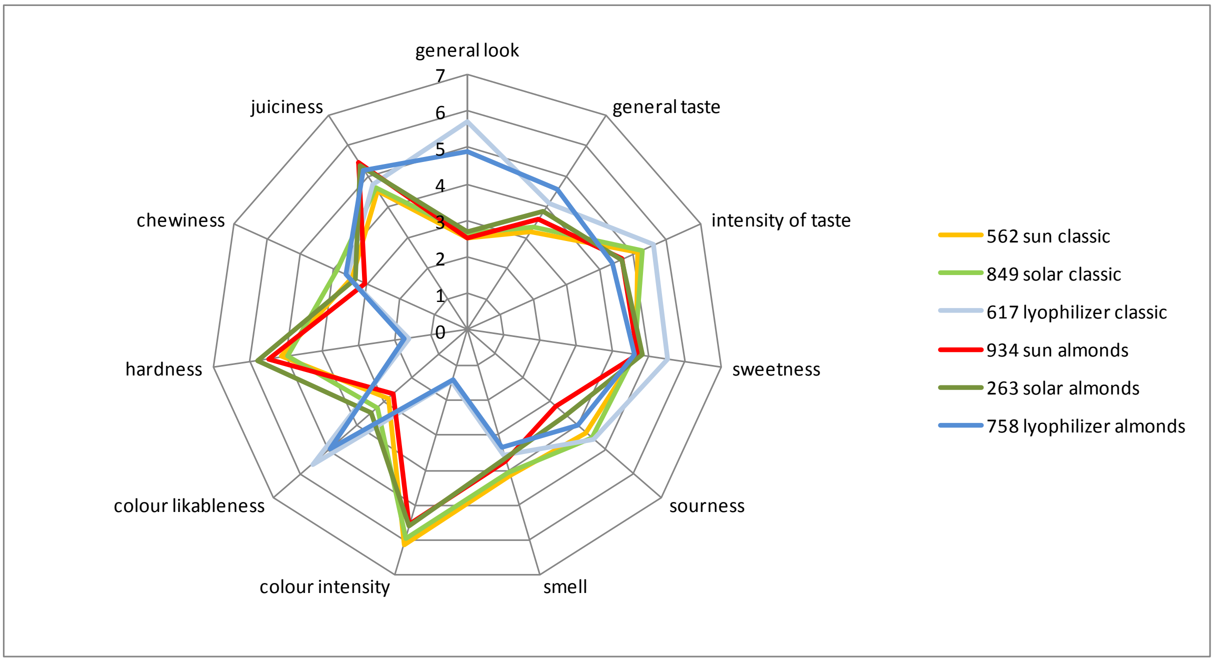

Figure 28. Spider diagram of sensory profiling of ćupter samples in Prague

As it is clear from the spider figures of sensory analysis (Figure 27 and 28) and tables (Table 3 and 4), analysis goes from like to dislike, not intensive to very intensive, light to dark, excellent to very bad with the numbering from zero (0) to seven (7) respectively. It means more as the number gets greater that sample is darker, more disliked, more intensive, more sweet or more sour depends on the parameters.

The results of the sensory profile analysis for the parameters as general look, general taste, intensity of taste, sweetness, sourness, smell, colour likableness, chewiness, juiciness showed that there is not significant difference between the drying methods sun drying and solar drying and also not significant difference in types of ćupter according the assessors from Mostar and Prague. Addtion to this, the assessors from Prague also agreed that there is not significant difference between the samples due to parameter of hardness. This shows us solar drying can be used for ćupter drying process. It gives the desirable results as traditional open sun drying method.

The colour intensity parameters of sun drying and solar drying are not significantly different. But the types of ćupter have different results. Adding almonds to the ćupter which dried with solar dryer has impact on the results significantly. There (p < 0.05) were found. But the difference is not significant for sun drying according to the assessors in Mostar. Even though colour intensity of ćupters with almonds and without almonds different in the case of solar drying, the assestors from Mostar liked the all samples of ćupters in same level. The colour likebleness of samples are not significantly different according to the Mostar participants.

On the other hand assessors could not distinguish the differences of juiciness related with moisture content. The moisture contents are slightly higher in the samples with almonds than the ćupters without almonds in the first experiment. But the moisture content of the ćupters without almonds are relatively higher than the ones with almonds in the second experiment. The samples were served from mixed of both experiments.

Table 3. Overall sensory evaluation of ćupter samples in Mostar

	Sun Classic		Solar Classic		Sun Almonds		Solar Almonds	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
General Look	3.92[a]	2.57	4.13[a]	2.7	2.50[a]	1.26	2.29[a]	2.23
General Taste	4.48[a]	2.64	4.07[a]	2.37	3.37[a]	2.24	4.05[a]	2.63
Intensity of Taste	5.23[a]	2.5	5.45[a]	2.45	5.32[a]	2.12	5.12[a]	2.13
Sweetness	5.19[a]	1.76	5.34[a]	2.46	4.47[a]	2.03	5.27[a]	2.29
Sourness	4.03[a]	2.04	5.07[a]	2.05	3.56[a]	2.06	3.82[a]	2.12
Smell	3.56[a]	2.06	3.4[a]	1.91	3.52[a]	2.3	3.23[a]	2.34
Colour Intensity	4.48[ab]	1.71	3.46[a]	1.42	4.92[b]	1.69	5.68[b]	1.81
Colour Likableness	2.91[a]	2.23	2.97[a]	2.24	2.38[a]	1.52	2.76[a]	2.26
Hardness	3.41[a]	2.08	3.5[a]	1.92	4.86[ab]	1.92	5.84[b]	2.08
Chewiness	2.42[a]	2.34	2.42[a]	2.22	3.5[a]	2.37	3.81[a]	2.83
Juiciness	3.44[a]	2.04	3.67[a]	2.53	3.74[a]	2.19	4.18[a]	3.26

Moreover, the ćupters dried with lyophilizer method were tested in sensory analysis in Prague. This comparision of three different methods of drying and two different types of ćupters shows us, general look and colour likebleness of ćupter which dried with the lyophilizer are significantly different then the other methods. Lyophilizer dried ćupter with almonds has statistically significant difference in terms of the colour likeableness parameters if we compare with traditional open sun dried ćupter.

Hardness of the lyophilizer ones significantly different to the other drying method ones. They have softer texture than the traditional open sun drying and solar drying. Lyophilizer dried ćupters do not have the jelly-like texture of the traditional ćupter. The lyophilizer ones have less intense colour. Lyophilizer has the least desirable texture in terms of hardness and also general look parameters. There is no significant difference between sun drying, solar drying and lyophilizer in terms of some parameters such as smell, sourness and sweetness.

Table 4. Overall sensory evaluation of ćupter samples in Prague

	Sun Classic		Solar Classic		Sun Almonds		Solar Almonds		Lyophilizer Classic		Lyophilizer Almonds	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
General Look	2.50^{a}	1.5	2.65^{a}	1.46	2.53^{a}	1.75	2.67^{a}	1.69	5.69^{b}	2.23	4.87^{b}	2.57
General Taste	3.18^{a}	2.37	3.35^{a}	2.35	3.62^{a}	2.42	3.87^{a}	2.68	4.13^{a}	2.75	4.56^{a}	3.04
Intensity of Taste	5.13^{a}	2.39	5.24^{a}	2.16	4.67^{a}	2.61	4.64^{a}	2.04	5.61^{a}	2.14	4.35^{a}	2.42
Sweetness	4.66^{a}	2.03	4.62^{a}	1.67	4.69^{a}	1.44	4.82^{a}	2.17	5.53^{a}	2.08	4.63^{a}	2.76
Sourness	4.31^{a}	2.37	4.50^{a}	2.08	3.18^{a}	1.83	3.56^{a}	2.23	4.59^{a}	2.19	4.01^{a}	2.46
Smell	4.15^{a}	1.97	4.06^{a}	1.89	3.74^{a}	1.97	3.67^{a}	1.96	3.56^{a}	2.07	3.34^{a}	1.66
Colour Intensity	6.11^{b}	1.84	5.94^{b}	2.09	5.54^{b}	1.86	5.59^{b}	2.14	1.47^{a}	1.06	1.4^{a}	1.11
Colour Likableness	2.85^{a}	1.7	3.26^{ab}	1.67	2.69^{a}	1.65	3.47^{ab}	2.35	5.59^{c}	2.54	4.96^{bc}	2.81
Hardness	5.14^{b}	2.23	4.95^{b}	1.92	5.45^{b}	1.9	5.78^{b}	2	1.59^{a}	1.25	1.73^{a}	1.66
Chewiness	3.44^{a}	2.5	3.92^{a}	2.48	3.07^{a}	1.61	3.34^{a}	2.24	3.58^{a}	3.42	3.63^{a}	3.03
Juiciness	4.55^{a}	2.44	4.61^{a}	2.07	5.45^{a}	1.9	5.35^{a}	1.98	4.74^{a}	3.11	5.2^{a}	2.01

Solar dryer is better and preferable method of drying compared with open sun drying in generally speaking. It is proved by many researches tried with different fruits and vegetables (Gallali et al. 2000). Solar drying is an important method of preservation especially because of the economic and ecologic effects considered.

L * a * b * are used to sembolised colours; L * lightness, a * red / green value and b * yellow / blue shows the value (Krokida et al. 2008). Colour characteristics were studied to put forth the difference of the different drying methods of ćupter. A comparison of color measured by spectrophotometer of drying methods of ćupters with and without almonds is presented in Figure 29 and 30 for experiment 1 and 2.

The color change of the sun dried ćupter is more evident than the solar dried ones in the first experiment. In the second experiment, the colour change of the solar dried ones is higher than the sun dried one. There is higher colour change difference in the sun dried ćupters with almonds. Thus, it is evident that type of dryer and adding almonds can influence the final color of the product.

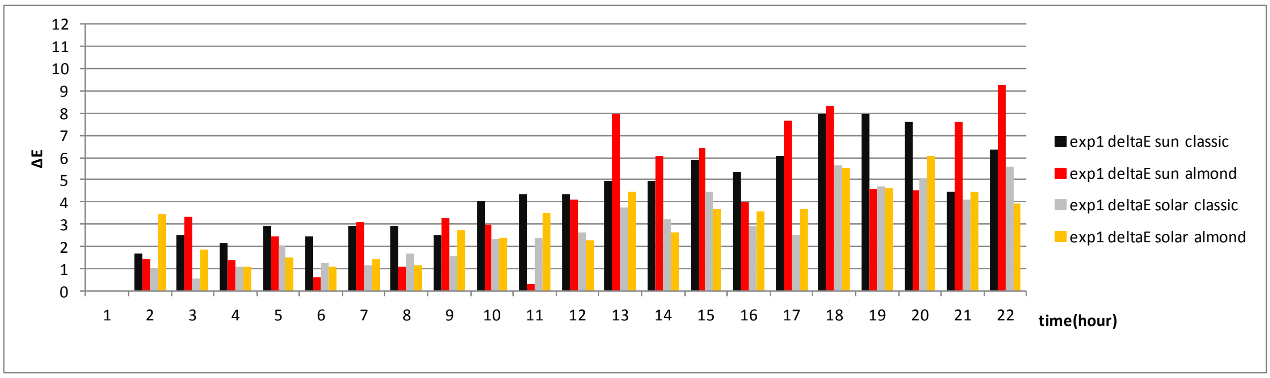

Figure 29. Total colour difference ΔE, experiment 1

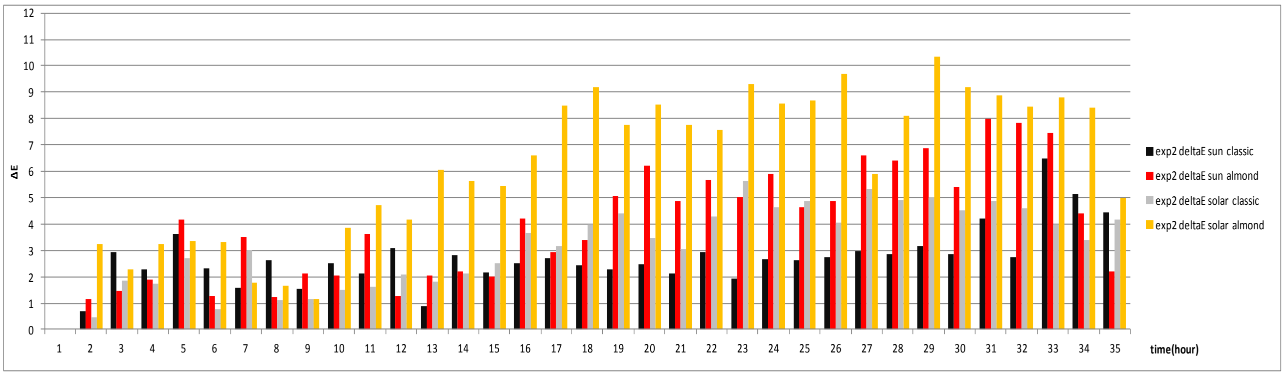

Figure 30. Total colour difference ΔE, experiment 2

The ćupters dried with freeze drying have lighten colour. It can be understood even by visual seeing. Because they did not see the sunlight and the pigments did not change much as the one dried with solar radiations. But as it is clear from the Figure 29 and Table 4, the freeze dried ćupters are the least favourable ones with regard to general look, general taste, colour likableness.

For raisins the colour is a important quality parameter and it should be avoid to have dark colour with exposure of sunlight in solar drying (Sharma & Somkuwar 2019). In case of the ćupters, sensory analysis shows that assessors like more the sun dired and solar dried ćupters than freeze dried ćupters. It is clear from the Figure 29 and Table 4 that even though the ćupters dried with freeze drying have lighter colour than the sun and solar dried ćupters, freeze dried ones are the least favourable according to sensory analysis.

Most desirable raisins have a soft texture (Sharma & Somkuwar 2019). In case of ćupters, the ćupters dried with freeze drying have softer texture but again they are not as desirable as the sun and solar dried ćupters. The freeze drying with lyophilizer did not give us a desirable results as traditional ćupters. The freeze dried ćupters are not favourable even though there is no significant difference between freeze drying, sun drying and solar drying regarding to general taste. The final product must meet all desired quality parameters such as taste, colour, texture etc. The sensory analysis on ćupters showed us this clearly.

4.4. Limitations and Recommendations

All the drying process was planned to be done at the campus of the University of Mostar. It was assumed to measure drying behaviours of ćupters excluding the time after 6 pm till other day 9 am for both two experiments. But there were some difficulties with weather conditions such as heavy rain, thunderstorm and lack of sunlight during the experiments especially in the second experiment as you can see from the pictures attached.

As it is seen in the pictures, because of the physical difficulties, it was not possible to move the solar dryer as it should be every hour. It was too heavy to carry by one person alone. On week days help was asked from other students and lecturers but on weekend the dryer was not moved.

It was already known that it is necessary to choose the place wisely. Optimal place to observe maximum sunlight was chosen. But the place where the dryer was in the garden surrounded by walls, buildings, trees and cars around. After 4.30 pm there was no direct sunlight anymore even though sunset time was quite later. The place is not enough sunny to make solar dryer work properly and constantly. Air fan of the solar dryer works only when there is sunlight to the solar panel. It was necessary to replace solar dryer and solar panel manually every 10 minutes to sunnier direction. It extended the drying time because of lack of enough sunlight. The open air sun drying table was much more easier to replace, that's why it is moved according to sunward. It affected the result of drying process. It is also possible to have external power supply or some batteries to fill the energy during the days and use it during the nights when there is no sunlight to continue drying process. The solar dryer would be upgraded in this way. But of course it means get cost higher. The calculation should be done wisely.

Drying experiments were approximately 3-4 drying days for open sun dry and solar drying. Solar drying was faster than open sun relatively. The fastest one was lyophilizer. It was not known how long it would take to dry ćupters in lyophilizer. Because there was no any other research published about how to dry ćupters. Therefore it was necessery to stop the lyophilizer machine in some certain hour periods for checking. Stopping machine and starting it again -including warming up the machine for 30 min- were consumed more time than a proper lyopilizer drying. This lack of literature researhes leaded us to decide about when it is time to stop drying. It is decided to stop drying when sample reaches below 0.6 water activity comparing with the other dried grape products such as raisins, pestil and köme. Also the comumnity of local people was agreed that our dried ćupters were seemed to be ready in terms of look and texture. Data of water activity is only informatic measurement to calculate moisture content. Eventually the final moisture content of the samples was higher than as expected. The drying process could be extended to reach safer moisture content for shelf-life of the final product. But it was impossible to know the moisture content before stop drying. They were successful experiments as the first attempt to understand the deep knowledge of ćupter drying and show the drying kinetics in a scientific research. But choosing longer drying time and choosing the drying place wisely would be recommendations for future researchs.

While drying process, all the measurements of parameters were noted by each hour carefully and immediately every hour from 9 am till 6 pm. Measuring and taking note were taken 45-50 minutes in the beginning of the first experiment. In the rest of the time the solar dryer and solar panel were replaced according to direction of sunlight. Measuring had been taken faster by the practicing time as much as 25-30 minutes eventually.

The second experiment had been done with the same amount of ingrediants and with same preparation process. It was not possible to do the second experiment same time with the first experiment, because of the physical conditions.

5. Conclusions

Open sun drying, solar drying and freeze drying methods were applied to dry the traditional Herzegovinian grape jelly sweet ćupter. Two types of ćupter were prepared as classic plain ćupter and ćupter with almonds. The average values of ambient temperature, RH and solar radiation were 27.4 °C - 24.67 °C, 46.46 % - 52.16 % and 435.78 W/m² - 244.63 W/m², during the first and second experiment respectively. The average values of drying air temperature, drying air RH and mean drying air velocity were 31.96 °C - 26.88 °C, 36.26 % - 46.97 % and 2.08 m/s - 1.39 m/s, during the first and second solar experiment respectively. Both experiments had been done under quite different climatic conditions. Solar drying is a sensitive process in general. Because the only energy resource used was solar energy. The success of the all experiments strongly depands on the weather conditions. The fruit can be spoiled partly or as whole during the process easily. When there is heavy rain and almost no solar radiation, it is quite challenging for drying process. Loose of food may occur. It was under that risk in the second experiment of ćupter drying. But we were able to save the ćupters from any contaminations appeared during the experiments. Only it had taken longer time to get the ćupters dry.

As a conclusion, in statistical point of view, the drying behaviors of ćupters with sun drying and solar drying significantly different. Also there is a statsitically difference between classic ćupters and ćupters with almonds. Only in the first experiment there is not significant difference between classic ćupter and ćupter with almonds with sun drying method. But the rest of the results shows us, there is statistically significant difference.

It is proved that solar drying method has better drying behavior than sun drying even though the results seemed slightly different from the drying curves. Solar dryer method is more efficient than open sun drying due to drying behavior. Solar dryer has more advantages than traditional open sun drying method regarding to control of process with time and energy efficiency. But solar dying still depands on natural solar energy. Power supply is still solar radiations. Solar dryer depands on phsical and weather conditions such solar radiation, air velocity, humidity. If the location of drying is chosed wisely, solar dring has more chance to have better results.

The colour change (ΔE) of the ćupters is meaningful to see which drying method gives more desirable final product. The appearance of the final product is quite important for consumer. The colour, texture, size, shape of the product shall be desirable from the consumer. Ćupters which dried with solar drying method has no significant difference on general look and general taste for both sensory analysis in Mostar and Prague. The attendees in Mostar agreed that there is no significant difference between the sun dried ćupters and solar dried ćupters with and without almonds in terms of colour likableness. The sensory analysis in Prague shows us that there is no significant difference between the sun dried ćupters and solar dried ćupters in terms of colour intensity and colour likableness. They liked the colour of ćupters without almonds slightly more than ćupters with almonds. Within this research, it has seen that solar drying method can be applied to ćupter preparation without any significant difference on colour likableness, general look and general taste. In the case of freeze dring with lyophilizer, there is no significant difference found in terms of general taste. But because of the drying method, the colour of the ćupter with freeze drying had light colour. The pigments of the product did not change by the solar radiation. The sensory analysis shows that freeze dried ćupters have the least desirable look and colour even though there is no significant difference in general taste.

Ćupter is rich in nutritional value due to grapes in it. It is also an advantage that there is no additives nor chemicals in ćupter preparation. There is no processed-refined sugar in ćupter unlike most of the mass production of jelly sweets that easy to find in the market. So it would suits in healthy diets and it would be preferable for kids for its sweet taste as healthy snacks. It is a novel food need more people to know especially consumers are seeking for organic, healthy, pure alternatives in modern times.

6. References

Augustus Leon M, Kumar S, Bhattacharya SC. 2002. A comprehensive procedure for performance evaluation of solar food dryers. Renewable and Sustainable Energy Reviews **6**: 367-393.

Akdeniz B. 2011. Geleneksel Usullerde Sultani Çekirdeksiz Üzüm Çeşidinin Kurutulması, Electronic Journal of Food Technologies **6**: 13-22.

Badet C. 2011. Chapter 65 - Antibacterial Activity of Grape (Vitis vinifera, Vitis rotundifolia) Seeds. Pages 545-552 in Preedy VR, Watson RR, Patel VB. editors. Nuts and Seeds in Health and Disease Prevention. Academic Press, San Diego.

Baini R, Langrish TAG. 2007. Choosing an appropriate drying model for intermittent and continuous drying of bananas. Journal of Food Engineering **79**: 330-343.

Batu A, Kırmacı B. 2006. Lokum Üretimi ve Sorunları. Gıda Teknolojileri Elektronik Dergileri **3**: 37-49.

Bayram H.U. 2018. Geleneksel Gümüşhane Pestil Ve Kömesinin Üretim Yöntemlerinin Ve Kalite Parametrelerinin İncelenmesi [MSc. Thesis] Karadeniz Teknik Üniversitesi, Trabzon.

Belessiotis V, Delyannis E. 2011. Solar Drying, Solar Energy **85**:1665-1691.

Beljo J. 2017. Atlas of Viticulture and Wine of Bosnia and Herzegovina, LAP Lambert Academic Publishing, Sarajevo.

Bolin HR. 1980. Relation of Moisture to Water Activity in Prunes and Raisins. Journal of Food Science **45**: 1190-1192.

Brenndorfer B, Kennedy L, Mrema GC. 1985. Solar Dryers: Their Role in Post-harvest Processing. Commonwealth Science Council, Commonwealth Secretariat.

Chua KJ, Chou SK. 2003. Low-Cost Drying Methods For Developing Countries. Trends İn Food Science & Technology, Volume **14**: 519-528.

Chou SK, Chua KJ, Mujumdar AS, Hawlader MNA, Ho JC. 2000. On the Intermittent Drying of Agricultural Products. Food and Bioproducts Processing **78**: 193-203.

Crespan M, Botta R, Milani N. 1999. Molecular Characterization of Twenty Seeded and Seedless Table Grape Cultivars (Vitis vinifera L.), Vitis **38**: 87-92.

Diatek. 2015. Pestil Üretimi. Diagonistik Ürünler ve Teknik Danışmanlık. Available from https://www.diatek.com.tr/Makale-Yontem/Genel/Pestil-Uretimi_3345.htm (accessed March 2020).

Diken B, Tepeci M. 2017. Determination of The Effects ff Grapes And Grape Products On The Development Of (Gastronomic) Tourism In Manisa. Pages 110-123 in Öztürk B, Bucak T editors. The 3rd International Gastronomic Tourism Congress. Izmir.

Eissen W, Mühlbauer W, Kutzbach HD. 2010. Solar Drying of Grapes, Drying Technology. An International Journal **3**: 63-74.

Ekechukwu OV, Norton B. 1999. Review of solar-energy drying systems II: an overview of solar drying technology. Energy Conversion and Management **40**: 615-655.

Erraach Y, Sayadi S, Gomez A, Parra-Lopez C. 2014. Consumer-Stated Preferences Towards Protected Designation Of Origin (PDO) Labels In A Traditional Olive-Oil-Producing Country: The Case Of Spain. New Medit **13**: 11-19.

Esmaiili M, Sotudeh-Gharebagh R, Cronin K, Mousavi MA, Rezazadeh G. 2007. Grape Drying: A Review. Food Reviews International **23**: 257-280.

Fani A, Rezaei M, Moini A, Fani P, Mirzajani P, Malekirad AA, Rafeie M, Atabak N. 2013. Aflatoxin occurrence in nuts consumed in Arak, Iran. International Journal of Food Nutrition and Safety **4**: 91-97.

FAO, OIV. 2016. Table And Dried Grapes Non-Alcoholic Products Of Vitivinicultural Sector Intended For Human Consumption, FAO-OIV FOCUS 2016.

Farakos SMS, Schaffner DW, Frank JF. 2014. Predicting Survival of Salmonella in Low–Water Activity Foods: An Analysis of Literature Data. Journal of Food Production **77**: 1448-1461.

Fudholi A, Sopian K, Ruslan MH, Alghoul MA, Sulaiman MY. 2010. Review of Solar Dryers For Agricultural and Marine Products. Renewable and Sustainable Energy Reviews **14**: 1-30.

Gaeta D, Begalli D, Corsinovi P. 2012. The Alignment Of European Law İn Pre-Candidate Countries: The Case Of Bosnia And Herzegovina Wine Law, European Association of Agricultural Economists The 126th Seminar, Italy.

Gallali YM, Abujnah YS, Bannani FK. 2000. Preservation Of Fruits And Vegetables Using Solar Drier: A Comparative Study Of Natural And Solar Drying, III; Chemical Analysis And Sensory Evaluation Data Of The Dried Samples (Grapes, Figs, Tomatoes And Onions). Renewable Energy **19**: 203-212.

Gamboa GG, Cerdán TG, Simunovic YM' Álvarez EPP. 2019. Amino Acid Composition of Grape Juice and Wine: Principal Factors That Determine Its Content and Contribution to the Human Diet. The Science of Beverages **12**: 369-391.

Gıdatarım. 2015. TARİŞ 40 bin ton kuru üzüm alımı yapacak. Available from https://gidatarim.com/tarim/taris-40-bin-ton-kuru-uzum-alimi-yapacak-c85463.html (accessed March 2020).

Gloria EMD. 2011. Aflatoxin Contamination Distribution Among Grains and Nuts. Pages 75-90 in Pacheco IT, editor. Aflatoxins - Detection, Measurement and Control. InTech, Brasil.

Gould GW. 2012. New methods of food preservation. Springer-Science, Business Media, Salisbury.

Gumushaneden. 2019. Available from https://gumushaneden.com/urun/cevizli-pestil/ (accessed March 2020).

Gülcü M, Demirci AŞ, Güner KG. 2008. Siyah Üzüm Zengin Besin İçeriği ve Sağlık Açısından Önemi. Türkiye 10. Gıda Kongresi, Erzurum.

Harari YN. 2011. Sapiens: A Brief History Of Humankind, Vintage.

Hassan D, Monier-Dilhan S. 2006. National brands and store brands: Competition through public quality labels. Agribusiness **22**: 21-30.

House L, Patel P, Thomas S. 2009. How do Different Countries use PDO/GI Standards: A Case Study Comparing Wisconsin Cheddar to Parmesan-Reggiano. Pages

199-203 in Fritz M, Rickert U, Schiefer G, editors. System Dynamics and Innovation in Food Networks. University of Bonn, Germany.

Hugo WG. 1991. A Brief History Of Heat And Chemical Preservation And Disinfection, Journal Of Applied Bacteriology **71**: 9-18.

Kaur M, Agarwal C, Agarwal R. 2009. Anticancer and Cancer Chemopreventive Potential of Grape Seed Extract and Other Grape-Based Products. The Journal of Nutrition **139**: 1806-1812.

Kaya S, Gögüs F. Maskan M. 2002. Moisture Sorption Isotherms Of Grape Pestil And Foamed Grape Pestil. Nahrung Food **46**: 73-75.

Kaya S, Maskan A. 2003. Water Vapor Permeability Of ‘Pestil’ (A Fruitleather) Made From Boiled Grape Juice With Starch. J Food Eng, **57**: 295–299.

Krokida MK, Maroulis ZB, Saravacos GD. 2008. The Effect Of The Method Of Drying On The Colour Of Dehydrated Products. The Institue of Food Science & Technology **36**: 53-59.

Kuşat N. 2012. Bölgesel Kalkınmada Geleneksel Gıda Ürünlerinin Rolü ve Geleneksel Gıdalarda İnovasyon Belirleyicileri Üzerine Bir Çalışma: Afyon Örneği. Yönetim ve Ekonomi Dergisi, **19**: 261-275.

Knec S. 2019. Geleneksel Türk Tatlısı: Cevizli Sucuk (Köme). Available from https://www.turktoyu.com/geleneksel-cevizli-sucuk-yararlari-ve-tarifi (accessed March 2020).

Lopez-Velez M, Martinez-Martinez F, Valle-Ribes C. 2003. The Study of Phenolic Compounds as Natural Antioxidants in Wine Critical Reviews. Food Science and Nutrition, **43**: 233-244.

Manisahaberleri. 2018. Bankacı Mucitten Üzüm Kurutma Fırını. Available from https://www.manisahaberleri.com/manisa/bankaci-mucitten-uzum-kurutma-firini-h91400.html (accessed March 2020).

Marasmarket. 2019. Available from https://www.marasmarket.com/beyaz-kopuk-un-sucugu-500-grantep-fistikli (accessed March 2020).

Martinez-Micaelo N, González-Abuín N, Ardèvol A, Pinent M, Blay MT. 2012. Procyanidins And İnflammation: Molecular Targets And Health İmplications Biofactors **38**: 257-265.

Maskan A, Kaya S, Maskan M. 2002. Hot Air And Sun Drying Of Grape Leather (Pestil). Journal Of Foof Engineering **54**: 81-88.

Midilli A, Olgun H, Ayhan T. 1999. Experımental Studıes On Mushroom And Pollen Dryıng. International Journal Of Energy Research **23**: 1143-1152.

Migicovsky Z, Sawler J, Money D. 2016. Genomic Ancestry Estimation Quantifies Use of Wlif Species in Grape Breeding. BMC Genomics.

Mujumdar, AS, Devahastin S. 1997. Pages 1-22. Drying Fundamentals. in Baker CGJ, editor. Industrial Drying Of Foods. Blackie Academic & Professional, London.

Nathakaranakule A, Kraiwanichkul W, Soponronnarit S. 2007. Comparative Study Of Different Combined Superheated-Steam Drying Techniques For Chicken Meat. Journal Of Food Engineering **80**: 1023-1030.

Nireesha GR, Divya L, Sowmya C, Venkateshan N, Niranjan Babu M, Lavakumar V. 2013. Lyophilization/Freeze Drying - An Review. International Journal of Novel Trends in Pharmaceutical Sciences **3**: 87-98.

Nurković R. 2017. Geographical Distribution Of The Vineyards And Wine Production In Rural Areas Of Bosnia And Herzegovina, Folia Geographica **59**: 50–59.

Olufayo AA, Ogunkunle OJ. 1996. Natural Drying of Cassava Chips in The Humid Zone of Nigeria. Bioresource Technology **58**: 89-91.

Oraman Y. 2015. Geographical Indication Products in Turkey. Balkan and Near Eastern Journal of Social Sciences **1**: 76-85.

Pinent M, Auví CA, Genovese MI, Serrano J, Casanova A, Blay M, Ardévol A. 2016. Antioxidant Effects Of Proanthocyanidin-Rich Natural Extracts From Grape Seed And Cupuassu On Gastrointestinal Mucosa. Journal Of The Science Of Food And Agriculture **96**: 178-182.

Rawat S. 2015. Food Spoilage: Microorganisms and Their Prevention. Asian Journal of Plant Science and Research **5**:47-56.

Resano H, Sanjuán AI, Albisu LM. 2012. Consumers' Response To The EU Quality Policy Allowing For Heterogeneous Preferences. Food Policy, **37**: 355-365.

Revilla E, García-Beneytez E, Cabello F, Martín-Ortega G, Ryan J. 2001. Value Of High-Performance Liquid Chromatographic Analysis Of Anthocyanins İn The Differentiation Of Red Grape Cultivars And Red Wines Made From Them. Journal of Chromatography **915**: 53-60.

Reazai M, Sayadi M, Akbarpour B, Mohammadpourfard I, Behzadi A, Teimoory H. 2014. Safety of Dried Fruits Marketed in Tehran as Assessed by Aflatoxins Contamination. International Journal of Food Nutrition and Safety **5**: 24-30.

Sajin A. 2015. Hercegovački Ćupter FP. Available from https://www.facebook.com/hercegovacki.cupter/?epa=SEARCH_BOX (accessed December 2019).

Salvadó MJ, Casanova E, Iglesias A.F, Arola L, Bladé C. 2015. Roles of Proanthocyanidin Rich Extracts in Obesity. Food & Function, **6**: 1053-1071.

Seçkin GU, Taşeri L. 2015. Semi-Dried Fruits and Vegetables. Pamukkale University Journal of Engineering Sciences **21**: 414-420.

Schaarschmidt S. 2016. Public And Private Standards For Dried Culinary Herbs And Spices Part I: Standards Defining The Physical And Chemical Product Quality And Safety. Food Control **70**: 339-349.

Sharma A. 2013. Grape drying -A Process Of Value Addition in Grapes.

Sharma A, Somkuwar R. 2019. Grape Drying: Raisin Making. Quality and Trade.

Sharma A, Chen CR, Vu Lan N. 2009. Solar-Energy Drying Systems: A Review. Renewable And Sustainable Energy Reviews **13**: 1185-1210.

Sharma VK, Colangelo A, Spagna G. 1995. Experimental Investigation of Different Solar Dryers Suitable for Fruit and Vegetable Drying. Renewable Energy **6**: 413-424.

Söylemezoğlu G, Atak A, Boz Y, Unal A, Sağlam M. 2016. Viticulture in Turkey Chronica Horticultura **56**: 27-31.

Spiers S, Cleaves F. 1999. Topical Treatment of The Skin With a Grapeseed Oil Composition, United States Patent. Available from https://patentimages.storage.googleapis.com/ (access on March 2020).

Thanaraj T, Dharmasena DAN, Samarajeewa U. 2004. Development of a Rotary Solar Hybrid Dryer for Small Scale Copra Processing. Tropical Agrisciences Resaerch **16**: 305- 315.

This P, Lacombe T, Thomas MR. 2006. Historical Origins And Genetic Diversity Of Wine Grapes. Trends in Genetics **22**: 511-519.

Turkiewicz IP, Wojdyło A, Lech K. 2019. Influence Of Different Drying Methods On The Quality Of Japanese Quince Fruit, LWT 114.

Tiwari A. 2016. A Review on Solar Drying of Agricultural Produce, Journal of Food Processing & Technology **7**: 1-12.

Uysal H. 2007. İhracata Yönelik Sofralık Üzüm Üretim ve Pazarlama Olanaklarının Geliştirilmesi, M.B.A.E. Manisa.

Verghese K, Lewis H, Lockrey S, Williams H. 2013. The Role Of Packaging In Minimising Food Waste in The Supply Chain Of The Future. Centre for Design. Melbourne.

Woods M. 2009. Rural Geography, Rural Geography: Processes, Responses and Experiences in Rural Restructuring. SAGE. London.

Yaldız O, Ertekin C. 2001. Thin Layer Solar Drying of Some Vegetables, Drying Technology. An International Journal **19**: 583-597.

Yıldız O. 2013. Physico-Chemical And Sensory Properties Of Mulberry Products: Gümüşhane Pestil And Köme, Turk. J. Agric. For. **37**: 762-771.

Zambrano MV, Dutta B, Mercer DG, MacLean HL, Touchie MF. 2019. Assessment Of Moisture Content Measurement Methods Of Dried Food Products in Small-Scale Operations in Developing Countries: A Review. Trends in Food Science & Technology **88**: 484-496.

Appendix 1: Cupter sensory analysis form

CZECH REPUBLIC
DEVELOPMENT COOPERATION

SENSORY ANALYSIS OF CUPTER
Mostar (Bosnia and Herzegovina)

Surname: .... Name: ....
Date: .... Time: ....

Number of sample: ....

GENERAL CHARACTERISTICS

General look	like	dislike
General taste	like	dislike
Intensity of taste	not intensive	very intensive
TASTE Sweetness	not sweet	very sweet
Sourness	not sour	very sour
ODOUR Smell	excellent	very bad
COLOR Intensity	light	dark
Likableness	like	dislike
TEXTURE Hardness	very soft	very hard

Chewiness	very good	very bad
Juiciness	very juicy	very dry

OFF TASTE
If any, describe…………………………………………………………………………………

AFTER TASTE
If any, describe…………………………………………………………………………………

VERBAL DESCRIPTION:
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

PREFERENCE
Taste each product and circle the product that you prefer, all things considered.

No almonds With almonds No preference

Appendix 2: Cupter questionnaire

As a part of the research questionnaire about traditional sweet cupter was prepared and carried out. After the pitote questionnaire, where 21 students and pedagogical staff of University of Mostar and Dzemal Bijedic University of Mostar answered the questions, questionnaire was slightly modified and prepared for the second main survey.

This questionnaire is prepared for a research QQQ in Mostar,Bosnia Herzegovina.

1. Which type of traditional sweets are you familiar with?

- Dried Fruits(fig etc.)
- Helva(tahan halva)
- Lokum(Turkish delight)
- Praline(small sweets with walnuts)
- Gummy bears(jelly sweets)
- Pestil(fruit pulp sheets dried under direct sunlights and folded, fruit leather)
- Cezerye(churchkhela)
- Hurmasica(kalburabastı)
- Smokvara
- Baklava
- Tufahije(apple filled with walnuts)
- Trileçe

2. Do you know cupter?

Yes

No

3.How do you like cupter?

Extremely like

Like

Neutral

Dislike

Extremely Dislike

1

4.Which ones do you prefer ? (you can choose more than one)

- Red grape(wine) cupter ☐
- White grape(wine) cupter ☐
- Cupter with almonds(badem) ☐
- Cupter classic(without nuts) ☐
- Cupter with walnuts ☐
- Soft ☐
- Hard ☐

5.How frequently do you have cupter in your diet?

- never ☐
- occassionally ☐
- sometimes ☐
- often ☐
- always ☐

6.How much cupter do you consume in once?

- Less than 50gr ☐
- 50-100gr ☐
- 100-150gr ☐
- More than 150gr ☐

7. Why do you eat cupter?

	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
Taste	☐	☐	☐	☐	☐
Traditional	☐	☐	☐	☐	☐
Healthy	☐	☐	☐	☐	☐

2

8. If you buy,where do you buy cupter?

	Never	Rarely	Sometimes	Often	Very often
Supermarket	☐	☐	☐	☐	☐
Bazaar	☐	☐	☐	☐	☐
Organic products store	☐	☐	☐	☐	☐
Friends/ Neighbours	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

Please specify …………………

9.Have you already prepare cupter at home alone/ with grandparents?

Yes ☐

No ☐

10.Have you ever seen cupter preparation?

Yes ☐

No ☐

11.If yes, which type of method did you use for drying?

Open sun ☐

Dryer ☐

Dryer- please specify…..

12. How do you recognise good cupter?

	Extra important	Important	Moderat. important	Slightly important	Not important
Taste	☐	☐	☐	☐	☐
Price	☐	☐	☐	☐	☐
Nutrition value	☐	☐	☐	☐	☐
Quality	☐	☐	☐	☐	☐
Colour	☐	☐	☐	☐	☐
Tradition	☐	☐	☐	☐	☐

13.During the last 10 years, your cupter consumption per week has:

Extremely decreased	Decreased	Remained constant	Increased	Exteremly increased
☐	☐	☐	☐	☐

14. Do you agree with these statements?

	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
It´s traditional	☐	☐	☐	☐	☐
It´s accessible	☐	☐	☐	☐	☐
It´s healthy	☐	☐	☐	☐	☐

15. What is your gender?

Female ☐

Male ☐

Prefer not to answer ☐

16.What is your age? .... Years

17.Number of the household members ....

Children (1-18 year) ....

Adults (19-65) ....

Retired (above 65 years) ....

18.Where do you live?

City ☐

Suburb ☐

Rural Area ☐

19. What is your educational status?

Basic ☐

High school ☐

University ☐

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20.What is your occupational status?

Government officer ☐

Private employee ☐

Unemployed ☐

Farmer ☐

Student ☐

Retired ☐

Businessman ☐