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APPLICATION OF SOUS-VIDE TECHNOLOGY ON ZUCCHINI AND EGGPLANT

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IN

FOOD ENGINEERING

BY

DİDEM SÖZÜDOĞRU

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Application of Sous–Vide Technology on Zucchini and Eggplant

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Supervisor

Assist. Prof. Dr. K. Bülent BELİBAĞLI

by

Didem SÖZÜDOĞRU

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Approval of the Graduate School of Natural and Applied Sciences

Prof. Dr. Ahmet Necmeddin YAZICI

Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Prof. Dr. Medeni MASKAN

Head of Department

This is to certify that we have read this thesis and that in our consensus opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Assist Prof. Dr. K. Bülent BELİBAĞLI

Supervisor

Examining Committee Members:	Signature
Assoc. Prof. Dr. Ali YILDIRIM	………………………
Assist. Prof. Dr. Hasene KESKİN ÇAVDAR	……………………...
Assist. Prof. Dr. K. Bülent BELİBAĞLI	……………..............

I declare that the relevant thesis is written accordance with the academic and ethical rules. I also declare that, all the literature information is included in the relevant thesis by reference.

Didem SÖZÜDOĞRU

ABSTRACT

APPLICATION OF SOUS- VIDE TECHNOLOGY ON ZUCCHINI AND EGGPLANT

SÖZÜDOĞRU, Didem

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In this study, sous-vide technique was applied at 85°C for zucchini and eggplant slices at 75 and 55 minutes, respectively. Products were then stored at + 3°C for 48 days. Samples were examined in terms of physical (moisture content, pH, color, texture, weight loss), sensory and chemical qualities (total phenolic content) at specific time intervals. The moisture content was detected in fresh samples remained almost constant by sous-vide process. During the storage period, statistically insignificant differences were observed in both vegetable groups at pH value. No weight losses observed during the storage period in cooked eggplant and zucchini slices. There was no statistically difference in total weight losses between zucchini and eggplant samples ($p>0.05$). Texture analysis of zucchini and eggplant samples were showed statistically differences ($p<0.05$). By the effect of sous-vide cooking, L* value was decreased in both vegetable slice samples according to the control samples. Fluctuations were observed both vegetable samples at a* value of both vegetable samples during the storage time. b* value of eggplant and zucchini slices showed similarities to that of control samples. There were also fluctuations in total phenolic content of both samples. According to results of sensory analysis, products kept their characteristics during the storage period.

Key words: Sous- vide technology, zucchini, eggplant

ÖZET

KABAK VE PATLICANDA VAKUMLU PİŞİRME TEKNİĞİNİN UYGULANMASI

SÖZÜDOĞRU, Didem
Yüksek Lisans Tezi, Gıda Mühendisliği
Tez Yöneticisi: Dr. Öğr. Üyesi Bülent BELİBAĞLI
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56 sayfa

Bu çalışmada, sous vide tekniği kabak ve patlıcan dilimleri için sırasıyla 75 ve 55 dakika olarak 85°C'de uygulandı. Ürünler 48 gün süreyle + 3°C'de depolandı. Örnekler belirli aralıklarla fiziksel (nem, pH, renk, tekstür, ağırlık kaybı), duyusal ve kimyasal özellikler (toplam fenolik içerik) açısından incelenmiştir. Taze örneklerde tespit edilen nem içeriği, sous- vide prosesiyle yaklaşık olarak sabit kalmıştır. Depolama süresi boyunca her iki sebze grubunda pH değerinde istatiksel olarak önemsiz farklılıklar gözlenmiştir. Kabak ve patlıcan dilimlerinde depolama süresi boyunca ağırlık kaybı gözlenmemiştir. Kabak ve patlıcan dilimlerinde ağırlık kaybı açısından istatiksel olarak bir farklılık yoktu ($p>0.05$). Kabak ve patlıcan dilimlerinin tekstür analizleri istatiksel olarak farklılık gösterdi ($p<0.05$). Sous-vide pişirmenin etkisiyle L* değerinde her iki sebze dilimi örneklerinde, kontrol örneklerine göre azalma gözlendi. Depolama süresi boyunca her iki sebze dilimi numunelerinde a* değerinde dalgalanma gözlenmiştir. Kabak ve patlıcan dilimlerinin b* değeri kontrol numuneleri ile benzerlik gösterdi. Her iki örneğin toplam fenolik içerik sonuçlarında da dalgalanmalar vardı. Duyusal analiz sonuçlarına göre ürünler depolama süresince duyusal özelliklerini korumuştur.

Anahtar sözcükler: Sous vide teknolojisi, kabak, patlıcan

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LIST OF SYMBOLS

AAAC	All Aluminium Alloy Conductor
ANOVA	Analysis of Variance
+a*	Redness
-a*	Greenness
+b*	Yellowness
-b*	Blueness
r	Pearson correlation coefficient
L*	Lightness-darkness
°C	Celcius
DB	Dry basis
°F	Fahrenheit
GAE	Gallic acid equivalent
SV	Sous vide
TPA	Texture profile analysis

CHAPTER I

INTRODUCTION

Sous-vide is a method of cooking foods under vacuum using controlled conditions (time and temperature). Sous-vide means that cooking under vacuum and sous-vide is applied to raw or half-baked foods (Yılmaz and Bilici, 2014).

Sous vide cooking method has following main stages:

1- Preliminary

2- Portioning products and putting in plastic pouches

3- Vacuum packaging

4- Pasteurization (by controlling time and temperature)

5- Rapid cooling in cooler or ice bath

6- Cold storage

7- Reheating during consumption and service (Yılmaz and Bilici, 2014).

Nowadays sous-vide technology is applied to different types of foods like vegetable, meat, soup, sauce and according the food type above process steps can change (Yılmaz and Bilici, 2014).

Since consumption of raw or processed fruits and vegetables protecting human body against diseases, they are essential for diary diet. With process such as washing and chopping, applied to vegetables, some losses occurs at nutritional value. To limit these losses and choosing optimum cooking technique is important (Coşansu and Kıymetli, 2016).

Providing that depending on applied time and temperature, generally this cooking method reveals keeping the nutritional value of vegetables (Coşansu and Kıymetli, 2016).

In this work, eggplant and zucchini were prepared in laboratory conditions by applying some preliminary (peeling, washing and chopping) after that they were treated by vacuum packaging and cooked at 85°C. Some parameters like: Moisture content, pH, color, total phenolic content, texture, sensory analyses, total weight loss and were analyzed for once a week beginning from first storage time. Fresh vegetable have been accepted as control samples.

Importance of the thesis:

1- To develop a process for sous-vide packaged and study the storage stability and quality of the product.

2- Protection of the products sensory quality parameters (color, texture, flavor of product).

3- To improve healthy and tasty products by using optimum process conditions (temperature and time).

4- Vegetables that are not in season are ready to be consumed whenever requested.

5- To get ready to use sliced and cooked vegetables for use in the kitchen.

CHAPTER II

LITERATURE REVIEW

2.1 Zucchini Vegetable and Composition

It is known that zucchini seeds were found in Mexican caves by scientists 10000 years ago. Zucchini came into existence the result of natural mutations. Zucchini is an important summer vegetable which is a member of the *Cucurbitaceae* family. It is known as summer squash and it is a botanically fruit (Gholami et al., 2012).

Zucchini is mostly produced in America, China, India and Russia. It is a very fresh plant. It has cylindrical shape and dark green shiny skin and some light speckling. Small and medium size of zucchini are more aromatic than the bigger size of zucchini. The darker the skin of the zucchini, the better the nutrients. It has no cholesterol and its' oil and sodium rate is very low. Zucchini is an important source of vitamin C and also the vegetable is a good source of magnesium and phosphorus (Gholami et al., 2012).

The chemical composition of zucchini is shown in Table 2.1

https://ndb.nal.usda.gov/ndb/search/list

Table 2.1 Composition of raw zucchini for 100 g

Nutrient	Unit	Value per 100 g
Water	g	92.73
Energy	kcal	21
Protein	g	2.71
Carbohydrates	g	3.11
Fiber, total dietary	g	1.1
Potassium	mg	459
Phosphorus	mg	93
Magnesium	mg	33
Calcium	mg	21
Sodium	mg	3
Vitamin A	IU	490
Vitamin C, total ascorbic acid	mg	34.1
Folate, DFE	µg	20

2.2 Eggplant Vegetable and Composition

Eggplant (*Solanum melongena* L.) is a member of *Solanaceae* family and perishable and sensitive tropical fruit. While eggplant grows as an annual plant at warm climates, It grows as perennial at tropical climates. Eggplants' native land is known as India also it has some wild species in Africa. Eggplant is grown as under cover and open area vegetable growing in Turkey, eggplant has high water content and it is a non-starchy vegetable. It has some nutrients such as potassium, magnesium, folic acid and vitamin B6 , vitamin A and its nutritional value is similar to tomato (Osidacz et al., 2013).

The oblong- fruited eggplant types have rich total soluble sugar content and long fruited eggplant types have high content of anthocyanin, phenols, free reducing sugar, amide proteins, dry matter and glycoalkaloid content. The high content of glycoalkaloids produce a bitter taste and off flavor. Its world production is around 32 million tons (Ali et al., 2011).

The chemical composition of eggplant is shown in Table 2.2 https://ndb.nal.usda.gov/ndb/search/list

Table 2.2 Composition of raw eggplant for 100 g

Nutrient	Unit	Value per 100 g
Water	g	92.3
Energy	kcal	25
Protein	g	0.98
Carbohydrates	g	5.88
Fiber, total dietary	g	3
Potassium	mg	229
Phosphorus	mg	24
Magnesium	mg	14
Calcium	mg	9
Sodium	mg	2
Vitamin A	IU	23
Folate, DFE	µg	22

2.3 Water Content

All foods have water and dry matter. Water content changes between the range of 3-4 % - 95-96 %. Fresh foods like meat, fruit, vegetable have high water content. For instance fresh fruits and vegetables have approximately 75-90 % of water. Foods have three types of water: free water, absorbed water and bound water. While determining water content of any food, free water and important quantity of absorbed water are analyzed. Determining water content is important due to economic reasons and shelf life stability of food (Cemeroğlu, 2010).

2.4 pH

pH means that degree of acidity or strength of acidity. To determine degree of acidity, pH should be measured. Actually pH is activity of hydrogen ions. The activity of hydrogen ions is depends on type of acid, temperature and buffer compounds. Number of bigger than pH 7.0 states rising alkalinity, number of lower than 7.0 states rising acidity. The degree of pH value 7.0 indicates neutral point (Cemeroğlu, 2010).

2.5 Color

Color is reproduced from some natural pigments in vegetables and fruits and it changes throughout maturation and ripening period of fruits and vegetables. The main color pigments are chlorophylls (green), caratenoids (yellow, orange, red) and the water soluble anthocyanins (red, blue), flavanoids (yellow) and betalains (red). Additionally, some enzymatic and non-enzymatic browning reactions can result in the occurrence of water soluble brown, grey and black colored pigments (Barrett et al., 2010).

Fresh-cut fruits and vegetables must seem to be fresh and also they should have shininess of color. A dried appearance is not preferred. Color and appearance of the package is the most important parameter for the consumer preference (Barrett et al., 2010).

2.6 Texture

The terms of texture, rheology, consistency, viscosity are often used alternatively, in spite of having different properties. Practically, the terms of texture is used mainly reference to solid or semi-solid foods. Most of fruits and vegetables have viscoelastic structure due to having liquids which show elasticity (deformation). Firstly a product is placed in the mouth, the smoothness, thickness, firmness, hardness or crispness qualities of the fruit and vegetable materials' are sensed (Barrett et al., 2010).

2.7 Phenolic Compounds

Phenolic compounds (polyphenols) have a benzene ring which has one or more of the hydroxyl group. The important part of phenolic compounds are responsible from flavour and sourness. On the other hand, phenolic compounds, for example anthocyanin provide specific color of fruits and vegetables. Most of the polyphenols cause enzymatic browning of fruits and vegetables in reactions which catalyzed by polyphenol oxydase enzyme. The important part of phenolic compounds have antioxidative capacity, for this reason they are important for human health (Cemeroğlu, 2011).

2.7.1 Phenolic acids

Phenolic acids are called cinnamic acid. The most common cinnamic acids in fruits, caffeic and coumaric acid and ferulic acids. Phenolic acids are not free in plants' cells and they are free after some treatments in plants (Cemeroğlu, 2011).

2.7.2 Flavanoids

Flavanoids are one of the most important group of vegetable phenolics. Flavanoids have five important groups: 1- anthocyanidins, 2- flavones and flavonels, 3- flavonenes, 4- catechines and leucoanthocyanidines, 5- proanthocyanidines (Cemeroğlu, 2011).

2.8 Sous-Vide Technique and Nutritional Benefits

Sous-vide (SV) was first used as an expensive culinary technique in kitchens in France in the 1970s and traditionally is a technique of cooking food in thermal water bath by using plastic pouches. Sous-vide has slowly been spreading all around the world and is finally used even in the home kitchens (Logsdon, 2010).

Sous-vide is a cooking method that vacuumed plastic pouches at precisely controlled temperatures. Sous-vide cooking method is different from traditional cooking methods by two main ways: using vacuum sealed in heat stable plastic pouches and applying precisely controlled heating (Baldwin, 2011).

There are some basis for sous-vide cooking. Determining right temperature is important for sous vide cooking. The right temperature depends on kinds of food (like meat, fruits and vegetables). On the other hand, center of the food must be cooked. Heat should penetrate the core of the food stuff. It is important that to achieve desired taste and textures (Baldwin, 2011).

1) Another important basic parameter is cooking time. Cooking time with sous- vide method are affected by a number of factors: initial temperature of the food its' mass and heat transfer characteristics (Baldwin, 2011).

The sous-vide cooking has some steps:

2) Setting thermal bath to the desired cooking temperature
3) Vacuum sealing the food
4) Positioning the vacuum sealing food in the thermal bath (Mcauley, 2016).

In the sous-vide technique, by using thermal water bath, by the effect of hot water or steam, a homogeneous cooking is supplied (Yılmaz and Bilici, 2014). The entire of food must be cooked perfect level of doneness. Most of the traditional cooking techniques like steaming, boiling, frying ,grilling, baking contains heat sources higher than sous- vide. Up to inside of the food reaches the critical temperature point, the outside is overcooked. On the contrary, holding food in a temperature controlled thermal bath, the core may reach the precise temperature without overcooking. The plastic bag allows whole surface of the food, contacting in the water also it keeps the fluids within the food.

Due to extending shelf life and protecting sensory quality and microbiological characteristics, sous-vide cooking technique is preferred (Yılmaz and Bilici, 2014).

Sous-vide is a good way to prevent cooking loss of preparing food. It has some advantages relating to reducing oxygen from environment and cooking at low temperatures. Due to the plastic barrier, oxidation is reduced. The plastic film also prevents the loss of moisture and flavors. The pouches eliminate mineral and vitamin losses (Petersen, 1993).

2.8.1 Advantages of Sous-Vide Technology

1) Increasing service efficiency and lowered food costs.
2) Preserving shelf life by using vacuum sealing bags.
3) By producing ready chilled meals, adding value raw materials for instance meat and fish.
4) Increasing weight through retention of moisture in packaging.
5) Extension of shelf life by lowering wastage during storage.
6) Reducing losses due to oxygen by vacuum packing.
7) Getting higher quality of food owing to more time presentation of food stuff.
8) More quick service of food to customers (Ghazala, 1998).

2.8.2 Disadvantages of Sous-Vide Technology

1) Higher packaging material costs.
2) Higher equipment costs (vacuum packing, pasteurizing, storage) for preparation.
3) Increasing risk of food poisoning if sous–vide pouches are subjected to lack of temperature doneness (Ghazala, 1998).
4) Some tougher cuts of meat (like ribs or brisket) it is suggested cooking at 130°F around at 36 hours (Logsdon, 2010).

2.8.3 Safety of Sous -Vide Technology

There is always a concern in any cooking methods. Two basic problems come to SV technology: pathogens and the dangers of cooking in plastic. Food grade plastic does not create any risk.

Bacteria begin to die at 130-135°F. At 135°F, it takes about 63 minutes for food become safe and 146°F it only takes 7 minutes to become safe (Logsdon,

2010).
The main concern is SV method is some bacteria especially *Salmonella, Clostridium botulinum, Escherichia coli* and *Listeria monocytogenes*. Most of these bacteria are found on the surface of the food. *C. botulinum* is the most dangerous bacteria. This bacteria produces some toxins which is extremely dangerous but this is killed of high temperatures (80°C).
Clostridium p*erfringens* is the main cause of foodborne illness to inadequate cooling and reheating (Baldwin, 2011).
To prevent microbiological spoilages, all food must be kept refrigerated at +3°C. Also the food always must be kept in the coldest part of cooler (Keller, 2008).
There are some risks about SV foods:

1) Foods held in temperature danger zone, known as 5°C to 60°C for long periods are potentially subject to bacterial growth.
2) Foods stored at refrigeration conditions to prevent against cold tolerant pathogens. The growth of *L. monocytogenes* and growth of *C. botulinum* is a risk.
3) Food cooked at low temperatures for short periods, if pathogens and parasites are present, they may survive.

These risks above will be reduced if;

1) In order to get rapid heating and cooling, thinner portions of food prepared.
2) Water bath temperatures should be at least 55°C to prevent growth of *C. perfringens.*
3) Equipment and enough heating capacity, good temperature control should be used .
4) Cooking water or temperatures should be checked sensitive thermometer which is accurate 0.1 °C (Baldwin, 2011).

2.8.4 Importance of Sous-Vide Method on Fruits and Vegetables

Sous-vide has a good effect on flavor, preventing oxidation and convenience of fruits and vegetables. Sealing vegetables with SV method reduces oxidation. Also, vegetables can be cooked so that they become tender without the possibility of overcooking (Keller, 2008).

Only some vegetables are not cooked with SV technique which are green vegetables because of losing their shiny color but the SV is a great technique for all other vegetables (Keller, 2008).

While cooking vegetables by using SV, they keep all their nutrients and all of their flavor. Natural sugars stay where they belong, if SV method is used. In traditional methods, these sugars leave from vegetable to water (steaming or boiling) (Eades, 2011).

The cooking temperatures of vegetables is shown in table 2.3

Table 2.3 Cooking temperatures (Mcauley, 2016).

Vegetable	°C	°F
Asparagus	85	185
Beets	85	185
Carrots	85	185
Cauliflower	85	140
Corn	60	185
Fennel	85	185
Leeks	85	185
Mushrooms	90	194
Onion	85	185
Potatoes	85	185
Squash	85	185
Turnips	85	185

Cooking time should be adjusted to initial temperature, heat transfer characteristics and thickness of the food being cooked (Mcauley, 2016).

Cooking time changes from 15 minutes to 1 hour 45 minutes according to type of food (Mcauley, 2016).

2.8.5 Sous-Vide Applications on Foods

Nowadays, with increasing demand for collective consumption, institutional catering establishments try to find a solution to store food longer time, increase the productivity of the staffs (Yılmaz and Bilici, 2014).

Sous- vide cooking method has a lot of advantageous reasons like extension shelf life, conversation of sensory and microbiological qualities. Owing to these reasons, this technique is preferred in institutional catering establishments (Yılmaz and Bilici, 2014).

Effective hygiene control should be provided at every stage of meat dishes produced with SV technique (Yılmaz and Bilici, 2014).

Çoban kavurma was the first meal processed, in the application of this new technology to Turkish traditional meat dishes. Sensory, chemical and microbiological qualities were determined periodically. After some processes and storage at 4°C for 42 days, a stable situation was observed and no significant changes were observed following control period till 63 days (Topal et al., 1996).

Another meat meal is salad with meat in mayonnaise. This is perishable food, having a short shelf life. The SV method of salad with meat in mayonnaise significantly decreases microbiological growth at 4°C and 10°C. SV method was found effective in extending the shelf life of salad with meat in mayonnaise at storage temperature 4°C and 10°C (Levkane et al., 2010).

A study was to investigate the suitable temperature for process storage of chicken meatballs made of minced chicken meat with SV method. Sensory, microbiological and chemical and texture profile analyses were performed on the samples. Chicken meatballs will perform consumer convenience criteria for 70 days if heat treated at 90°C for 10 minutes and stored at 2°C (Öp, 2015).

Application of sous-vide technology is searched on fishes. In a study, nutritional value of rainbow trout at the different cooking temperatures (70°C, 85°C and 90°C) were examined. When the effect of SV technique on nutritional value was examined, there was no significant change between raw fish and cooked fish. SV method can be applied to rainbow trout (Çetinkaya et al., 2015).

In a recent study, quality parameters and shelf life of zander filet stored at +2°C applied SV method in three different temperatures (60°C, 70°C and 80°C) was searched. Sous-vide processing was observed to have significant effect of the chemical contents of the products. After sensory analysis results; 60°C, 70°C, 80°C degree groups were found to be available at 28, 42 and 56 days (Çağlak et al., 2017).

CHAPTER III
MATERIALS AND METHODS

3.1 Materials

3.1.1 Vegetable Materials

Fresh zucchini and eggplant were purchased from a local market in Gaziantep, Turkey on 21 June 2017 and used as research material. Vegetables were randomly selected from the seller to make it 7 kg each.

3.1.2 Packaging Materials

Size of 30*40 cm vacuum bags which brand name was electrola were used in this study. Heat resistance of the pouches is 90°C as temperature. Film thickness of plastic pouches is 90 μm and pouches contains 30 % polyamide and 70 % polyethylene.

3.1.3 Chemicals

All chemicals used in this study were of analytical grade and purchased form Merck Chemical. Co. (Darmstadt, Germany).

3.2 Methods

3.2.1 Preparation of Zucchini and Eggplant

Firstly all vegetables were washed with tap water. Non-edible edges were taken off for zucchini and eggplant. Vegetables were peeled. All vegetables were cut into pieces 2.5 cm width by using a knife. The vegetable slices are immersed in 2 % ascorbic acid solution for 5 minutes to prevent enzymatic browning. Eight portions, each weighing 300 g separated for each plastic bag. After that each plastic pouch was vacuumed in Pak Form Type machine (Type- PP5/1101-2002 –POLAND).

Zucchini was cooked at 85℃ as 1 hour 15 minutes. Eggplant was cooked at 85℃ as 55 minutes in a water bath (Clifton-27183-2013). After cooking, all pouches were cooled in ice water (2/3 ice- 1/3 water) for 30 minutes. Products were stored at +3℃ in refrigerator.

Fresh vegetable → Basic preparation (peeling, washing ,slicing)

↓

Chopping vegetables ≅ 2.5 cm + dipping acid solution

↓

Vacuum packing

↓

Cooking at 85°C (cooking time for zucchini: 1 hour 45 minutes,

cooking time for eggplant: 55 minutes)

↓

Rapid cooling (in ice water)

↓

Cold storage +3℃

Figure 3.1 Flow chart of sous -vide technique for eggplant and zucchini

Figure 3.2 Cooked zucchini and eggplant in water bath

a) **b)**

c) **d)**

Figure 3.3 Packed zucchini and eggplant raw zucchini slices (a), raw eggplant slices (b), cooked eggplant slices (c) and cooked zucchini slices (d).

3.2.2 Physical Analysis

3.2.2.1 Moisture Content Determination

In order to determine moisture content, 5 g small pieced sample was dried in a convection oven (W.C.HERAEUS GMBH, HANAU, RT 500,GERMANY) at 105℃ for 3 hours. The measurements were carried out in triplicate (Cemeroğlu, 2010).

3.2.2.2 Texture Analysis

Texture was determined using a texture analyzer (TA.XT Plus Stable Micro Systems, UK, 41179). Texture profile analysis (TPA) was used to determine hardness, cohesiveness, chewiness, and springiness. This test was carried out by using compression plate with 36 mm diameter aluminum radius AACC. The texturometer was programmed so that the downward movement began at a point 5 mm above the surface of the sample. Test speed was 400 mm/sec and test period was 3 seconds. This test was carried out in duplicate for each group of samples. The average of two measurements each of hardness, cohesiveness, chewiness, and springiness were used for analyses (Alverez et al., 2002). The measurements were carried out in duplicate.

3.2.2.3 pH Value

The pH value of the sample was determined using a pH meter (Jenway 3010;Jenway LTD, Essex, UK) equipped with a J 95, 924001 electrode (Jenway LTD, Essex, UK). pH value was measured by adding 90 mL of distilled water to 10 g homogenized sample and mixture was mixed for 5 minutes in a magnetic stirrer (1/9: sample/water). The measurements were carried out in duplicate.

3.2.2.4 Color Analysis

The surface color measurement of zucchini and eggplant samples was performed using HunterLabColorFlex (A60-1010-615 Model Colorimeter-Hunter Lab and Reston VA) during storage. The L*, a*, b*, color values (also referred to as CIELAB) were used to express as L*(darkness/whiteness), a*(-a*values greenness/ +a* values redness), b*(-b*values blueness/ +b*yellowness) (Batu, 1997). Three measurements were taken for all samples and average values were shown. The instrument was calibrated against standard reference white tile 'L*=93.41, a*=-1.12, b*=1.07'. The measurements were carried out in triplicate.

3.2.2.5 Total Weight Loss Analysis

Weight loss was calculated by using this formula: (($\Delta M/Mo$) x 100) as a percentage. ΔM value is the change in weight during storage (g). Mo value is initial weight of zucchini or eggplant (g) (Demiröven, 2006).

3.2.3 Chemical Analysis

3.2.3.1 Total Phenolic Content Determination

The amount of total phenolic content of raw and cooked fresh vegetable samples were determined based on the principle of measurement of the blue colored molybdenum tungstate complex, at 765 nm by UV-VIS spectrophotometer (Pharmacia Biotech, Novaspec II,80-2094-37 E04, UK) formed as a result of oxidation of phosphotungstic and phosphomolybdic acid present in folin-ciocalteu reagent (Cemeroğlu, 2010).

For extraction of phenolic compounds 10 grams of the homogenized sample were extracted with 50 ml of ethanol (95%) in a flask with magnetic stirrer at 700 rpm for 1 hour. The sample extracts were then filtered whatman no:41 filter paper. The clear extract was used for the determination of phenolic content (Kalkan, 2013).

0.5 ml of Folin-ciocalteu reagent (2N), and 4 mL of sodium carbonate (Na_2CO_3) (75 g/l) was added to 0.5 mL of the clear extract. The mixture was completed to 25 ml with distilled water. After holding in an incubator at 50℃ for 5 min, the extract was cooled to room temperature and absorbance was measured at 765 nm by UV- VIS spectrophotometer. The total phenolic content of samples was calculated based on the gallic acic standard curve and the results were expressed as gallic acid equivalent (GAE/100 g dry weight). ($y = 0.0021x + 0.0374$; $R^2 = 0.9976$). The measurements were carried out in duplicate.

3.2.4 Sensory Analysis

Sensory evaluation of the eggplant and zucchini included odor, color, taste, texture and general assessment. To this aim, a specialized panelist group of ten people analyzed samples in terms of the given criteria. Scores were given according to a 1-5 scale, where 1 corresponded to very poor, 2 poor, 3 normal, 4 good and 5 very good. Once the samples were evaluated, acceptability score was determined (Altuğ and Elmacı, 2005). Sensory analysis form was shown in appendix (Table A.1).

3.2.5 Statistical Analysis

For statistical analysis, the results were processed using the SPSS 17 package program (SPSS for windows Stat Soft, Inc., USA). The differences between independent groups were specified by one way ANOVA and values of $p<0.05$ were regarded as statistically significant.

Relationships between analysis results were made by Pearson Correlations Analysis.

CHAPTER IV

RESULTS AND DISCUSSIONS

4.1 Moisture Content

Fresh zucchini which was used in this study contains 94.09 % moisture content. Moisture content of sous-vide groups showed similarities between each other. From the first storage day till last storage day the moisture content ratio was between the range of 94.03-94.34 % for the zucchini. However, when compared with literature Gholami et al. (2012) reported that the range of moisture content of fresh zucchini was between 92.8-96.5 % and in this study physical and chemical determination of zucchini has been determined. In another study by using microwave energy drying kinetics of zucchini has been investigated and moisture content of summer squash determined % 94 ±1 as wet weight. Therefore, this study showed parallelism with the literature in terms of moisture ratio (Çelen et al., 2017).

Fresh eggplant which was used in this study contains 92.35 % moisture content. Moisture content of sous- vide groups showed similarities between each other. From the first storage day till last storage day the moisture content ratio was between the range of 92.35-93.23 %. However, when compared with literature, Arivalagan et al. (2013) reported that the range of moisture content of fresh eggplant was between 90.86-94.08 % and mineral composition, genetic variability analysis of 32 types eggplant has been investigated. In another study 7 eggplant cultivars of the occidental type of eggplant has been investigated and moisture rate was determined 91-93.8 % as wet weight for eggplant (Camara et al., 2013). Therefore, this study showed parallelism with the literature in terms of moisture ratio.

Zucchini and eggplant moisture results were compared, there were significant differences between in moisture content results ($p<0.05$ in appendix).

In the study, samples which was in the package kept their juice in the plastic bag. It was observed that vacuum packed cooking process (SV method) protected the moisture content of samples. SV method was succeed in keeping the moisture ratio for both eggplant and zucchini.

Changes in moisture content of eggplant and zucchini were shown in Figure 4.1

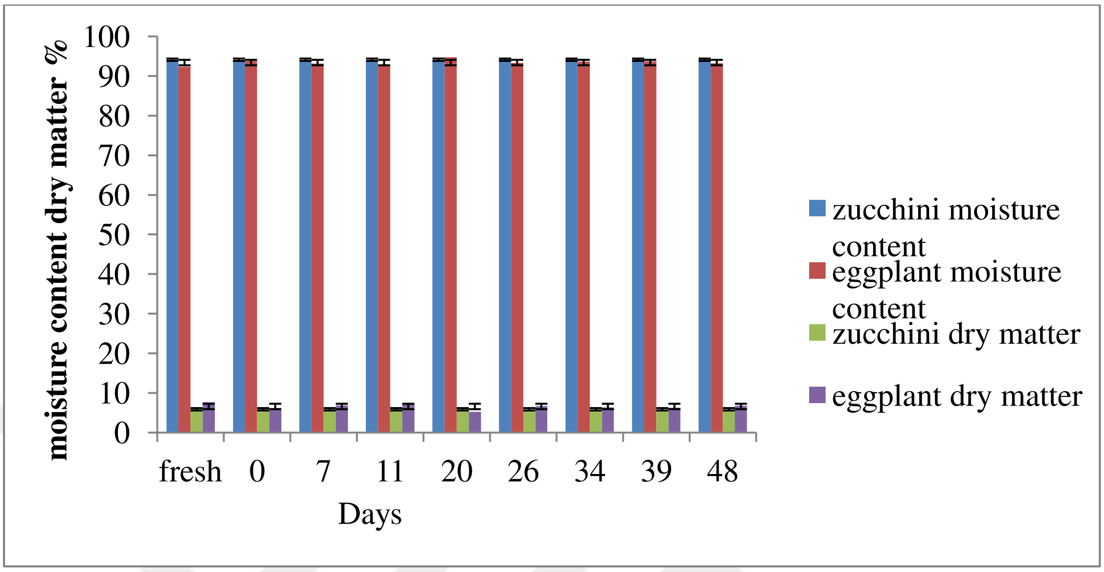

Figure 4.1 Plot of moisture content dry matter versus storage days*

*Results were showed with ± standard deviation in duplicate.

4.2 Texture

Texture was determined using a texture analyzer (TA.XT Plus Stable Micro Systems, UK, 41179). Instrumental definition of hardness is peak force of the first compression cycle. The definition of cohesiveness is calculated as the ratio of positive force area during the second compression portion to that during the first compression. Springiness is calculated as the ratio of the distance or time from the start of the second area up to the second probe reversal over the distance. Chewiness is calculated parameter hardness×cohesiveness×springiness (Alvarez et al., 2002). Texture analysis of zucchini and eggplant samples were showed statistically significant differences ($p<0.05$ in appendix). No data on the textural properties of sous- vide cooked eggplant and zucchini related storage time and temperature. There were some fluctuations in hardness values both zucchini and eggplant. This would mainly correspond to the structure of vegetables and difference in cooking time. With cooking, cellulose and fibrous structure were broken. However, higher values of the parameters measured in TPA (hardness, cohesiveness, springiness and chewiness) do not necessarily mean better quality. Good textural qualities of eggplant and zucchini samples should be determined together with a sensory test in order to establish most suitable range preferred by consumers. (Öp and Harun, 2014). Textural parameters of samples were shown in Table 4.1

Table 4.1 Textural parameters of experimental zucchini and eggplant*

Samples	Storage time (days)									
	Days	Fresh	0	7	11	20	26	34	39	48
Zucchini	Hardness (kg)	*	*	3.56 ± 0.74	2.54 ± 1.10	0.66 ±0	*	1.70 ±0.07	5.56 ±1.10	8.12 ±2.00
	Cohesiveness (mm/mm)	0.50 ±0.05	0.58 ±0.10	0.47 ±0.02	0.44 ±0.06	0.44 ±0.07	0.44 ±0.01	0.44 ±0.03	0.27 ±0.20	0.36 ±0.03
	Springiness (mm/mm)	0.55 ±0.02	0.59 ±0.10	0.66 ±0.03	0.76 ±0.05	0.56 ±0.07	0.54 ±0.11	0.54 ±0.02	0.65 ±0.17	0.61 ±0.12
	Chewiness (kg/mm)	4.05 ±4.70	4.84 ±2.60	1.10 ±1.20	0.79 ±1.20	1.11 ±0.50	2.97 ±1.2	0.41 ±0.9	1.22 ±1.3	1.78 ±0.05
Eggplant	Hardness (kg)	0.48 ±0	2.63 ±0	0.42 ±0.22	0.15 ±2.20	0.32 ±0.32	0.21 ±0.06	0.11 ±0.07	0.61 ±0.68	0.36 ±0.15
	Cohesiveness (mm/mm)	0.65 ±0.01	0.66 ±0.10	0.65 ±0.009	0.61 0.17±	0.62 ±0.03	0.57 ±0.05	0.61 ±0.002	0.50 ±0.02	0.62 ±0.09
	Springiness (mm/mm)	0.86 ±0.10	0.67 ±0.10	0.91 ±0.02	0.88 ±0.10	0.92 ±0.04	0.70 ±0.26	0.80 ±0.28	0.61 ±0.04	0.83 ±0.02
	Chewiness (kg/mm)	0.27 ±1.34	1.04 ±2.60	0.25 ±0.14	0.07 ±0.49	0.18 ±0.04	0.09 ±0.04	0.05 ±0.02	0.18 ±0.2	0.18 ±0.04

*: Not analyzed. (<10^1). Results were showed with ± standard deviation in duplicate.

4.3 pH

pH value of fresh zucchini was 6.27. At the beginning of the storage pH value of zucchini was 6.01, during storage time it slightly decreased till 26th day. Slight increases was obtained just for the last two weeks for zucchini slices. pH value of zucchini achieved 6.17 for the last storage day. When compared with a study which was applied some dipping treatments on zucchini, pH value remained in the 6.0<pH<6.40 range (Bruin et al., 2016). In another study effect of cut type on fresh cut zucchini quality was investigated and samples were packed with rigid polypropylene and sealed with cover of same polymer , the packages stored at 5 °C. In this study pH value of zucchini increased to 6.56 at the end of the storage. (Alves et al., 2011). Therefore, this thesis showed parallelism with literature.

The pH value of fresh eggplant was 5.69, but during storage time it slightly decreased (Fig 4.2). pH value of eggplant samples after storage time for 48 days achieved 5.52. When compared with literature, in a study which was investigated effect of osmotic dehydration, bleaching, and drying on eggplant, pH value of eggplant was determined at 4.75 (Osidacz et al., 2013). In this thesis pH value of eggplant was found higher than this study. In another study, effect of frying, baking and griddling on eggplant was searched and pH value was determined at 5.37, 5.00, 4.90 respectively (Bellılı et al., 2015). This thesis showed similarities with literature.

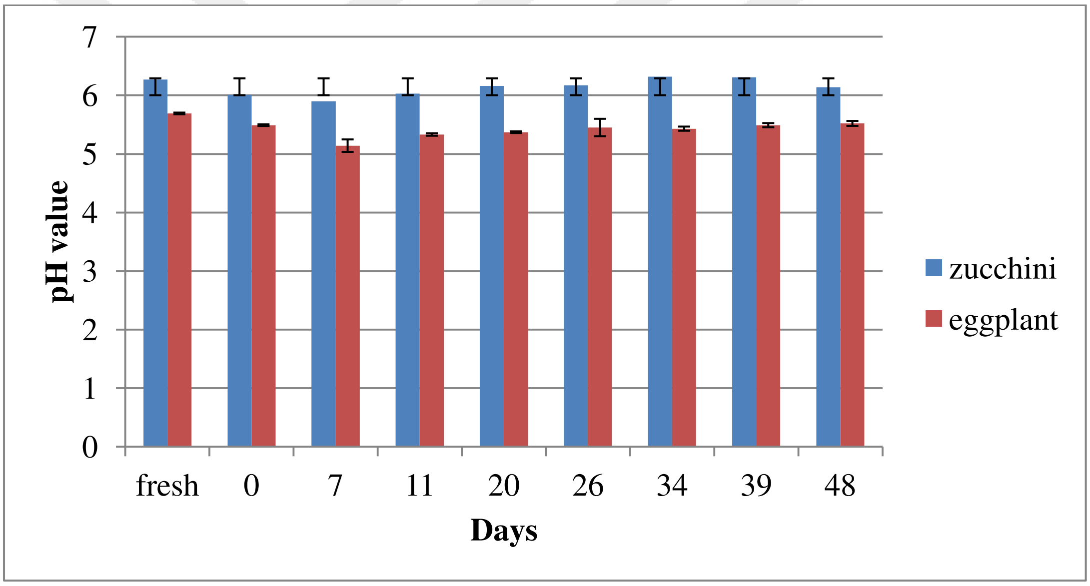

Figure 4.2 Plot of pH value versus storage days*

*Results were showed with ± standard deviation in duplicate.

Dipping ascorbic acid solutions probably lowered pH value in both vegetable slices. Difference between sous vide technology applied zucchini and eggplant samples was significant ($p<0.05$ in appendix). This difference was due to the type of vegetable.

4.4 Color

Surface color measurement was determined by Hunter Lab Colorimeter. The color brightness coordinate L* measures the whiteness value of a color and ranges from black at 0 to white at 100. The chromaticity coordinate a* measures red when positive and green when negative, and chromaticity coordinate b* measures yellow when positive and blue when negative (Batu, 1997).

In this study, color values of fresh zucchini were: L*= 81.54, a*= -1.33, b*= 33.15. By the effect of cooking L* value decreased 70.78 for the first storage day. During the storage period, L* value of zucchini samples showed similarities. It was observed that color was darkened by the effect of cooking. a* value of fresh zucchini was -1,33 at the beginning of the study. This value changed positively. This means that green color was lost, yellow shades of red became evident. Despite the increase of a* value for the 11^{th}, 34^{th} and 39^{th} days of storage, a decrease in 'a' value observed throughout the storage period. Changes in b* values showed similarities along the storage period for 48 days and achieved +34.1 in average.

Eissa et al. (2013) studied effect of different drying methods on the nutrients and non-nutrients compositions of zucchini and color parameters were found as: L* = 65.26, a* = 2.36, b* = 36.73 for fresh zucchini in the study. In another research investigation of drying kinetics of zucchini using microwave energy was investigated and color parameters were found as: 65.26 = L*, 2.36 = a*, 36.73 =b* for slices of dried zucchini (Çelen et al., 2017). When compared with these results, color can change depending on variety of the vegetables.

Color values of fresh eggplant were: L* = 71.92, a* = 1.95, b* = 26.77. By the effect of cooking L* value decreased to 64.72. Parameter L* of eggplant showed slight variations along the entire storage time. Parameter L* was 57.83 and 57.25, for the 7^{th} and 34^{th} days, respectively. At the end of the last storage day, this value remained constant 53.32. a* value for fresh eggplant was 1.95. By applying SV method this value decreased 0.17. After the first storage day, this value increased and changed between the range of 2.06- 2.62 until the last day of the storage. Changes in b* value showed an increase in regard to fresh eggplant. This parameter remained 27.44 at the last storage day.

Ali et al. (2011) studied on optimizing browning capacity of eggplant rings during storage before frying for eggplant and color parameters were found as: L* = 45.70, a* = 9.0, b* = 16.69 for fresh eggplant. When compared with these results, L* and b* values were found higher than this study in thesis.

In another study, the influence of postharvest storage on quality characteristics of fruit of eggplant cultivars was searched and samples were wrapped with PE stretch film and stored 16 °C. After storage, color parameters were found as: L*= 40.1, a*=1.0, b*=2.6 (Bajer et al., 2009).

According to these studies, the results vary depending on the plants growing in different regions and storage conditions. In this thesis, when compared the zucchini and eggplant samples L* and b* values were showed statistically significant differences ($p<0.05$ in appendix). There were no statistically significant differences in a* value between zucchini and eggplant samples ($p>0.05$ in appendix).

Color properties of experimental eggplant and zucchini were shown in Table 4.2

Table 4.2 Color properties of experimental eggplant and zucchini*

Samples	Storage time (days)									
	Days	Fresh	0	7	11	20	26	34	39	48
Zucchini	L*	81.54 ±0.02	70.78 ±0.59	68.68 ±0,20	71.31 ±0,21	70.15 ±0,37	66.62 ±0.45	66.83 ±0,51	60.98 ±0.16	65.91 ±0.05
	a*	-1.33 ±0.06	0.86 ±0.09	0.42 ±0.05	2.95 ±0.12	1.03 ±0.04	0.82 ±0.02	2.01 ±0.03	2.58 ±0.05	0.13 ±0.01
	b*	33.15 ±0.15	34.96 ±0.68	35.64 ±0.34	36.53 ±0.23	34.69 ±0.14	33.36 ±0.33	34.84 ±0.52	34.49 ±0.23	35.05 ±0.19
Eggplant	L*	71.92 ±2.20	64.72 ±0.37	57.83 ±1.00	56.19 ±0.35	53.26 ±0.22	55.59 ±0.40	57.25 ±0.64	51.15 ±0.16	53.32 ±0.07
	a*	1.95 ±1.10	0.17 ±0.04	2.06 ±0.15	1.70 ±0.03	1.47 ±0.04	2.18 ±0.06	2.62 ±0.03	3.36 ±0.04	2.62 ±0.07
	b*	26.77 ±1.50	32.37 ±0.12	30.72 ±0.13	30.27 ±0.57	30.71 ±0.32	31.60 ±0.11	33.01 ±0.38	27.31 ±0.20	27.44 ±0.22

*Results present means of triplicate determinations with ± standard deviation.

According to the results, sous-vide technique decreased color losses in both vegetable samples during the storage period.

4.5 Total Weight Loss

Weight loss which occurs in storage period, is generally dependent on water losses in the products (Demiröven, 2006). Since there were no water losses in the vacuum cooked packed samples, there were no weight losses during the storage period. Changes in total weight loss of zucchini and eggplant samples were shown in Figure 4.3

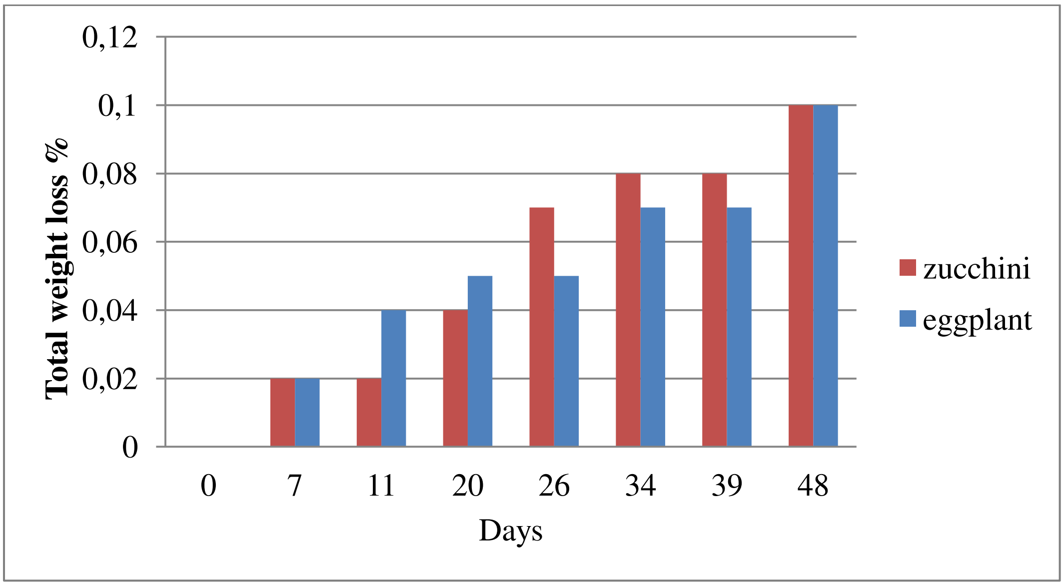

Figure 4.3 Plot of total weight loss versus storage days*

When compared zucchini and eggplant samples, there was no statistically difference in weight loss during storage period ($p>0.05$ in appendix).

4.6 Total Phenolic Content

Phenols, sometimes called phenolics, are a class of chemical compounds consisting of a hydroxyl group (-OH) bonded directly to an aromatic hydrocarbon group. Total phenolic content (TPC) was estimated as gallic acid equivalents (GAE) as described by Folin–Ciocalteau's (FC) method. Initial total phenol content value of zucchini (for fresh zucchini) was 633.16 mg/100g (as gallic acid equivalent, GAE/100 g dry basis (DB)).

This value was doubled by applying sous vide method for the first storage day. From the first day of the storage till 20th day, increasing of total phenol content was observed. There were some fluctuations until the last storage day.

Total phenolic content value of fresh eggplant was 1690.58 mg/100g (as gallic acid equivalent, GAE/100 g DB). This value was decreased by applying sous-vide technology. Results showed similarities both on the 7th and 6th, 0th and 48th days of storage for eggplant. There were some fluctuations until the last storage day. Changes in phenolic content value were shown in Table 4.3

Table 4.3 Total phenolic content of experimental eggplant and zucchini on DB*

Days (storage time)	Zucchini total phenol	Eggplant total phenol
fresh	633.16±2.02	1690.58±1.00
0	1161.30±3.36	1543.13±2.01
7	944.70±0.33	1788.04±0.67
11	953.74±2.35	1619.80±0.33
20	1109.68±3.36	2035.75±0.02
26	995.29±0.33	1800.59±0.33
34	886.12±6.73	1441.98±1.01
39	1148.19±0.14	1612.16±1.35
48	930.38±0.05	1558.64±1.05

*Results present means of triplicate determinations with ± standard deviation.

Magda et al. (2015) searched changes in nutritional quality of zucchini vegetables during maturity and reported that the phenolic content of fresh zucchini was 597.22 mg/100 g DB in an eggplant cultivar. In another study, stability of dietary phenolics and antioxidant properties of vegetables depends on cooking methodology was searched. Results were determined as dry matter. For fresh sample, total phenol content was determined as 173.09, after applying steaming total phenol content changed to 145.50 and by the effect of pressure boiling results of phenolic content changed to 138.84 mg GAE/100 g DW (Kalkan and Yücecan, 2013).

Kalkan and Yücecan (2013) reported that 912.64 mg/100 g DB for fresh eggplant. After applying steaming total phenol content changed to 792.26 and by the effect of pressure boiling, results of phenolic content changed to 809.13 mg GAE/100 g DB. In another study, effect of frying, baking and griddling on eggplant was searched and total phenol content value was determined at 4914.83, 7793.93, 5956.19 mg GAE/100 g DB, respectively (Bellılı et al., 2015).

When compared literature, eggplant and zucchini showed differences in this thesis in terms of total phenolic results on DB. The differences may be due to genetic and environmental factors including the climate, the soil mineral composition and the carrying and storage conditions. Also cultivar and stage of maturity and analysis method can affect phenolic composition (Bayili et al., 2011).

Bayili et al. (2011) was searched phenolic compounds and antioxidant activities in some fruits and vegetables. According to the study, the phenolic content of fresh zucchini was determined as 100.2 and the phenolic content of fresh eggplant 74.1 mg GAE/100 g fresh fruit. In the thesis, total phenol content determined 37.42 and 129.33 mg GAE/100 g for fresh zucchini and eggplant respectively. In regard to study some differences were observed in the thesis. This would mainly correspond to the variety of vegetable samples.

In this thesis, when compared the zucchini and eggplant samples' total phenolic content values were showed statistically significant differences ($p<0.05$ in appendix). Cutting and peeling of vegetables, cooking time affect the breakdown on phenolics (Kalkan and Yücecan, 2013).

4.7 Sensory Analysis

Sous-vide processing applied zucchini and eggplant samples were evaluated by scoring test.

The results of sensory evaluation of samples were shown in Table 4.4

Table 4.4 Results of sensory analysis of eggplant and zucchini with sous-vide method*

Vegetable samples	Storage time (days)								
	Days	0	7	11	20	26	34	39	48
Zucchini	Color	4.2	3.8	4.2	4.2	4.6	4.2	4.2	4.4
	Odour	3.8	3.8	4.2	4.4	4.2	4.2	4.2	4.6
	Taste	3.8	4	4.2	4.4	4.2	4.2	4.2	4.2
	Texture	3.8	4.4	4.8	5	5	4.2	4.8	4.4
	General assessment	3.8	4.2	4.6	4.8	4.8	4.2	4.4	4.4
Eggplant	Color	4.2	4.4	4	5	4.2	4.6	4	4
	Odour	4.6	4.4	3.8	4.8	4.2	4.8	4.4	4.4
	Taste	4.8	4.4	4.6	4.8	4.2	4.8	4.6	4
	Texture	4.4	3.8	4.2	4.8	4.2	4.6	4.8	4.2
	General assessment	4.2	4.2	4.2	4.8	4.2	4.8	4.8	4

When compared zucchini and eggplant samples, sensory analysis results showed similarities in terms of color, odor, texture and general assessment. Difference between vegetable samples (in terms of color, odor, texture and general assessment) was not significant ($p>0.05$ in appendix). The taste value of zucchini and eggplant samples were showed statistically significant differences ($p<0.05$ in appendix). Sensory analysis results showed that the samples could be stored for 48 days without loss of quality characteristics.

CHAPTER V

CONCLUSION

In this study, the effect of sous–vide technology on zucchini and eggplant was investigated in terms of physical, chemical and sensory quality characteristics.

- The moisture content of zucchini and eggplant samples were approximately constant during the storage period and when compared with zucchini and eggplant moisture results there were significant differences between the results $p<0.05$. It was observed that vacuum packed cooking process (SV method) protected the moisture content of samples. SV method was succeed in keeping the moisture ratio for eggplant and zucchini.
- The pH value of both zucchini and eggplant samples showed insignificant differences during the storage period separately.
- Difference between sous-vide technology applied zucchini and eggplant samples was significant in terms of pH value ($p<0.05$).
- There were significant differences in texture of zucchini and eggplant samples during the storage period ($p<0.05$).
- In this study, when compared the zucchini and eggplant samples, L* and b* values were showed statistically significant differences ($p<0.05$). There were no statistically significant differences in a* value between zucchini and eggplant samples ($p>0.05$). According to the results, sous-vide technique decreased color losses in both vegetable samples during the storage period.
- When compared zucchini and eggplant samples, there was no statistically difference in weight loss during storage period ($p>0.05$). No weight loss observed during storage period in both vegetables.

- When compared the zucchini and eggplant samples, total phenolic content values were showed statistically significant differences ($p<0.05$).
- There were fluctuations in total phenolic content values of all samples.
- When compared zucchini and eggplant samples, sensory analysis results showed similarities in terms of color, odor, texture and general assessment. The taste value of zucchini and eggplant samples were showed statistically significant differences ($p<0.05$ in appendix).
- Sensory analysis results showed that the samples could be stored for 48 days without loss of quality characteristics.
- In the correlation analysis of all vegetable samples (Table A.2) results represented pearson correlation (r) between a* value and sensory evaluation (general assessment) (r= 0.228).
- Between b* value and sensory evaluation (general assessment) there was positive correlation (r=0.095).
- When correlation analysis was applied to all vegetable samples used in the research, between L* value and sensory evaluation (general assessment) correlation was found (r= - 0.376).
- Between moisture content and sensory evaluation (general assessment) correlation was found (r= 0.017).
- Between moisture content and pH there was a moderate positive correlation (r=0.557).
- Between total weight loss and sensory evaluation (general assessment) correlation was found (r=0.263).
- Between pH and sensory evaluation (general assessment) correlation was found (r=-0.233).
- Between total phenol and sensory evaluation (general assessment) a positive correlation was found (r=0.357).
- Between hardness and sensory evaluation (general assessment) correlation was found (r=0.05).
- Between cohesiveness and sensory evaluation there was a negative correlation (r= -0.039).

- Between chewiness and sensory evaluation (general assessment) there was a negative correlation (r= -0.481).
- Between springiness and sensory evaluation (general assessment) there was a positive correlation (r=0.323).
- Between pH and total phenol content the correlation was found (r=-0.888).
- Between moisture content and total weight loss the correlation was found (r=0.237).

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APPENDIX

ANOVA RESULTS

Descriptives

Moisture content

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
zucchini	9	94,1311	,30180	,10060	93,8991	94,3631	93,67	94,47
eggplant	9	93,4211	,69019	,23006	92,8906	93,9516	92,35	94,77
Total	18	93,7761	,63283	,14916	93,4614	94,0908	92,35	94,77

Test of Homogeneity of Variances

Moisture content

Levene Statistic	df1	df2	Sig.
2,891	1	16	,108

ANOVA

Moisture content

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2,268	1	2,268	7,995	,012
Within Groups	4,540	16	,284		
Total	6,808	17			

Descriptives

Hardness

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
zucchini	9	2,4600	2,84681	,94894	,2718	4,6482	,00	8,12
eggplant	9	,5878	,78240	,26080	-,0136	1,1892	,11	2,63
Total	18	1,5239	2,24270	,52861	,4086	2,6392	,00	8,12

Test of Homogeneity of Variances

Hardness

Levene Statistic	df1	df2	Sig.
9,218	1	16	,008

ANOVA

Hardness

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	15,773	1	15,773	3,619	,075
Within Groups	69,732	16	4,358		
Total	85,505	17			

Descriptives

Chewiness

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
zucchini	9	2,0300	1,55933	,51978	,8314	3,2286	,41	4,84
eggplant	9	,2567	,30348	,10116	,0234	,4899	,05	1,04
Total	18	1,1433	1,42127	,33500	,4366	1,8501	,05	4,84

Test of Homogeneity of Variances

Chewiness

Levene Statistic	df1	df2	Sig.
17,210	1	16	,001

ANOVA

Chewiness

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	14,151	1	14,151	11,215	,004
Within Groups	20,189	16	1,262		
Total	34,340	17			

Descriptives

Cohesiveness

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
zucchini	9	,4378	,08614	,02871	,3716	,5040	,27	,58
eggplant	9	,6100	,04950	,01650	,5720	,6480	,50	,66
Total	18	,5239	,11178	,02635	,4683	,5795	,27	,66

Test of Homogeneity of Variances

Cohesiveness

Levene Statistic	df1	df2	Sig.
,770	1	16	,393

ANOVA

Cohesiveness

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	,133	1	,133	27,048	,000
Within Groups	,079	16	,005		
Total	,212	17			

Descriptives

Springiness

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
zucchini	9	,6067	,07314	,02438	,5504	,6629	,54	,76
eggplant	9	,7889	,10775	,03592	,7061	,8717	,61	,92
Total	18	,6978	,12950	,03052	,6334	,7622	,54	,92

Test of Homogeneity of Variances

Springiness

Levene Statistic	df1	df2	Sig.
1,552	1	16	,231

ANOVA

Springiness

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	,149	1	,149	17,619	,001
Within Groups	,136	16	,008		
Total	,285	17			

Descriptives

Avalue

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Zucchini	9	1,3478	,96731	,32244	,6042	2,0913	,13	2,95
eggplant	9	2,0144	,89267	,29756	1,3283	2,7006	,17	3,36
Total	18	1,6811	,96590	,22766	1,2008	2,1614	,13	3,36

Test of Homogeneity of Variances

Avalue

Levene Statistic	df1	df2	Sig.
,376	1	16	,548

ANOVA

Avalue

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2,000	1	2,000	2,309	,148
Within Groups	13,860	16	,866		
Total	15,860	17			

Descriptives

Bvalues

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
zucchini	9	34,7456	1,04078	,34693	33,9455	35,5456	33,15	36,53
eggplant	9	30,0222	2,30626	,76875	28,2495	31,7950	26,77	33,01
Total	18	32,3839	2,98635	,70389	30,8988	33,8690	26,77	36,53

Test of Homogeneity of Variances

Bvalues

Levene Statistic	df1	df2	Sig.
7,045	1	16	,017

ANOVA

Bvalues

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	100,394	1	100,394	31,363	,000
Within Groups	51,216	16	3,201		
Total	151,611	17			

Descriptives

Lvalues

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Zucchini	9	69,2000	5,60204	1,86735	64,8939	73,5061	60,98	81,54
Eggplant	9	57,9144	6,51754	2,17251	52,9046	62,9243	51,15	71,92
Total	18	63,5572	8,27479	1,95039	59,4423	67,6722	51,15	81,54

Test of Homogeneity of Variances

Lvalues

Levene Statistic	df1	df2	Sig.
,193	1	16	,666

ANOVA

Lvalues

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	573,137	1	573,137	15,519	,001
Within Groups	590,890	16	36,931		
Total	1164,027	17			

Descriptives

ANOVA

pH value

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1,828	1	1,828	36,798	,000
Within Groups	,795	16	,050		
Total	2,622	17			

pHvalue

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
zucchini	8	6,1463	,15390	,05441	6,0176	6,2749	5,90	6,32
eggplant	10	5,5050	,26433	,08359	5,3159	5,6941	5,14	6,14
Total	18	5,7900	,39274	,09257	5,5947	5,9853	5,14	6,32

Test of Homogeneity of Variances

pH value

Levene Statistic	df1	df2	Sig.
,325	1	16	,576

Descriptives

Totalweightloss

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
zucchini	8	,0513	,03603	,01274	,0211	,0814	,00	,10
eggplant	8	,0500	,03117	,01102	,0239	,0761	,00	,10
Total	16	,0506	,03255	,00814	,0333	,0680	,00	,10

Test of Homogeneity of Variances

Totalweightloss

Levene Statistic	df1	df2	Sig.
1,065	1	14	,320

ANOVA

Totalweightloss

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	,000	1	,000	,006	,942
Within Groups	,016	14	,001		
Total	,016	15			

Descriptives

Totalphenolcontent

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
zucchini	9	973,6236	162,53912	54,17971	848,6850	1098,5622	633,16	1161,31
eggplant	9	1676,7457	177,17773	59,05924	1540,5548	1812,9366	1441,98	2035,76
Total	18	1325,1846	397,58096	93,71073	1127,4723	1522,8970	633,16	2035,76

Test of Homogeneity of Variances

totalphenolcontent

Levene Statistic	df1	df2	Sig.
,155	1	16	,699

ANOVA

Totalphenolcontent

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2224713,233	1	2224713,233	76,965	,000
Within Groups	462487,294	16	28905,456		
Total	2687200,527	17			

Descriptives

Color

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
zucchini	8	4,225	,2252	,0796	4,037	4,413	3,8	4,6
eggplant	8	4,300	,3546	,1254	4,004	4,596	4,0	5,0
Total	16	4,262	,2895	,0724	4,108	4,417	3,8	5,0

Test of Homogeneity of Variances

Color

Levene Statistic	df1	df2	Sig.
2,211	1	14	,159

ANOVA

Color

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	,023	1	,023	,255	,621
Within Groups	1,235	14	,088		
Total	1,258	15			

Descriptives

Odour

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
zucchini	8	4,175	,2712	,0959	3,948	4,402	3,8	4,6
eggplant	8	4,425	,3284	,1161	4,150	4,700	3,8	4,8
Total	16	4,300	,3183	,0796	4,130	4,470	3,8	4,8

Test of Homogeneity of Variances

Odour

Levene Statistic	df1	df2	Sig.
,191	1	14	,669

ANOVA

Odour

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	,250	1	,250	2,756	,119
Within Groups	1,270	14	,091		
Total	1,520	15			

Descriptives

Taste

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
zucchini	8	4,150	,1773	,0627	4,002	4,298	3,8	4,4
eggplant	8	4,525	,3012	,1065	4,273	4,777	4,0	4,8
Total	16	4,337	,3074	,0769	4,174	4,501	3,8	4,8

Test of Homogeneity of Variances

Taste

Levene Statistic	df1	df2	Sig.
3,101	1	14	,100

ANOVA

Taste

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	,563	1	,563	9,211	,009
Within Groups	,855	14	,061		
Total	1,417	15			

Descriptives

Texture

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
zucchini	8	4,550	,4243	,1500	4,195	4,905	3,8	5,0
eggplant	8	4,375	,3454	,1221	4,086	4,664	3,8	4,8
Total	16	4,463	,3845	,0961	4,258	4,667	3,8	5,0

Test of Homogeneity of Variances

Texture

Levene Statistic	df1	df2	Sig.
,618	1	14	,445

ANOVA

Texture

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	,122	1	,122	,819	,381
Within Groups	2,095	14	,150		
Total	2,218	15			

Descriptives

General assesment

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
zucchini	7	4,400	,3651	,1380	4,062	4,738	3,8	4,8
eggplant	9	4,400	,3162	,1054	4,157	4,643	4,0	4,8
Total	16	4,400	,3266	,0816	4,226	4,574	3,8	4,8

Test of Homogeneity of Variances

General assesment

Levene Statistic	df1	df2	Sig.
,051	1	14	,824

ANOVA

General assesment

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	,000	1	,000	,000	1,000
Within Groups	1,600	14	,114		
Total	1,600	15			

Table A.1 Sensory analysis form

SENSORY ANALYSIS FORM

<table>
<tr><td colspan="3">SCORING TEST</td></tr>
<tr><td colspan="2" rowspan="2">Evaluate the samples separately given to you in terms of the following criteria from 5 points.</td><td>Date:</td></tr>
<tr><td>Name:</td></tr>
<tr><td>Quality Parameters</td><td>Zucchini</td><td>Eggplant</td></tr>
<tr><td>Color</td><td></td><td></td></tr>
<tr><td>Odour</td><td></td><td></td></tr>
<tr><td>Taste</td><td></td><td></td></tr>
<tr><td>Texture</td><td></td><td></td></tr>
<tr><td>General assessment</td><td></td><td></td></tr>
<tr><td colspan="3">1 : very poor 2.poor 3. normal 4. good 5.very good</td></tr>
</table>

GALLIC ACID CALIBRATION CURVE

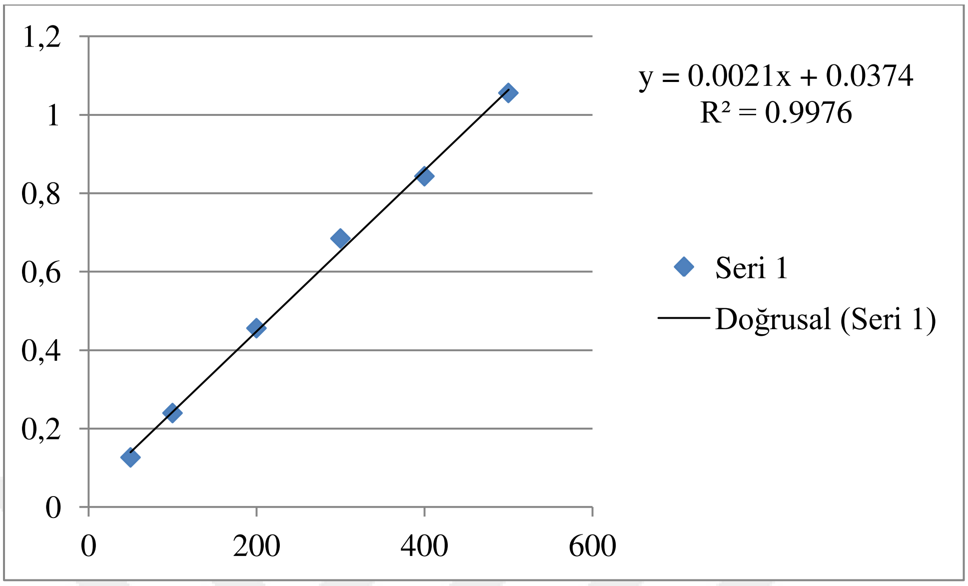

Figure A.2 Plot of gallic acid solutions versus absorbance

Table A.2 Pearson correlations

Correlations

		moisturecontent	a*	b*	L*	ph	totalweightloss	totalphenol	hardness	cohesiveness	springiness	chewiness	color	odor	taste	texture	gen. assement
moisturecontent	Pearson Correlation	1	-,276	,579*	,124	,557*	,237	-,433	,334	-,589*	-,520*	,406	-,067	,001	-,046	,207	,017
	Sig. (2-tailed)		,267	,012	,624	,016	,378	,073	,176	,010	,027	,095	,805	,997	,867	,441	,949
	N	18	18	18	18	18	16	18	18	18	18	18	16	16	16	16	16
avalue	Pearson Correlation	-,276	1	-,403	-,447	-,257	,515*	,301	-,296	,033	,343	-,491*	,182	,419	-,110	,157	,228
	Sig. (2-tailed)	,267		,097	,063	,303	,041	,224	,232	,897	,164	,038	,500	,106	,684	,561	,396
	N	18	18	18	18	18	16	18	18	18	18	18	16	16	16	16	16
bvalues	Pearson Correlation	,579*	-,403	1	,523*	,655**	,009	-,723**	,456	-,608**	-,524*	,443	-,311	-,229	-,288	,498*	,095
	Sig. (2-tailed)	,012	,097		,026	,003	,974	,001	,057	,007	,025	,066	,241	,394	,280	,050	,725
	N	18	18	18	18	18	16	18	18	18	18	18	16	16	16	16	16
Lvalues	Pearson Correlation	,124	-,447	,523*	1	,709**	-,598*	-,753**	,124	-,286	-,494*	,665**	-,199	-,608*	-,517*	-,248	-,376
	Sig. (2-tailed)	,624	,063	,026		,001	,014	,000	,623	,250	,037	,003	,460	,012	,040	,355	,151

	N	18	18	18	18	18	16	18	18	18	18	18	16	16	16	16	16
phvalue	Pearson Correlation	,557*	-,257	,655**	,709**	1	-,105	-,888**	,412	-,808**	-,772**	,587*	-,217	-,324	-,485	,011	-,233
	Sig. (2-tailed)	,016	,303	,003	,001		,699	,000	,089	,000	,000	,010	,420	,222	,057	,967	,385
	N	18	18	18	18	18	16	18	18	18	18	18	16	16	16	16	16
totalweightloss	Pearson Correlation	,237	,515*	,009	-,598*	-,105	1	,274	-,206	-,127	,093	-,442	,137	,341	-,049	,274	,263
	Sig. (2-tailed)	,378	,041	,974	,014	,699		,305	,443	,640	,733	,087	,613	,196	,857	,305	,324
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
totalphenol	Pearson Correlation	-,433	,301	-,723**	-,753**	-,888**	,274	1	-,382	,697**	,758**	-,614**	,304	,459	,581*	,003	,357
	Sig. (2-tailed)	,073	,224	,001	,000	,000	,305		,118	,001	,000	,007	,253	,074	,018	,993	,174
	N	18	18	18	18	18	16	18	18	18	18	18	16	16	16	16	16
hardness	Pearson Correlation	,334	-,296	,456	,124	,412	-,206	-,382	1	-,655**	-,228	,009	-,030	,257	,313	,134	,005
	Sig. (2-tailed)	,176	,232	,057	,623	,089	,443	,118		,003	,362	,973	,912	,337	,238	,620	,987
	N	18	18	18	18	18	16	18	18	18	18	18	16	16	16	16	16
cohesiveness	Pearson Correlation	-,589*	,033	-,608**	-,286	-,808**	-,127	,697**	-,655**	1	,635**	-,251	,017	-,106	,201	-,253	-,039

	Sig. (2-tailed)	,010	,897	,007	,250	,000	,640	,001	,003		,005	,316	,950	,695	,457	,345	,887
	N	18	18	18	18	18	16	18	18	18	18	18	16	16	16	16	16
springiness	Pearson Correlation	-,520*	,343	-,524*	-,494*	-,772**	,093	,758**	-,228	,635**	1	-,602**	,450	,621*	,509*	-,004	,323
	Sig. (2-tailed)	,027	,164	,025	,037	,000	,733	,000	,362	,005		,008	,081	,010	,044	,988	,223
	N	18	18	18	18	18	16	18	18	18	18	18	16	16	16	16	16
chewiness	Pearson Correlation	,406	-,491*	,443	,665**	,587*	-,442	-,614**	,009	-,251	-,602**	1	-,380	-,614*	-,501*	-,327	-,481
	Sig. (2-tailed)	,095	,038	,066	,003	,010	,087	,007	,973	,316	,008		,146	,011	,048	,216	,059
	N	18	18	18	18	18	16	18	18	18	18	18	16	16	16	16	16
color	Pearson Correlation	-,067	,182	-,311	-,199	-,217	,137	,304	-,030	,017	,450	-,380	1	,651**	,436	,274	,508*
	Sig. (2-tailed)	,805	,500	,241	,460	,420	,613	,253	,912	,950	,081	,146		,006	,091	,305	,045
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
odour	Pearson Correlation	,001	,419	-,229	-,608*	-,324	,341	,459	,257	-,106	,621*	-,614*	,651**	1	,640**	,338	,539*
	Sig. (2-tailed)	,997	,106	,394	,012	,222	,196	,074	,337	,695	,010	,011	,006		,008	,201	,031
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16

taste	Pearson Correlation	-,046	-,110	-,288	-,517*	-,485	-,049	,581*	,313	,201	,509*	-,501*	,436	,640**	1	,329	,558*
	Sig. (2-tailed)	,867	,684	,280	,040	,057	,857	,018	,238	,457	,044	,048	,091	,008		,214	,025
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
texture	Pearson Correlation	,207	,157	,498*	-,248	,011	,274	,003	,134	-,253	-,004	-,327	,274	,338	,329	1	,871**
	Sig. (2-tailed)	,441	,561	,050	,355	,967	,305	,993	,620	,345	,988	,216	,305	,201	,214		,000
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
generalassesment	Pearson Correlation	,017	,228	,095	-,376	-,233	,263	,357	,005	-,039	,323	-,481	,508*	,539*	,558*	,871**	1
	Sig. (2-tailed)	,949	,396	,725	,151	,385	,324	,174	,987	,887	,223	,059	,045	,031	,025	,000	
	N	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).