

**UNIVERSITY OF GAZİANTEP
GRADUATE SCHOOL OF
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**AN INVESTIGATION OF CHANGES IN
PHYSICAL AND CHEMICAL
PROPERTIES OF KAVURMA DURING
PROCESSING**

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IN
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**An Investigation Of Changes In Physical and
Chemical Properties Of Kavurma During Processing**

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**Supervisor
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**by
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TO MY ALL,

MY DEAR FATHER

SADIK UZUN

ABSTRACT

AN INVESTIGATION OF CHANGES IN PHYSICAL AND CHEMICAL PROPERTIES OF KAVURMA DURING PROCESSING

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In this study, changes in pH, moisture content, 2-thiobarbituric acid reactive substance (TBARS) value, Hunter colour values (L^* , a^* , b^*), browning index (BI), textural attributes and headspace flavour of cooked meat product (Kavurma) were followed during the processing. Three different salt (1.5%, 2.0% and 2.5%) concentrations and fat percentages (20%, 25% and 30%) were studied during 160 minutes of cooking. Salt, fat and time had significant effects ($P < 0.05$) on the pH, moisture content, TBARS, Hunter L^* and a^* values. Increase in salt and fat content caused to decrease ($P < 0.05$) in pH, moisture content, Hunter L^* and a^* values. However, increase in time caused to increase in pH and TBARS. TBARS values were in the range of 0.14 - 2.05 mg/kg during the cooking process. Among all the samples at the end of cooking, the lowest TBARS value (0.67 mg/kg) was obtained at the salt content of 2.0 % and at the fat content of 25% (S5). The a^* value decreased sharply during the first 40 minute, after that remained constant. However, L^* value firstly increased ($P < 0.05$) up to 80-100 minutes, then decreased. Hunter b^* values affected significantly ($P < 0.05$) by salt content and time but fat didn't cause a significant change in b^* value. Among 25 flavoring compounds identified by headspace GC- MS technique, the major compounds were n-butane, n-heptane, n-hexane, n-octane, n-butanal, 3-methylbutanal, n-pentanal, 2,3-pentadione, n-hexanal, heptanal, 3-methyl-1-butanol, and n-octanal. Time didn't cause a significant change in hardness and chewiness in most of the samples. Adhesiveness values sharply increased ($P < 0.05$) in the samples of S1 (1.5% Salt- 20% Fat), S3 (1.5% Salt- 30% Fat), S4 (2.0% Salt- 20% Fat) and S6 (2.0% Salt- 30% Fat) within the first 20 min of processing and then became constant ($P > 0.05$) until end of the process.

Key Words: Cooked meat product (Kavurma), GC-MS, flavour, texture, TBARS, colour

ÖZET

KAVURMANIN ÜRETİMİ SÜRECİNDE MEYDANA GELEN FİZİKSEL VE KİMYASAL DEĞİŞİMLERİN İNCELENMESİ ÜZERİNE ARAŞTIRMA

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Bu çalışmada, kavurmanın üretimi esnasında, pH, nem içeriği, 2-tiyobarbitürik asit reaktif maddeleri (TBARS), renk değerleri (Hunter L*, a*, b*), kahverengileşme indeksi, dokusal ve koku özelliklerinde meydana gelen değişimler incelenmiştir. 160 dakika süren üretim işleminde 3 farklı tuz (%1,5, %2,0 ve %2,5) ve 3 farklı yağ miktarı (%20, %25 ve %30) çalışılmıştır. Tuz ve yağ miktarının ve pişirme zamanının kavurmanın pH, nem içeriği, TBARS değeri, L* ve a* renk değerlerini önemli derecede etkilediği görülmüştür. Tuz ve yağ miktarındaki artış pH, nem içeriği, Hunter L* ve a* değerlerinde düşüşe neden olurken, pişirme sürecindeki artış ile pH ve TBARS değerlerinin de arttığı gözlemlenmiştir. Pişirme süreci içerisinde, kavurma numuneleri TBARS değerlerinin 0,14- 1,94 aralığında değiştiği görülmüştür. Pişirme sonunda ise, en düşük TBARS değeri (0,67 mg/kg) %2 tuz ve %25 yağ miktarına sahip olan numunede (S5) bulunmuştur. Prosesin ilk 40 dakikasında a* değerinin keskin bir şekilde azaldığı sonrasında ise sabit kaldığı tespit edilmiştir. L* değerinin ise sürecin 80 ve 100 dakikasına kadar arttığı fakat sonrasında azaldığı görülmüştür. Tuz miktarı ve pişirme süresinin b* değerine önemli derecede etki ettiği gözlenirken, yağ miktarının b değerine herhangi bir etkisi olmadığı tespit edilmiştir. Gaz kromatografisi- kütle spektrometresi (GC-MS) tekniği belirlenen 25 aroma bileşenleri arasında n-butane, n-heptane, n-hexane, n-octane, n-butanal, 3-methylbutanal, n-pentanal, 2,3-pentadione, n-hexanal, heptanal, 3-methyl-1-butanol, and n-octanal'ın başlıca bileşenler olduğu bulunmuştur. Pişirme zamanının, kavurma numunelerinin birçoğuna sertlik ve çiğnenebilirlik bakımından önemli derecede etki ettiği tespit edilmiştir. Yapışkanlık değerinin ise S1 (%1,5 Tuz- %20 Yağ), S3(%1,5 Tuz - %30 Yağ), S4 (%2,0 Tuz- %20 Yağ) and S6(%2,0 Tuz- %30 Yağ) numunelerinde ilk 20 dakika içerisinde ani bir şekilde arttığı, sonrasında sürecin bitimine kadar sabit kaldığı gözlemlenmiştir.

Anahtar Kelimeler: Kavurma, GC- MS, koku ve aroma, doku, TBARS, renk

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ABBREVIATIONS

AOAC	Association of Official Analytical Chemists
ANOVA	Analysis of Variance
a [*]	Redness-greenness
b [*]	Yellowness-blueness
BI	Browning Index
L [*]	Lightness-darkness
SPSS	Statistical Package for Social Sciences
TBARS	2- Thiobarbituric Acid Reactive Substance
ND	Not Detected

CHAPTER I

INTRODUCTION

Kavurma is a traditional cooked (fried) meat product manufactured to preserve meat. Kavurma is prepared by cutting beef or lamb into pieces smaller than 7 cm³ and placed in a boiler for cooking. Salt, beef fat, tallow or tailed fat are added to the meat and all are collectively cooked (Kayaardı et al., 2005). Spices or other flavour-giving ingredients may be incorporated to the mix while the product is still warm and then it is filled into natural or artificial cases (such as collagen) and stored under anaerobic conditions (Aksu and Kaya, 2005).

Kavurma is produced in a large amount in various parts of Turkey by traditional methods in small-scale enterprises by open-pan cooking. Manufacturing of the Kavurma is differed with regionally; especially in formulations and techniques. Variety of spices and addition substances are changed according to demands.

For high quality Kavurma; meat pieces must not be elastic, should be easily torn up and be light-brown, there must be no air in the casing, fat content must be 25- 30 % of meat and fat between two meat pieces must not be more than 1-2 cm². General specialties and quality of kavurma are determined according to Turkish Standard Institute (Anonymous, 2002).

A standard and technological method has not been developed and adapted for Kavurma production throughout the country. Thus, serious economical and health problems come from the lack of a standard technology. Many quality characteristics of the Kavurma, i.e. colour, flavour, odour, texture may not be optimised; also some toxic materials can be formed under these conditions. This may resulted in loss of safety and economical values.

There is a few information in the literature with regard to Kavurma. Research on the investigation of changes in physical and chemical properties of Kavurma during the

processing is almost not existing. Aksu and Kaya (2005) determined the effect of α -tocopherol and butylated hydroxyanisole on the colour properties and lipid oxidation of Kavurma made from beef. Kayaardi et al. (2005) studied the chemical characteristics of Kavurma with selected condiments. Yetim et al. (2006) investigated the effects of nitrite on the survival of *Clostridium sporogenes* and the autoxidation properties of the Kavurma made from beef. İbik et al. (2008) also studied the effect of spices on colour changes, autooxidation and sensory properties of Kavurma made from beef and chicken. There has been no study reporting how different salt and fat concentrations and cooking time affect the quality of Kavurma during the processing.

Fat and salt are essential ingredients of Kavurma and their contents are indicative parameter for quality perception of; flavour, texture, colour, lipid oxidation etc. Melted tail fat and table salt are used for Kavurma and they give a typical taste and flavor to the Kavurma. Salt limits the bacterial growth, shortens the time of cooking and gains tender to the meat. Fat also provides apparent taste and tenderness. However, since the amount of fat in Kavurma is higher than other meat products, lipid oxidation is a major problem. High amount of fat affects the quality due to lipid oxidation during the production and also during the storage adversely (Aksu and Kaya, 2005). Meat quality parameters such as colour, flavour, odour, texture and even the nutritional value are affected adversely as a result of oxidation. However, main flavouring compounds are formed by this reaction and therefore it is a major cause of quality factors in meat products (Molly et al., 1996; Fernandez et al., 1997).

Cooking technique is also important for Kavurma production. Because it influences the rate of heat transmission through a meat product and the extent of cooking (King and Whyte, 2006). Thereby affects the quality characteristics of Kavurma; colour, flavour, texture, lipid oxidation, moisture content and pH. Generally, there are two methods which are open pan (atmosphere) and closed pan (pressurised) cooking. Open pan cooking is a traditional way of Kavurma production. Pressure cooking is the other method that shortens the cooking time and retains the nutrients. Cooking method has not been standardized for Kavurma production, it should be designated for the case of understanding the feasible one.

1.1. Aim of the Research

In this work, Kavurma was prepared by open pan cooking technique with different fat and salt concentrations and different cooking times to investigate the changes in physical and chemical properties during the processing. Moisture content, pH, flavour profile, 2-thiobarbituric acid reactive substance (TBARS) values were monitored for chemical changes and colour, texture values were monitored for physical changes in Kavurma during the processing.

Therefore, aim of the research was to;

1. monitor the **chemical** (pH, flavour profile, TBARS values) changes during the processing of Kavurma
2. monitor the **physical** (moisture content, colour, texture) changes during the processing of Kavurma
3. detect the effect of different salt (1.5%, 2.0 % and 2.5%) and fat (20%, 25% and 30%) concentrations on the physical and chemical attributes of Kavurma during the processing
4. determine the optimum cooking time for Kavurma processing according to the moisture content level of kavurma at the end of cooking.
5. develop a **standard method** for Kavurma process with considering quality attributes and optimum conditions (cooking time, fat and salt concentration). By these scientific informations, to shed light on the literature and contribute to the economy.

CHAPTER II

LITERATURE REVIEW

2.1. Meat

Meat is defined as the animal tissue used as food, mostly skeletal muscle and associated fat. It may also refer to organs, including livers, skin, brains, bone marrow, kidneys, in some countries lungs, and a variety of other internal organs as well as blood. As it is the most biological material, it is rather variable in composition. Typical values for different components in skeletal muscle (lean) are given in Table 2.1; the actual composition for a given muscle will vary with the species, age, sex, and diet of the animal as well as its anatomical location.

The lean or muscle tissues which comprises the bulk of all carcasses is the most important meat constituents. It's value lies in it's palatability and nutritive value. Consequently it is the part of the meat in which the consumer must firstly interested in. Fats are the most variable constituents of meat, the amount depending on the manner in which the animal was fed. Fat has a high energy value and contributes to the flavor and tenderness of the lean (Oliphant, 1998).

2.1.1. Meat Composition

Meat is composed of lean tissue or muscle fiber cells, fat and connective tissue. Fat or adipose cells can be found in up to three depots or locations in meat. Fat can be deposited intramuscularly as marbling or contained between muscles (defined as intermuscular fat) or it can be found as external fat or subcutaneous fat. Additionally, meat may include bone, but the trend has moved toward boneless meat cuts. Nervous tissue and components of the blood system are contained within meat but their total weight or proportional contribution to meat is small. These three major components of meat; fat, lean or the myofibrillar component, and connective tissue, affect meat quality in different ways (Miller, 2002).

Table 2.1. Approximate composition of lean meat (percent wet basis)

Component	Composition (%)
Water	75.0 (range 65-80 %)
Protein	18.5 (range 16-22 %)
Lipids	3.0 (range 1.5-13 %)
Non-protein nitrogenous substances	1.5
Free amino acids	0.3
Carbohydrates	1.0
Inorganic constituents	1.0

2.1.1.1. Fat Component

Intramuscular fat content has been shown to affect flavor, juiciness, tenderness and visual characteristics of meat. In general, as fat content increases, palatability increases; however, improvements in palatability with increasing fat percentage are not equal across all fatness levels. Too much visible fat has raised questions about consumption of fat in meat products and increased incidence of coronary heart disease, obesity or some forms of cancer in humans; these issues can affect consumers' perception of acceptability. Therefore, meat with intramuscular fat content between 3 and 7.3 % is generally considered acceptable (Miller, 2002).

2.1.1.2. Lean or Muscle Fiber Component

The major component of meat is lean and lean is mainly composed of muscle fibers. Muscle fibers form the cellular structure that possesses the contractile apparatus of the muscle. Muscle proteins also are the components in the muscle fiber that bind water or interact with water to hold it in the muscle fiber. The structural integrity and the ability of the muscle proteins to bind water affect meat tenderness and juiciness (Miller, 2002).

2.1.1.3. Connective Tissue Component

Perimysium, connective tissue surrounding muscle bundles, and endomysium, connective tissue surrounding muscle fibers, provide structural support to muscles. High-use muscles used for work or major movements have higher connective tissue content than low-use muscles or muscles that provide structural support. Muscles with higher amounts of connective tissue are tougher.

In summary, the three major components of meat, fat, lean and connective tissue, contribute to meat quality with each uniquely contributing to meat juiciness, tenderness and flavor. While each of these components has been discussed separately, they are not independent components, but they are interconnected and interact biologically within the muscle or meat system. Therefore, ante-mortem and post-mortem factors that affect meat quality may affect any of the three components and subsequently affect meat quality (Miller, 2002).

2.1.2. Characteristic of Raw Meat

2.1.2.1. pH

The pH of meat is a measurement of acidity. In a normal living muscle the pH is approximately 7.2. It may decrease after slaughter to pH 5.4 to 5.7 in normal meat, since glycogen is broken down to lactic acid when muscle turns into meat. The highest quality meat tend to fall in the pH range of 5.7 to 6.0. If initial glycogen is limited in muscle, the pH stays high and the meat remains Dark, Firm and Dry (DFD, as it is in the old animal). If the pH decline is rapid (affecting muscle proteins while still warm) or extensive (giving a low ultimate pH), the meat becomes Pale, Soft and Exudative (PSE). Thus, the pH of raw meat has a profound effect on colour, firmness and water-holding capacity, as well as subtle effects on taste, tenderness and rate of post-mortem conditioning (Swatland, 2002). The effect of ultimate pH on the colour of the meat is given in Figure 2.1.

A low meat pH is often associated with low water holding capacity (WHC) and pale meat colour. WHC is the ability of meat to retain its water during processing, storage and cooking. Low WHC often results in high drip loss (negatively affect the appearance) and poor eating quality (drier and tougher in the cooked state). In addition, meat with pale colour and low pH often has a metallic and off-flavour taste. Conversely, high meat pH often causes a dark meat colour and shorter shelf life. Both pale and dark colours are unattractive meat colours to consumers. Also, meat with a higher ultimate pH, which retains more water during storage, will also keep more juice after preparation of the meat. More juice in the prepared meat will give a juicier, more succulent and tender eating experience.

Another important point, the ultimate pH of meat or meat products will affect how the meat colour changes during cooking. If the meat has a high pH, it will have to be cooked to higher endpoint temperatures to get the same visual degree of doneness as one with normal pH. Frequently, complaints of this hard to cook defect are associated with a high pH of the meat or meat product

Consequently, pH is a very important measurement for determining critical meat qualities such as colour, water holding capacity, flavour, cooking property and also impacts eating quality characteristics such as juiciness, tenderness, and taste.

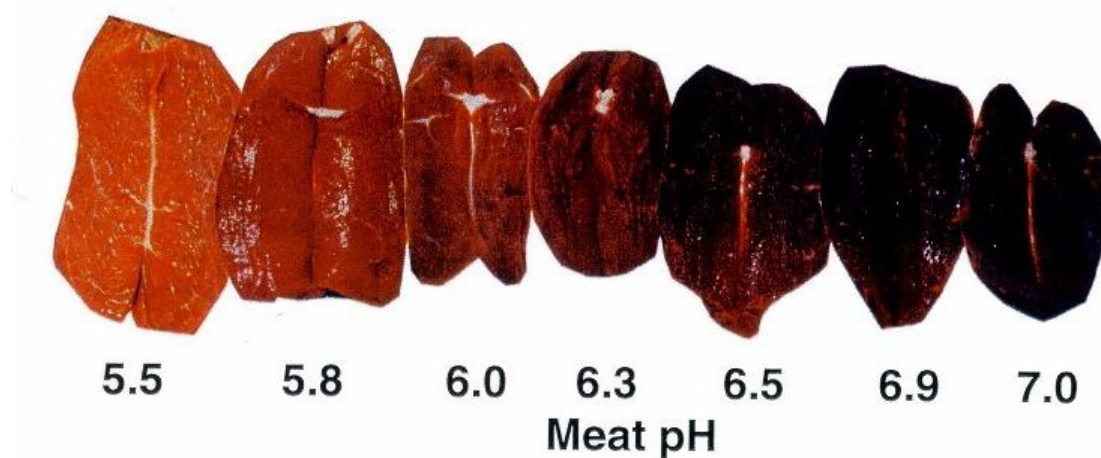


Figure 2.1 The effect of ultimate pH on the meat colour
(<http://animalrange.montana.edu/courses/meat/meatcol.pdf>)

2.1.2.2. Moisture Content

Water is the major compound in the meat. Moisture constitutes about 70 to 77% of raw muscle. The moisture content falls as the fat content of the meat increases, and it can be markedly lowered in processed meats, such as sausages, that contain additional ingredients. In many processed products, reliable control of the moisture content is important for preservation because a low moisture content lowers water activity and helps inhibit microbial growth (Young et al., 2001). Determination of the moisture content is important for the economic perspective for defining physical, chemical and sensory criteria. When moisture content is higher in meat, cooking will be hard and taking time. It is not desirable.

2.1.2.3. Colour

The colour of the fresh meat is an important quality attribute which determines the consumer appeal of the product. Myoglobin is the principal heme pigment responsible for the fresh meat colour (Govindarajan, 1973). As myoglobin content increases, colour intensity of the meat increases from white or pink to very dark red (Miller, 2002).

In fresh meat, the pigment can exist in three different forms: The reduced form of myoglobin (Mb) is purplish, the oxygenated form (MbO₂) is bright red, and the oxidized form (MMb) is brown. Fresh meat colour is determined by the relative abundance of these three forms. The consumer often associates the natural bright red colour (due to oxygenated form) to the freshness of the product since brown colour of the oxidized pigment results from prolonged storage (Govindarajan, 1973).

Besides the concentration and oxidative status of myoglobin, pH change is also important for the colour of fresh meat as indicated before. A fast pH fall early postmortem results in a pale colour whereas a high ultimate pH results in a dark, red colour. A too pale or too dark colour often means that the consumer rejects the meat.

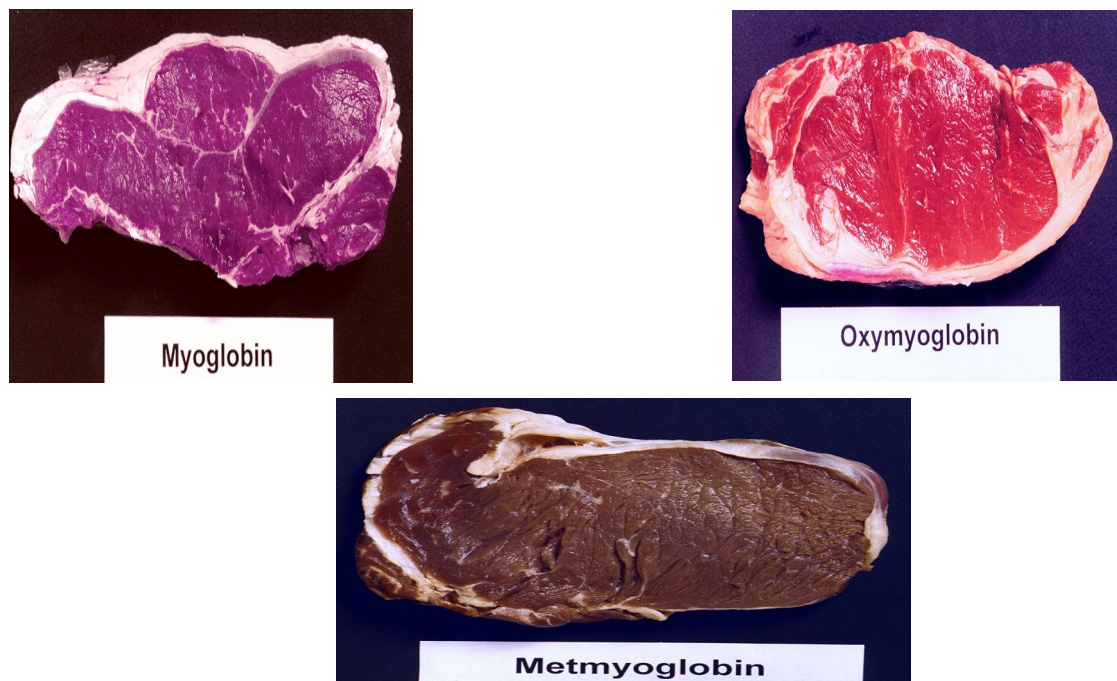


Figure 2.2 Different forms of pigment in meat
(<http://animalrange.montana.edu/courses/meat/meatcol.pdf>)

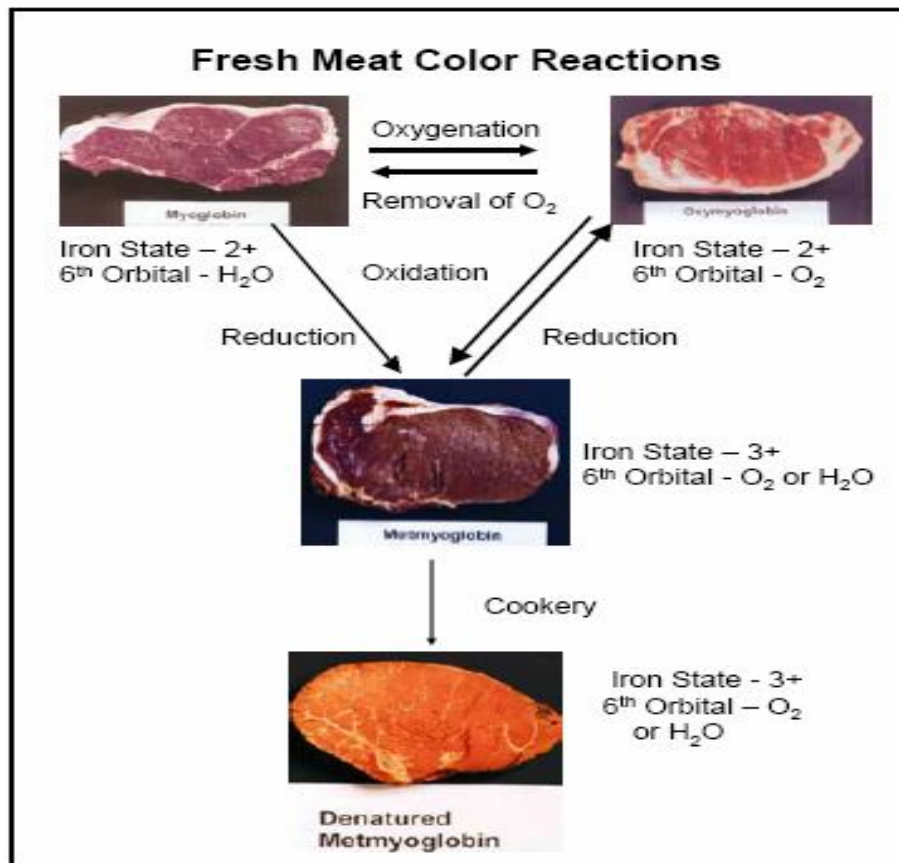


Figure 2.3 Fresh meat colour reactions

(<http://animalrange.montana.edu/courses/meat/meatcol.pdf>)

2.1.2.4. Flavour

Flavour is a very complex attribute of meat palatability (Calkins and Hodgen, 2007) and comprises mainly the two sensations of taste and aroma. The flavour of meat is an important quality criteria because it influences the judgement of the consumer even before it is eaten.

Meat is not ordinarily consumed in raw state. The meat in the fresh, raw state have little flavour of their own, upon heat processing their specific meaty aroma develops (Shahidi, 1989; Farmer, 1992). Also, Cheng and Ockerman (1998) reported that the flavour of raw meat is minimal; however cooked meat usually has a desirable flavour. The odour of raw fresh meat is usually very slight in intensity and reminiscent of commercial lactic acid and blood-like. So, the flavour of meat is thermally derived. However, substances in raw meat have particular importance for flavour forming reactions during cooking. These are free aminoacids, peptides, sugars and also

phospholipids and their fatty acids, while various vitamins and minerals can alter the rate and the extend of these reactions. The amounts and proportions of these compounds will dictate the progress of flavour forming reactions and, hence, the ultimate flavour of the cooked meat (Farmer, 1994).

Flavour and aroma compounds found in meat are shown in Table 2.2. It includes broad array of compounds; hydrocarbons, aldehydes, ketones, alcohols, furans, thiophenes, pyrroles, pyridines, pyrazines, oxazols, thiazols, sulfurous compounds and many others (Macleod, 1994; Ho et al., 1994).

Table 2.2. Compounds identified in beef and characteristic flavours and/or aromas associated with those compounds (Macleod, 1994; Ho et al., 1994)

Compound Name	Characteristic Flavour/Aromas
Benzaldehyde	Volatile almond oil, bitter almond, burning taste
Benzene	Pleasant, distinct
<i>sec</i> - Butanamine	Seafood, green, onion
Butenal	Malty, green, roast
<i>n</i> -Caprioc acid	Goaty
3-Carene	Sweet and pungent odor
Cyclobutanol	Roasted
2,2,6-Trimethylcyclohexanone	Mint, acetone
2,4-Decadienal	Deep fat flavour, chicken flavor at 10 ppm
Decanal	Powerful, waxy, aldehydic, orange, citrus peel
2-Decanal	Tallow, orange
1,3-Bis(1,1-dimethylethyl) benzene	Cooked beef
2,3-Dimethyloxirane	No reference
<i>N,N'</i> -Dimethyl 1,2-ethanediamine	Ammonia
5-Ethylcyclopent-1- enecarboxaldehyde	Fragrant, perfume
2-Pentylfuran	Green bean, butter
2,4-Heptadienal	Nut, fat
Heptanal	Oily, fatty, rancid, unpleasant
5-Methyl 2-heptanamine	No reference
1-Heptanol	Fragrant, woody, oily, green, fatty, winey, sap, herb
2-Heptanone	Fruity, spicy, cinnamon
6-Methyl 2-heptanone	Cloves, menthol, eugenol
2-Heptenal	Soapy, fatty, almond, fishy, unpleasant
3-Ethyl-2-methyl 1,3-hexadiene	No reference
Hexanal	Fatty-green, grassy, strong green, tallow, fat
Hexane	Faint peculiar odor
Hexanol	Woody, cut grass, chemical winey, fatty, fruity
2-Ethyl 1-hexanol	Resin, flower, green
2-Hexen-1-ol	Green, sharp, leafy, fruity, unripe banana
Hydroxymandelic acid	No reference; catecholamine metabolite
Limonene	Pleasant lemon-like, turpentine, citrus, fruity, fresh
Bis(2-trimethylsilyethyl ester) malonic acid	No reference
3-Methylbutanal	Pungent apple-like odor, malt
Methyl salicylate	Cooling sensation, wintergreen, gaultheria
2,4-Nonadienal	Fat, wax, green, watermelon, geranium, pungent
Nonanal	Floral, citrus, fatty, grassy, waxy, green

2-Nonanone	Hot milk, soap, green, fruity, floral
2-Nonenal	Cardboardy, orris, fat, cucumber, paper
Octadecanal	Oil
Octanal	Harsh, fatty, orange, peel, soapy, lemon, green, honey
1-Octanol	Penetrating aromatic odor, fatty, waxy, citrus, burnt
2-Methyl 3-octanone	Herb, butter, resin, gasoline
2-Octenal	Green, nut, fat
(Z)-3-Octene	Fruity, old apples
1-Octen-3-ol	Mushrooms, compound excreted by many insects
2-Octen-1-ol	Green citrus
3-Octen-2-one	Nut, crushed bug, earthy, spicy, herbal, sweet, hay
Hexadecyl oxirane	No reference
Pentanal	Almond, malt, pungent, acrid
Pentane	Very slight warmed overflavor oxidized
1-Pentanol	Mild odor, fusel oil, fruit, balsamic
5-Amino 1-pentanol	Mild
α -Pinene	Piney, fruity, citrus, turpentine
β -Pinene	Pine, citrus, fruity, resin, turpentine
Piperazine	Salty
N-Methyl 1,3-propanediamine	No reference
Propanol	Alcoholic
Styrene	Penetrating odor, sweet smell
Tetradecane	Alkane
Tridecane	Alkane
2-Tridecenal	Sweet, strong, spicy
Undec-4-enal	No reference

2.1.2.5. Texture

Texture is one of the major sensory characteristics of meat and meat products (Szczesniak, 2002; Huidobro et al., 2005; Bozkurt and Bayram, 2006). According to Hammond (1932), texture, as seen by the eye, is a function of the size of the bundles of fibres into which the perimysial septa of connective tissue divide the muscle longitudinally.

Texture includes a variety of characteristics, such as hardness (some authors call it toughness), springiness, chewiness, and some authors also include juiciness, and even greasiness (Brandt et al., 1963). Among texture attributes, hardness is the most important to the consumer, as it decides the commercial value of a meat (Chambers and Bowers, 1993).

Hardness is the force necessary to attain a given deformation or a penetration in a product; in a food it is achieved with molar teeth (Szczesniak, 2002). Springiness (or elasticity) is the rate at which a deformed food goes back to its undeformed condition after the deforming force is removed (Szczesniak, 2002). Juiciness is related to the rate

at which moisture is released and the amount of moisture present (Brandt et al., 1963). Cohesiveness is the strength of the internal bonds making up the body of the sample. Gumminess is the force needed to disintegrate a semisolid sample to a steady state of swallowing. Chewiness is the work needed to chew a solid sample to a steady state of swallowing (Esteves et al., 2005).

For measuring the textural characteristics of meat, the method of Warner-Bratzler shear test is the most widely used texture method. However, Huidobro et al. (2005) declared that texture profile analysis is more convenient than Warner-Bratzler shear test.

Raw meat has a chewy, slippery texture. All of its water is trapped inside the muscle and connective tissue. Pounding a piece of meat doesn't release much juice. Variations in meat texture originate from inherent differences within the structure of raw meat tissue. It is related to contractile protein structures, connective tissue framework, lipid and carbohydrate components as well as the external factors like cooking and sample handling (Solomon et al., 2008). Differences in texture in the meat mostly described as the result of these changes.



Figure 2.4 Fresh meat texture (<http://www.crestock.com/image/25888-Raw-meat-texture.aspx>)

2.1.2.6. Lipid Oxidation

Lipid oxidation is a major cause in the deterioration of the quality of meat and meat products. It has an effect on the flavour, colour, texture and nutritive value.

The oxidation of lipids begins at the moment of slaughter and then continues during storage, processing, heating and further storage of meat. The most important process in oxidation of lipids in meat is peroxidation of polyunsaturated fatty acids from cell membranes (Keller and Kinsella, 1973) which involves the degradation of polyunsaturated fatty acids and the production of secondary decomposition products (Stodolak et al., 2006). One such product is malonaldehyde which has been extensively measured by reacting it with 2- thiobarbituric acid to give so called “TBARS values” which have been used to estimate rancidity development in muscle foods (Pearson et al., 1983).

The major catalysts of the peroxidation of polyunsaturated fatty acids are transition metal ions, such as Fe^{2+} and Cu^{+} . Heme compounds of meat can also contribute to this process, but it is known that the participation of heme iron in accelerating lipid peroxidation is less significant than that of non-heme iron. Heme iron was found to initiate the oxidation of lipids in both raw and heated meat, while non-heme iron played a major role in facilitating the peroxidation of lipids in heated meat (Kanner et al., 1988; Decker and Welch, 1990; Pikul, 1992). The main sources of non-heme iron in meat are chromoproteins (Pikul, 1992). Lipid peroxidation products and free radicals are involved in the oxidation of myoglobin to metmyoglobin, which leads to brown discoloration (Renerre and Labas, 1987).

The mechanism of lipid oxidation in fresh meat is complicated because of the presence of heme pigments which are generally accepted as biocatalysts for the meat lipid oxidation (Dawson and Gartner, 1983). Pearson et al. (1983) indicated that heme and nonheme iron act as catalysts of lipid oxidation in meats. Muscle tissue contains a considerable amount of iron bound to proteins. Myoglobin is the major oxygen storage protein in muscle cells and resembles hemoglobin. Muscle tissue also may contain hemoglobin residues from residual blood. In addition muscle cells also contain cytochromes. All these protein contains the prosthetic group, heme which has an iron

atom at its center. The iron atom by itself promotes oxidation of fats; in the case of heme, the whole iron heme molecule has been claimed to participate in the oxidation reaction (Pearson et al., 1983)

2.1.3. Preservation of Meat

Meat preservation - principally concerned with the application of measures to delay meat spoilage which are caused by municipal chemical and physical changes. Meat chemistry is complex and preserving meat brings even complex chemistry; mostly because there are so many different methods of preservation (www.reichertspr.com)

2.1.3.1. Methods of Meat Preservation

2.1.3.1.1. Drying

Drying is based on the removal of moisture from meat from its original water content (70%) to about 15%. There are two ways of drying which are natural and artificial drying. In natural drying, natural sunlight is used to reduce the moisture content of meat. However, in artificial drying, chamber is used that is equipped with heating elements maintained at a 43°C – 49°C and relative humidity of 85% is used for drying (<http://www.mixph.com/2007/10/meat-preservation-tips.html>)

2.1.3.1.2. Smoking

It is a process of subjecting meat to the action of smoke and heat generated by burning hard wood and/or saw dust. If smoke vapors are allowed to penetrate the surface, meat lasts longer and acquire a preferred flavor. Smoking gives a drying effect to the meat, imparts a desirable taste, gives a pleasant odor, brings out the color of the meat, and helps keep the meat from going rancid and from spoiling (Ellis, 2001).

2.1.3.1.3. Salting

It is a simple method of dehydration in which the salt causes the withdrawal of water from the tissue of both meat and spoilage organisms. Salt inhibits the growth of microorganisms by drawing water out of microbial cells through osmosis. Salt added to a meat system serves three main functions: extracting salt-soluble proteins, enhancing flavor, and extending the shelf life (Claus et al., 1994).

2.1.3.1.4. Curing

Curing is the application of salt, sugar, nitrite (potassium or sodium nitrite) and other preservatives and adjuncts. The highest quality cured product can not be produced by using salt alone, because salt hardens the meat fibres and tends to make meat salty and dry. That is why in most cases sugar and nitrite are added into curing solution. In case of products smoked at low temperatures it also provides margin of safety preventing possibility of botulism (<http://www.wedlinydomowe.com/curing-meat.htm>).

2.1.3.1.5. Refrigeration

Refrigeration is a good way to store meat for the short periods of time. In this preservation process, meat is exposed to 2°C - 10°C to retard mold and bacterial growth for a limited period (www.mixph.com/2007/10/meat-preservations-tips.html). Refrigerated meat should be wrapped to prevent dehydration, odor absorption, and contamination of the meat and other foods in refrigerator (http://ag.ansc.purdue.edu/meat_quality/freezing_and_storage.html).

2.1.3.1.6. Freezing

It is the exposure of meat to a temperature range of -18°C - 0°C resulting to crystallization of the water in the tissues, thus, inhibiting the bacteria and inactivating the enzymes (www.mixph.com/2007/10/meat-preservations-tips.html). Freezing reduces enzyme activity in meat and stops the growth of bacteria and molds. It does not tenderize nor sterilize the meat (www.four-h.purdue.edu/foods/Freezing%20meat%20and%20poultry.htm).

2.1.3.1.7. Canning

It is the hermetic or air tight sealing of food in cans or jars and heating under pressure (pressure cooker, retort, autoclave) to reach the temperature above 100°C at specific period of time. Canning is basically a heat processing operation where heat flows from a hot body (heating medium) to a cold body (food inside the can). The aim of canning is to destroy microbial populations (vegetative cells and spores) and/or enzymes responsible for meat deterioration (Legarreta, 2001).

2.1.3.1.8. Irradiation

Food irradiation is the process of exposing food to radiant energy in order to reduce or eliminate bacteria. Large amount of energy is transferred extremely to result in very rapid and selective biological and chemical changes in meat (www.mixph.com/2007/10/meat-preserved-tips.html). Food is most often irradiated commercially to reduce the numbers of pathogenic microorganisms, to extend shelf-life, or to eliminate insect pests.

2.1.3.1.9. Cooking

Cooking is an another preservation method which makes the meat safe to eat. Cooking is the main process in Kavurma production (Aksu and Kaya, 2005). It develops flavor, color and aroma in the meat. So, making meat delicious, more tender and easier to digest.

2.2. Kavurma

Kavurma, one of the important meat product which is preserved by the technique of cooking, is manufactured and consumed in Turkey, Greece, Germany, Netherland and Middle East countries (Arvanitoyannis et al., 2000; Aksu and Kaya, 2005). Kavurma has been produced for many years in homes and recently in modern plants since it is a very important ready to eat meat product which has the highest shelf life, so satisfying the meat demand in everytime.

To make Kavurma, beef or lamb is cut into pieces smaller than 7×7×7 cm and placed in a boiler for cooking. Salt, beef fat, tallow or tailed fat are added to the meat and all are collectively cooked. Spices or other flavor-giving ingredients may be incorporated to the mix while the product is still warm and then it is filled into natural or artificial cases. Tallow used in production of Kavurma increases the stability of the product; however, it plays an important role in the deterioration of quality due to oxidation. Herbs and spices are used in meat products for various purposes. In addition to enhancing taste properties of meat products, the condiments may have a functional role such as reducing rancidity (Kayaardı et al., 2005).

The research on Kavurma is very limited in the literature. So, in this study a standard method will be developed by considering quality attributes and optimum conditions

(cooking time, fat and salt concentration). Results of this study will shed light to the literature and contribute to the economy.

2.2.1. Preparation of Raw Material for Kavurma

Generally Kavurma is produced from cattle and sheep meat. For the production of Kavurma, meat, fat, salt, antimicrobial and antioxidant materials are used. Also curing material such as NaNO_3 and NaNO_2 can be added. Sometimes with the purpose of giving different tastes to Kavurma, black pepper, thyme, nut or similar ingredients can be added.

According to Anonymous (2002), Kavurma is classified according to the type of meat; such as Cattle animal's Kavurma: Oxen Kavurma, Cow Kavurma, Cattle Kavurma etc. Sheep/goat animal's Kavurma: Lamb Kavurma, Goat Kavurma, Sheep Kavurma etc. Kavurma must be categorized and then should be sold to the market, shops, butcher etc. Cattle Kavurma is only made from cattle meat without bone, and the meat of other animals are not added. If it is sheep Kavurma, according to desire is bony or without bone it is only produced from sheep's meat.

Besides making Kavurma from healthy animal's meat, we can also make Kavurma by, in some conditions, meat of ill animals, but the illness must have been cured and microorganisms of the meat must have been eradicated totally. But, the producer must inform the customer by writing to the package, for example "Made from the meat which produced from an animal with tuberculosis".

Meat of Kavurma; should be fresh, enough mature and frozen after being cut into pieces, then before production, melted and cleared from its cartilage, lymph lump.

For the production of Kavurma using as fat, every kind of species which can make Kavurma from it is meat can be added it is fat to Kavurma, but fat must be clear and must not have a rancid taste. And also, it is necessary that free fatty acid and make number of peroxide must be low. Fat for storage, must frozen under -30°C in vacuum packaging after this freezing event, fat must be deposited.

2.2.1.1. Salt ingredient

Salt is used as an ingredient in Kavurma production. It has many functions in all meat products, thereby in Kavurma also.

It limits the bacterial growth by increasing osmotic pressure and also by decreasing the solubility of CO₂ in the muscle tissue. Another important function of the salt is giving a typical taste and flavour to the food products. Moreover salt is effective in the shortening of the cooking time and heating, because a definite salt content with the heating effect provides the death of microbial load in a short time. Salt also has ability to make tender the food products. During cooking, when salt is added, it increases the boiling temperature and makes easy to cook process thereby gives a tenderness to the meat. Finally, salt provides water binding of proteins by untie of helix structure. Therefore, it increases the water binding capacity of the meat.

According to Anonymous (2002), maximum salt content in Kavurma should be 4% by weight.

2.2.1.2. Fat ingredient

Melted tail fat is also used as an ingredient for Kavurma production. It is obtained from sheep and it has a very deep flavor. It gives an apparent taste, flavour and tenderness to the Kavurma. However, it plays an important role in the quality deterioration due to oxidation since lipid oxidation leads to rancidity in the meat products which is undesirable.

Kavurma is classified in 3 groups according to its fat content which are high fat, medium fat and low fat kavurma. The properties of these types are given in the Table 2.3 (Anonymous, 2002).

Table 2.3. The Variable Fat Contents in Kavurma (Anonymous, 2002)

Type	Fat's (% Weight)
High Fat	35(Interior) - 30(Exterior)
Medium Fat	30(Interior) - 25(Exterior)
Low Fat	25(Interior) - 20(Exterior)

2.2.2. Technology in Kavurma Production

Production scheme of Kavurma is given in Figure 2.5. After trimming of meat, it is generally cutted into 3-7 cm in a meat cutter machine. For bony sheep meat Kavurma, meat and bone are cutted with saw and knife together. Then salt as 2-5 % of meat's weight is added. After that melted tail fat is added as 20-30 % of meat's weight. However, fat should be initially separated into two parts. At the beginning, 20 % of it is added. If it is added more than explained above, mixing will not be easy, and the meat can be crushed. Cooking is started at 50-60 °C. After 30 minutes, the rest of the tallow (80 %) required for the Kavurma production is added to the mix and the temperature is increased to 120 °C. For homogeneous cooking, Kavurma should be mixed very carefully during cooking not to damage meat and it can be advised to mix Kavurma for 20 minute. When the inside meat color turns from red to dark gray, elasticity is lost and meat become easy to fracture by hand, the cooking process is finished. In cooked Kavurma; meat must not be elastic, should be easily teared up and be brown. The reality about Kavurma's, testing after cooking is its moisture content, it should be 40% (Anonymous, 2002).

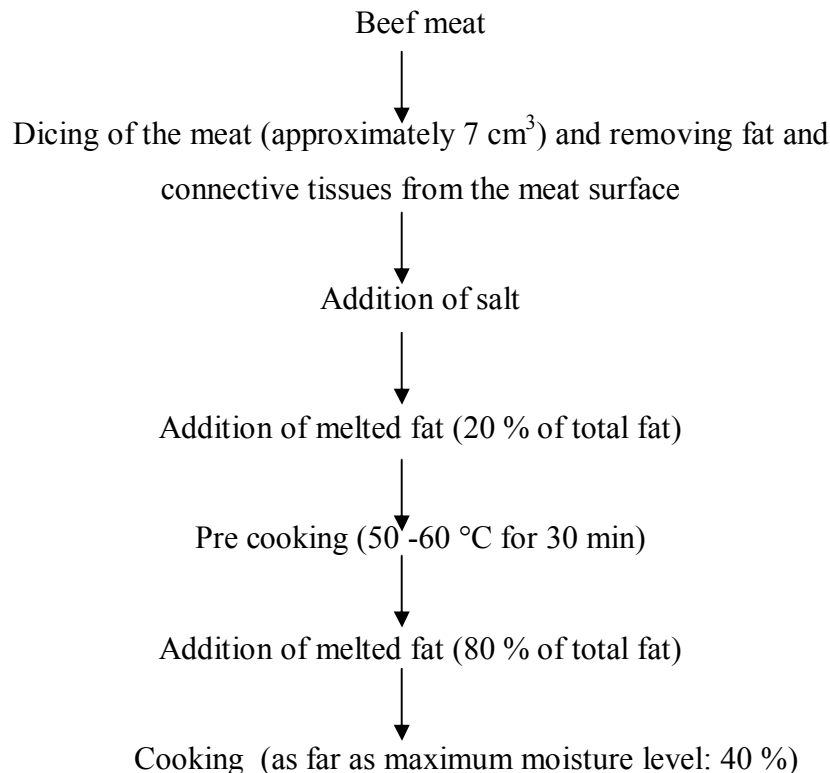


Figure 2.5 Production scheme of Kavurma (Anonymous, 2002).

2.2.3. Techniques of Kavurma Production

2.2.3.1. Open Pan (Atmosphere) Cooking

Open pan cooking is a traditional way of Kavurma production. In this method, meat is cooked uncovered, in hot air, in an oven. It is a slow method of cooking meat that is well-suited to larger cuts where the heat needs time to reach through to the middle. During cooking, meat should be mixed at definite intervals.

In open pan cooking, as time and temperature increases, heat causes the protein in meat to reform and coagulate. But at a certain temperature, the protein begins to coagulate to the point where it starts to squeeze out moisture and juices, and the meat starts to consequently shrink, dry out and get tough.

2.2.3.2. Closed Pan (Pressurised) Cooking

Pressure cooking is also another technique for Kavurma production. In pressure cooking, liquid inside the meat boils, it is trapped inside the pot, having nowhere else to go and so steam builds up pressure. This results in higher cooking temperature and short cooking times (Norton et al., 1994).

Pressure cooking also retains more nutrients than traditional cooking method. Because cooking is done quickly in an almost airless environment, and with very little liquid, vitamins, minerals, and other nutrients aren't boiled away during cooking.

Elmore et al. (2004) also indicated that pressure cooking has an advantage in that there is no sample loss and temperature control is straightforward.

2.2.4. Changes in the characteristics of Kavurma during production

2.2.4.1. Moisture Content

Meat is categorized as perishable food due to its high moisture content. But by cooking, it will be more stable, durable and nonperishable. It is known that Kavurma production is based on the cooking process. Cooking causes the squeezing out water and the longer you cook meat, the more water is forced out. So, moisture content will be decreased

during the production of Kavurma as time passes. The loss of water causes muscle to shrink and become firmer (www.reichertspr.com).

Moisture content of Kavurma is very important, because, it is an objective criteria for checking the end of cooking process. It should be maximum 40% (Anonymous, 2002).

2.2.4.2. Colour

Kavurma is a cooked meat product. Colour measurement in cooked meat can provide reliable information about eating quality attributes. The myoglobin protein is the primary heme pigment responsible for meat colour, but there are other forms contributing to colour changes during the cooking of meat (deoxymyoglobin, oxymyoglobin, sulfmyoglobin, metmyoglobin). The more metmyoglobin that is present in the raw state, the more rapidly meat turns brown-gray, indicating that the oxidative state of meat affects the colour obtained on cooking (García-Segovia et al., 2007). Liu and Chen (2001) reported that during cooking, three forms of myoglobin interconvert and are degraded through oxygenation and oxidation and reduction reactions, ultimately influencing the appearance of meat colour.

During the cooking process, myoglobin is denatured. The cooked pigment is denatured metmyoglobin. It is brown and is easily recognized in cooked meat products (<http://animalrange.montana.edu/courses/meat/meatcol.pdf>).



Figure 2.6 Cooked meat pigment, denatured metmyoglobin
(<http://animalrange.montana.edu/courses/meat/meatcol.pdf>).

By cooking, meat tends to lighten in colour and also tends to turn to a brown-gray hue. The lightening is due to an increased reflection of light arising from light scattering by

denatured proteins. The loss of chroma and change in hue arise from changes in myoglobin (Young et al., 2001). Pearson and Tauber (1984) indicated that meat with an appreciable myoglobin concentration changes from red to greyishbrown when cooked. The brown pigments formed during cooking include denatured globin nicotinamide hemichromes, denatured myoglobin, Maillard reaction products, metmyochromogen and haematin diimidazole complexes.

By cooking for longer, a reddish reduction (DeoxyMb and OxyMb denaturation) and an increase in brownish-red and greenish (MetMb and SulfMb species) colour is obtained. CIELAB colour analysis suggested that the cooked steaks is generally lighter (higher L^*) and more yellow (higher b^*), whereas a^* (red colour) decreased as temperature and cooking time increases (García-Segovia et al., 2007). Resurrección (2003) reported that, a higher L^* value indicates a lighter colour, which is desirable in order to ensure that the meat products will have high consumer acceptance.

Besides cooking itself, other factors affecting the colour of Kavurma during production include pH of raw meat and salt and fat content of Kavurma.

Several studies have identified a correlation between the raw beef pH and the amount of undenatured myoglobin remaining in the cooked product, which itself correlates with red colour (King and Whyte, 2006). When compared to beef of normal pH, the proportion of myoglobin denatured during cooking in high- pH beef is less, and a more intense red colour is measurable. Using absorbance as a measure of myoglobin denaturation, the proportion of myoglobin denatured in ground beef at a normal pH (about) 5.50 can be higher than the same with the pH adjusted to 6.50 when both formulations are cooked to a variety of internal temperatures (Trout, 1989). Swan and Boles (2002), also reported that roasts with high pH (> 5.6 , mean 6.5) were found to have higher L^* , a^* and b^* values than normal pH (5.3 to 5.6, mean 5.5) roasts, that is they were significantly redder. So, it can be easily understood that, generally meat with a pH above normal slows the denaturation of myoglobin and meat can still remain pink even cooked. That's why consumers perceive that high meat pH is less cooked, and will proceed to continue cooking higher temperatures or for a longer time, with subsequent losses in quality such as texture, juiciness.

The addition of salt also can increase the denaturation of myoglobin. Trout (1989) demonstrated that when ground beef patties with concentrations of NaCl between 0% and 3% were cooked and the higher NaCl concentrations increased the percentage of myoglobin denatured. Lytras et al. (1999) also found that the rate of myoglobin denaturation in ground beef with 1.5% to 3% NaCl was almost twice that of salt free meat. As a consequence, the presence of salt causes faster browning of meat, and may cause meat to be visually assessed as cooked before microbiologically safe cooking has occurred (King and Whyte, 2006).

There are publications indicating that fat content does not influence the colour of cooked meat in any readily discernable way (Trout et al., 1992b; Berry, 1994). However, several studies suggest that the fat content of meat may have some effects on the final cooked colour, with higher fat patties appearing less pink (Berry, 1998). So, fat might have an influence on the colour of cooked meat but not as effective as pH and salt.

2.2.4.3. Flavour

Flavour formation during Kavurma production is particularly important. Since raw state have little flavour of their own, upon heat processing their specific meaty aroma develops (Shahidi, 1989; Farmer, 1992). By heating, meat constituents undergo a series of thermally induced reactions to afford a large number of volatile compounds that contribute to its aroma. Some of the non-volatile precursors of volatile flavour compounds are also known to contribute to the taste of cooked meat. The most important taste-active components of meats are amino acids, peptides, organic acids, nucleotides and other flavour enhancers, among others (Shahidi, 1989). Volatile meat flavouring compounds include hydrocarbons, alcohols, carbonyls, carboxylic acids, esters, lactones, ethers, sulphur-containing compounds as well as different classes of heterocyclic compounds, namely furans, pyridines, pyrazines, oxazoles, thiazoles and thiophenes. The volatile compounds, formed during cooking, determine the aroma attributes and contribute most to the characteristic flavours to the meat (Mottram, 1998).

Main flavouring compounds are formed during cooking by Maillard reaction, lipid oxidation, protein degradation and oxidation of flavouring compounds (Shahidi, 1998; Wood et al., 2003; Machiels et al., 2004; Rhee et al., 2005; Calkins and Hodgen, 2007).

The Maillard reaction is mainly responsible for the large number of heterocyclic compounds which have been found in the volatiles of cooked meat and are responsible for savoury, roast and boiled flavours (Mottram, 1998). The Maillard reaction, or nonenzymatic browning, helps explain amines and carbonyl reactions in food. In general, amino compounds condense with the carbonyl group of a reducing sugar in the presence of heat. This produces glycosylamine which is rearranged and dehydrated to form furfural, furanone derivatives, hydroxyketones and dicarbonyl compounds. All of these compounds contribute to flavour to the meat (Calkins and Hodgen, 2007).

Lipids in muscle foods, particularly their phospholipid components, undergo degradation to produce a large number of volatile compounds. The degree of lipid oxidation is mainly dependent on the phospholipid composition. Mottram and Edwards (1983) reported that the characteristic aroma of cooked meat disappeared by the removal of phospholipid from meat, indicating that phospholipids played a significant role in the generation of cooked meat flavor.

Hydroperoxides, the primary products of lipid oxidation, are odorless and tasteless, their degradation leads to the formation of an array of secondary products such as aldehydes, hydrocarbons, alcohols, ketones, acids, esters, furans, lactones and epoxy compounds as well as polymers. These latter classes of compounds are flavour-active, particularly aldehydes, and possess low threshold values in the parts per million or even parts per billion levels, thus they are responsible for the development of warmed-over flavour (WOF), as coined by Tims and Watts (1958), and meat flavour deterioration (MFD) (Drumm and Spanier, 1991). In addition, lipid oxidation products lead to the loss of nutritional value and safety, colour, texture and other functional properties of cooked meat.

Beside the flavours formed by cooking, there is an also effect of pH on the flavour of Kavurma during production. Mottram and Madruga (1995), reported that, as pH increases, colour and polymeric compounds increase and nitrogen containing compounds like pyrazines are favored. Calkins and Hodgen (2007) also indicated that the meat above the normal pH range is perceived to have a decrease in the meat flavour intensity.

Salt is an important ingredient of Kavurma. It contributes characteristic flavour and also it acts as a prooxidant, but sometimes also as an antioxidant. It may promote the displacement of iron from binding sites of heme compounds by interfering with iron-protein interactions. The free iron ions so formed may catalyze lipid peroxidation that leads to develop flavouring compounds.

Fat content is shown to affect palatability, including flavour. As intramuscular fat increases, the fat flavour increases (Miller, 2002). As an ingredient, tail fat is used for the production of Kavurma. It gives an apparent flavour to the meat but it plays an important role in quality loss due to oxidation since lipid oxidation leads to rancidity in meat products.

Cooking rate and the holding time is also effective for the flavour of meat. Cooking at a slower rate and holding for a longer time reduce the intensity of off flavour. It is stated that the slower cooking and longer hold time allow the undesirable volatile compounds to dissipate (James and Calkins, 2005).

2.2.4.4. Texture

Cooking makes connective tissue more tender by converting collagen to gelatin, it coagulates and tends to toughen the proteins of the myofibril. Both these effects depend on time and temperature, the former being more important for the softening of collagen and the latter more critical for myofibrillar toughening. Prolonged cooking times and relatively low temperatures are thus justified for meat which has much connective tissue and conversely. The tenderizing effects of prolonged cooking is additional to that of ageing (conditioning).

Generally, textural quality of Kavurma is tested by a finger or a sharp knife. Turkish Standard Institute (2002) declared that textural attributes of Kavurma are; easily sliceable, mosaic view, no air pocket in it, firm, not too hard, fat should not be either liquid or solid. The main texture defects during the production of Kavurma come from low quality raw material, none or wrong cooking, high water and fat content, conditions of cooking, high fat content, and pH values etc. (Yetim et al., 1992; Aksu and Kaya, 2005; Yetim et al., 2006). Due to the more heat treatment more browning and too hard texture could be attained (Yetim et al., 1992).

2.2.4.5. Lipid Oxidation

Cooked meat is more susceptible to lipid peroxidation than raw meat due to the heating process resulting in acceleration of oxidative reactions with the lipids in meat (Fasseas et al., 2007).

As it is known that cooking is the main process of Kavurma production and the amount of animal fat is higher in Kavurma than other meat products lipid oxidation is an important problem. As mentioned before, cooking makes meats even more vulnerable to oxidation since antioxidative enzymes in the muscle, like catalase and superoxidase dismutase, may denature and lose their activity, while iron containing proteins at the same time become a source of catalytic iron or, like myoglobin and hemoglobin, may be transformed into partly denaturated forms with peroxidase activity (Aksu and Kaya, 2005). That is why cooking leads to dramatic increase in lipid oxidation and developing a warmed over flavor in cooked meats (Tims and Watts, 1958).

2.2.5. Quality of Kavurma

General specialties and quality of Kavurma are determined according to TSI (Anonymous, 2002).

While checking quality of Kavurma, firstly package should be checked. There must not be hole, deformation etc. Label of the package must be checked, after weighting it, checking can be finished partly.

1. Specialities of quality of Kavurma:

- Fat and meat of Kavurma must be in appearance like mosaic. Namely, it must not be deformed and meat and fat must not be mixed etc.
- Fat must not be at the bottom of the can in the frozen form.
- Color's of Kavurma meat; it should be brown or dark brown and it should not be grey and pale. Color of inside should be high brown. Color of meat should not be like red and pink. These colors indicate that Kavurma is not ready for eating and show that it was not well-cooked.

2. Color of Kavurma fat: It should be a kind of yellow which look like white and bright. It should not be grey or white.

- Kavurma should not be so harsh and easily teared up
3. Taste of Kavurma: It should be own style, its salt shouldn't be much, it should not have a rancid taste.

Table 2.5. TSI Values for some chemical properties of Kavurma (Anonymous, 2002)

Properties	Value
Salt (Weight) (wb)	Min. 3%, Max 4%
Acidic Degree Of Fat	Max 2% (Oleic Acid)
Peroxide Value Of Fat	Max 20 mg/kg
pH Value	4.8 – 6.2
Ligament Texture	Max 20%
Moisture Content	Max 40%
Metallic Contamination	
Arsenic (Weight)	Max 0.4 mg/kg
Lead (Weight)	Max 0.2 mg/kg
Copper (Weight)	Max 20 mg/kg

CHAPTER III

MATERIALS AND METHODS

3.1. Materials

Beef, sheep tail fat, and table salt were obtained from a local supermarket in Gaziantep, Turkey. 1,1,3,3- tetraethoxypropane (TEP) and 2-thiobarbituric acid were obtained from Sigma (St. Louis, MO); glacial acetic acid from Merck (Darmstadt, Germany), and perchloric acid from JT Baker (Holland). All chemicals were analytical grade (extra pure).

3.2. Experimental Design

An experimental design for full factorial design was chosen to investigate the effect of salt and fat contents and cooking time on the quality of Kavurma during the processing. In this study, open pan cooking was applied on an oven (Velp, Italy) for Kavurma production. Three different salt content (1.5%, 2.0%, 2.5%) were used and each salt concentration includes three different fat contents (20%, 25%, 30%). Two batches were prepared for each run for all cooking techniques.

Table 3.1. Full factorial experimental design for open cooking of Kavurma

Run number	Salt content (%)	Fat content (%)
S1	1.5	20
S2	1.5	25
S3	1.5	30
S4	2.0	20
S5	2.0	25
S6	2.0	30
S7	2.5	20
S8	2.5	25
S9	2.5	30

3.3. Kavurma Production

Kavurma was produced according to the procedure described by Aksu and Kaya (2005). First of all, beef was trimmed from fat and connective tissue, and was cut into pieces of about 5 x 5 x 5 cm. For 1000 g meat weight, 15, 20 and 25 g table salt (refined and ground) was used and added to meat pieces. Tail fat was melted before usage and 200, 250 and 300 g of melted tail fat was added to 1000 g of meat. First of all, about 20 % of the total tail fat (40, 50 and 60 g/kg of meat) was added to the salty meat and slow cooking at about 50 °C was started in an open kettle for 30 minute. The end of this time was assumed as the beginning time of the Kavurma processing and called $t=0$. After that temperature was increased to 120 ± 2 °C, and the remaining melted tail fat (160, 200 and 240 g/ kg of meat) was added. The meat was cooked in an open pan for 160 minutes and sampling was done by 20 minute intervals (Figure 3.1). Meat pieces were stirred time to time for homogeneous cooking. When the meat colour turned from red to brown, elasticity of meat was lost and meat become easy to fracture by hand and then the cooking was stopped.

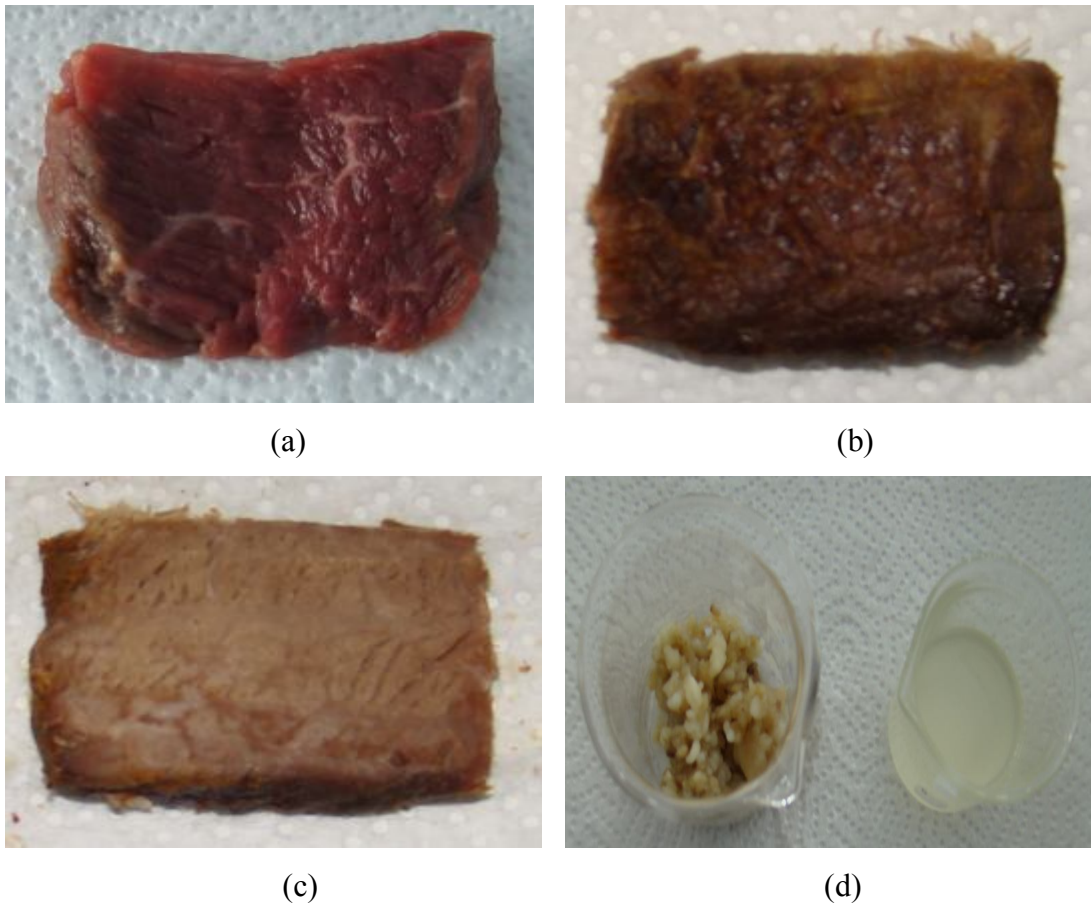


Figure 3.1 (a) Raw meat sample, (b) Kavurma sample, (c) A cutaway piece of Kavurma sample, (d) Tail fat and melted tail fat

3.4. Sampling

Raw meat, melted tail fat and two pieces of meat from each batch removed in time 0th, 20th, 40th, 60th, 80th, 100th, 120th, 140th and 160th minute were used for analysis. Moisture content, pH, Hunter colour values (L*, a* and b*), flavouring compounds, textural attributes and TBARS values of the samples were determined in these time intervals.

3.5. Sample Preparation

Texture and colour attributes were determined on the whole meat. A 2 cm length of meat was cut by sharp knife for texture analysis.

The remaining samples were cut into small pieces (about 5x5x5 mm) and homogenized using a Waring blender (Torrington, CT, USA). Twenty grams of the homogenized samples were used for the determination of flavour, moisture content, pH and TBARS values.

3.6. Determination of Moisture Content

Moisture content of the samples was determined by oven methods (AOAC, 1990) at 105°C until constant weight was reached.

3.7. Determination of pH

The pH value of the sample was determined using a pH meter (Jenway 3010; Jenway LTD, Essex, UK) equipped with a J95, 924001 electrode (Jenway LTD, Essex, UK).

The measurement of pH value was carried out on 10 g of sample homogenised in distilled water (1/10: sample/water).

3.8. Determination of TBARS

2-Thiobarbituric acid reactive substances (TBARS) values of Kavurma were determined by the spectrophotometric method (Bozkurt, 2006). Two g of the homogenized kavurma sample was taken and TBARS were extracted twice with 10 ml of 0.4 M perchloric acid. Extracts were collected and made up to 25 ml with 0.4 M perchloric acid and centrifuged for 5 minutes at 1790 xg. After centrifugation 1 ml of supernatant was pipetted into glass stoppered test tubes. 5 ml of TBA reagent was added and the mixture heated in a boiling water bath for 35 min. After cooling the absorbance of sample was

read against the appropriate blank at 538 nm. A standard curve was prepared using 1,1,3,3-tetraethoxypropane (TEP).

3.9. Determination of Hunter colour values

Colour measurement (Hunter L^* , a^* and b^*) were made by using a Hunter lab ColorFlex (A60-1010-615 Model calorimeter, Hunter lab, Reston, VA). The instrument was standardized each time with a white and black ceramic plates ($L_0 = 93.01$, $a_0 = -1.11$, and $b_0 = 1.30$). The Hunter L^* , a^* , and b^* values correspond to lightness (L^*), greenness ($-a^*$) or redness ($+a^*$), and blueness ($-b^*$) or yellowness, ($+b^*$), respectively. The colour measurements of Kavurma were performed at room temperature ($20^\circ\text{C} \pm 2$) in duplicate for each batch. Browning index (BI; Eq. (1)) were calculated using Hunter L^* , a^* and b^* values (Bozkurt and Bayram, 2006) as;

$$BI = \frac{[100 \times (x - 0.31)]}{0.17} \quad (1)$$

where

$$x = \frac{(a^* + 1.75 \times L^*)}{(5.645 \times L^* + a^* - 3.012 \times b^*)} \quad (2)$$

3.10. Determination of headspace flavour composition

Headspace flavour composition was analysed by using headspace unit (Perkin Elmer HS40 Turbomatrix) equipped with GC-MS (Clarus 500; Perkin Elmer) (Figure 3.2). Flavouring compounds were separated in a Supelcowax 10 capillary column (30 m long, 0.25mm i.d., 0.25 μm film thickness). Volatile compounds were determined in raw meat, melted tail fat and produced flavour during the cooking process (Uzun and Bozkurt, In Press).

Grinded and homogenized meat pieces taken, about 1.5 g, were placed in a 22 ml headspace vial and sealed with a PTFE-butyl septum (Perkin Elmer). The vials were heated at 120°C for 1 h for equilibration of headspace volatile flavouring compounds. After that, vials were placed into Static Headspace unit and reheated in the headspace oven at 75°C for 3 min. Headspace unit temperatures were set to 80°C for needle and



Figure 3.2 Photograph of GC-MS

85°C for transfer line. The other parameters adjusted to 0.5 min for withdraw, 1 min for pressurizing, 0.08 min for injection, 3 min for thermo-stating time on the headspace unit. The GC oven program was started at 40°C and hold for 2 min; then the temperature was increased to 200°C at a rate of 5 °C/min and held for 5 min. Helium at 1 ml/min was used as the carrier gas. The MS was operated in EI⁺ mode with electron energy of 70 eV, source temperature was 180°C scanned from m/z 30 to 350. Identification of the peaks was based on comparison of the spectra of Wiley and NIST/EPA/NIH libraries.

Quantification of flavouring compounds was done by using isoamylalcohol (Merck, Germany) as internal standard.

3.11. Texture profile analysis (TPA)

For texture profile analysis (TPA), meat pieces were cut into 20±0.5 mm height, and hold for equilibration to room temperature (~20°C). TPA tests were performed using a TA.XT2 Texture Analyzer (Figure 3.3) (Texture Technologies Corp., Scarsdale, NY/Stable Microsystems, Godalming, UK) to determine hardness (N), adhesiveness (g.s), springiness, cohesiveness, gumminess, chewiness, and resilience (Kahyaoğlu and Kaya, 2003). Test conditions were: aluminium rectangular probe (4cmx5cm); test speed 1 mm/s; pre-test speed 2 mm/s, post-test speed 1 mm/s; compression (strain) 25 %; and 25 kg load cell. Data collection and calculation were done using the Texture Expert Exceed Version 2V3 (Stable Micro Systems, 1998).

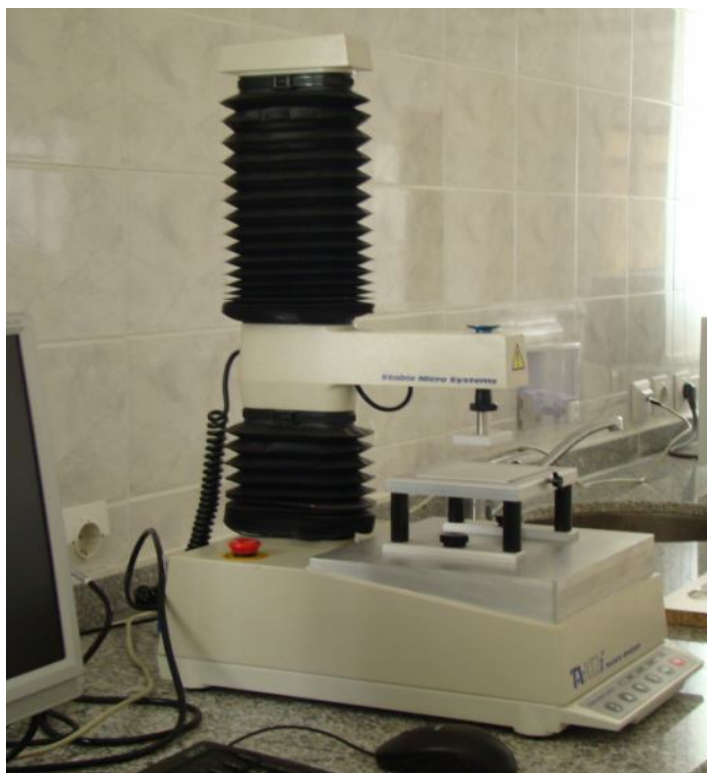


Figure 3.3 Photograph of Texture Analyzer

3.12. Statistical analysis

An ANOVA was performed for flavour, texture, colour attributes, pH, and TBARS values as a function of cooking time to determine significant differences ($P < 0.05$) using the SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). Duncan's multiple range test was also carried out during the cooking period for determination of homogeneous groups. Trends were considered as significant when the means of compared parameters differed at a $P < 0.05$ significance level.

CHAPTER IV

RESULTS AND DISCUSSION

4.1. pH Value

The change in pH values was observed during the production of Kavurma at definite time intervals and specified salt and fat contents (Figure 4.1). Statistical analyses were applied in order to find how salt, fat and the time affected the pH value and to observe the differences of these effects on the pH value of Kavurma. For this reason three and one way ANOVA analysis were applied. One way ANOVA results are shown in Tables 4.1.

Three way ANOVA results showed that salt, fat and time had a significant effect ($P < 0.05$) on the pH value. Increase in salt and fat content caused to a decrease ($P < 0.05$) in pH value. However, by time passing during the production of Kavurma, it was observed that pH value increased. Kayaardi et al. (2005) also observed that pH of Kavurma increased within storage time. The interaction of fat-salt also affected ($P < 0.05$) the pH value. However, fat-time, salt-time and fat-salt-time interactions were not observed ($P > 0.05$).

According to one way ANOVA results, time generally had a significant effect ($P < 0.05$) on the pH value, except S2, S4, S9 samples (Table 4.1). In the samples containing 1.5% and 2.0% salt content, the increase of fat generally didn't affect ($P > 0.05$) the pH value. However, in the samples containing 2.5% salt content, the increase of fat affected ($P < 0.05$) the pH value of Kavurma. So, it could be concluded that, the increase of fat was only effective on the pH value at the high salt content.

For the samples containing same fat content, it was observed that pH was affected ($P < 0.05$) by the increase of salt content only at the high content of fat (30%). In the

Table 4.1. Statistical results for changes in pH values of kavurma recipes during the production with respect to time of cooking, salt and fat content

Time(min.)	Samples								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
0	5.86aAX	6.06aAX	5.86aAX	5.72aAX	5.78abAX	5.68aAY	5.91aAX	6.00abAX	5.80aBXY
20	6.01abAX	5.93aAX	5.94abAX	5.82aAX	5.76aAX	5.75abcAY	5.97bAX	6.04bAX	5.78aAXY
40	6.20abAX	5.97aAX	6.00bcAX	5.86aAY	5.75aABX	5.73abBY	5.99bAY	5.94abAX	5.79aBY
60	6.35bAX	6.05aAX	6.01bcAX	5.81aAX	5.75aAX	5.78bcAY	6.00bAX	5.94abBX	5.84aCY
80	6.28abAX	6.04aAX	6.03bcAX	5.85aAX	5.81abAX	5.76abcAZ	6.01bAX	5.94abABX	5.86aBY
100	6.41bAX	6.04aABX	5.99bcCX	5.83aAY	5.88bAX	5.78bcAY	6.02bAY	5.91abBX	5.82aBY
120	6.19abAX	6.06aAX	6.06cAX	5.80aAZ	5.83abAX	5.81bcAY	6.02bAY	5.86abBX	5.83aBY
140	6.18abAX	6.01aAX	6.06cAX	5.85aAZ	5.85abAX	5.82cAY	5.97bAY	5.89abAX	5.80aAY
160	6.28abAX	6.06aAX	5.98bcAX	5.85aAY	5.80abAX	5.77abcAY	5.99bAY	5.85aABX	5.82aBY

S1: 1.5 % table salt and 20 % sheep tail fat of 1000g beef meat added recipe; S2: 1.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S3: 1.5 % table salt and 30 % sheep tail fat of 1000g beef meat added recipe; S4: 2.0 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S5: 2.0 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S6: 2.0 % table salt and 30% sheep tail fat of 1000g beef meat added recipe; S7: 2.5 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S8: 2.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe and S9: 2.5 % table salt and 30% sheep tail fat of 1000g beef meat added recipe;

Different small letters indicate statistical difference between cooking time values at $\alpha=0.05$ level in each column.

Different capital letters; A, B, C indicate statistical difference between fat content values at same salt content (S1, S2, S3; S4, S5, S6; S7, S8, S9) at $\alpha=0.05$ level among products at each time.

Different capital letters; X, Y, Z indicate statistical difference between salt content values at same fat content (S1, S4, S7; S2, S5, S8; S3, S6, S9) at $\alpha=0.05$ level among products at each time.

20% and 25% fat containing samples, pH wasn't affected significantly ($P>0.05$) by the increase of salt.

In this study, the pH of raw meat was measured as 5.74. The pH range of 5.7 to 6.0 indicated the highest quality meat (Klont, 2005). Along the duration (0-160 min) of the Kavurma production, the lowest pH value was measured as 5.68, while the highest pH value was 6.41. The pH value of the Kavurma ranged between the 5.77 and 6.28 at the end of cooking. According to Kavurma standard (Anonymous, 2002), the pH of Kavurma should be between 4.5 and 6.4. The results obtained in this study was in this range. Vural and Öztan (1989) reported that the pH values of Kavurma were found to be within 6.15- 6.45. Çetin (2000) found that the average pH value in Kavurma sold in market place in Erzurum was 6.06 while Tiryakioğlu and Yücel (1995) reported that the average pH value of Kavurma was 6.39. Arvanitoyannis et al. (2000) found that pH values of Cavourmas (Greek type Kavurma) varied between 6.1 and 6.7. Aksu (2009) observed that the pH value of Kavurma was 6.11 and increased during storage.

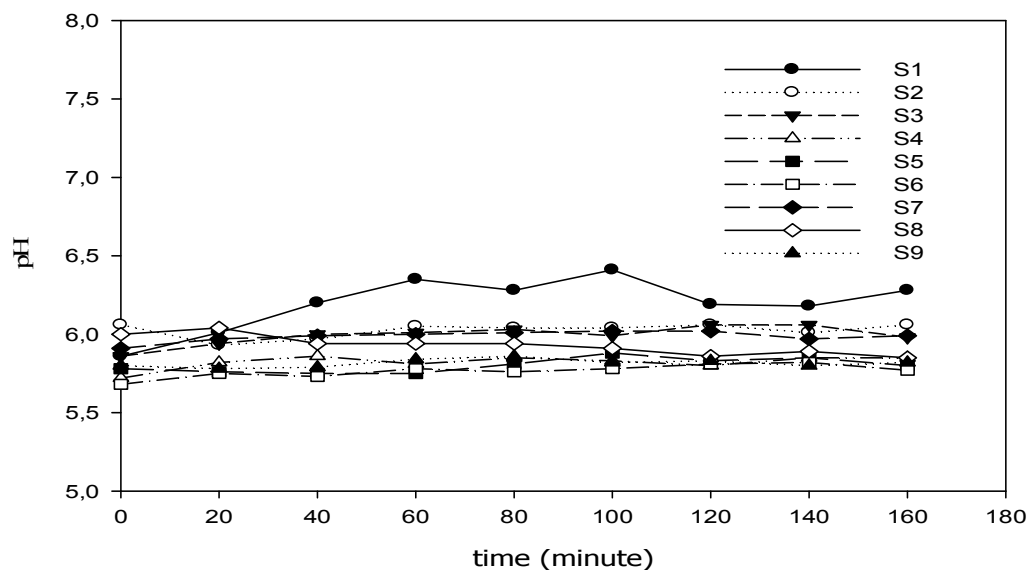


Figure 4.1. The change in pH values of Kavurma samples during the production

4.2. Moisture Content

Moisture content of samples was followed during the cooking process (Figure 4.2). The change in moisture content values and statistical analysis results (one way ANOVA) are shown in the Tables 4.2.

According to three way ANOVA results, the significance value for salt, fat and time was lower than the $\alpha = 0.05$. Each of these factors had a significant effect on the moisture content value. It means that, process time, the use of different salt and fat content caused to obtain different ($P < 0.05$) moisture content values. In this study, as a general, the increase of salt content caused to decrease in moisture content. In the same way, as the fat content was increased, moisture content decreased. When it was looked from the time point of view, moisture content values of samples decreased regularly by the time during the processing. Because, more water could force out and the longer you cooking the meat, moisture content could fall.

The moisture content values of samples were found to be in the range of 69.25% – 41.71% during the processing (Table 4.2 and Figure 4.2). The lowest moisture content value was obtained at the end of processing time as 41.71% in S5. The moisture content values of kavurma in this study were close to the values reported in the literature. Cheng and Ockerman (1998) obtained moisture content as 52.15% in roast beef. Çetin (2000) found that the moisture content in kavurma ranged from 27.37%-58.39%. Arvaniyotannis et al. (2000) determined the moisture content as 46.7%, which is a mean value of 48 samples.

Statistical analysis of one way ANOVA revealed that moisture content of samples prepared with different salt and fat content were affected by the time significantly and decreased ($P < 0.05$) regularly between the 0 and 160th minute of cooking. This can be obviously seen in the Table 4.2.

In the 1.5% salt containing samples, the increase of fat content from 20% to 30% didn't affect ($P > 0.05$) the moisture content during the first 60 minute of process. After that time, moisture content values were affected significantly and decreased ($P < 0.05$) to about 44.82% by the increase of fat content. This could be due to hydrophobic properties of fat. The increase of fat content caused to increase of

Table 4.2. Statistical results for changes of moisture content of kavurma recipes during the production with respect to cooking time, salt and fat content

Time (min.)	Samples								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
0	69.25aAX	64.04aAX	67.48aAX	64.59aAX	64.41aAX	64.51aAX	66.54aAX	63.20aAX	64.22aAX
20	62.01bAX	62.64aAX	62.10bAX	54.62bAZ	54.86bAY	56.78bAZ	58.71bAY	57.03bAY	59.65bAY
40	60.05bcAX	58.40bAX	61.66bAX	54.35bAY	53.29bAY	54.03cAX	55.99bcAY	56.44bcAXY	55.34cAX
60	58.71bcAX	57.72bAX	57.21bcAX	54.05bAY	52.93bAY	52.74cdAY	53.66cdAY	53.02bcAY	53.13cdAY
80	58.30cAX	56.53bcABX	53.58cdBX	51.46bcAY	48.99cBZ	51.59deAX	53.18cdAY	52.14bcAY	52.60deAX
100	57.36cAX	54.18cdBX	52.09cdeBX	50.24bcAY	48.39cAZ	49.39efAX	51.10dAY	51.88bcAY	51.54defAX
120	56.61cAX	53.27cdBX	50.76deCX	49.04cAY	48.05cAY	48.98fAX	50.91dAY	50.77bcAXY	51.45defAX
140	52.97dAX	51.30deAX	46.68efBX	48.91cAY	43.90dBY	45.77gBX	46.57eAY	50.25cBX	50.42efBY
160	50.54dAX	49.12eAX	44.82fBX	47.08cAY	41.71dBY	44.90gAX	44.89eAY	42.56dAX	49.19fAY

S1: 1.5 % table salt and 20 % sheep tail fat of 1000g beef meat added recipe; S2: 1.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S3: 1.5 % table salt and 30 % sheep tail fat of 1000g beef meat added recipe; S4: 2.0 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S5: 2.0 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S6: 2.0 % table salt and 30% sheep tail fat of 1000g beef meat added recipe; S7: 2.5 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S8: 2.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe and S9: 2.5 % table salt and 30% sheep tail fat of 1000g beef meat added recipe;

Different small letters indicate statistical difference between cooking time values at $\alpha=0.05$ level in each column.

Different capital letters; A, B, C indicate statistical difference between fat content values at same salt content (S1, S2, S3; S4, S5, S6; S7, S8, S9) at $\alpha=0.05$ level among products at each time.

Different capital letters; X, Y, Z indicate statistical difference between salt content values at same fat content (S1, S4, S7; S2, S5, S8; S3, S6, S9) at $\alpha=0.05$ level among products at each time.

water. So, it could be easy to remove water from the sample. For the samples containing 2.0% salt content, the increase of fat content didn't cause to a significant effect ($P>0.05$) on the moisture content during the first 60 minute like in the 1.5% salt containing samples. But after that time, increasing the fat content caused to obtain significant difference ($P<0.05$) in moisture content of samples from each other. In the sample containing 2.5% salt content, there was no statistically difference ($P>0.05$) between the values of moisture content during the processing period except 140th minute. Afterwards, the increase of fat content didn't affect ($P>0.05$) the moisture content because salt could start to bind the water.

For each same fat containing sample, the increase of salt content from 1.5% to 2.5% created similar effects on the moisture content values. In all samples, at the time of 0th, increase of salt content didn't affect significantly to the moisture content. This could be due to that salt may not start to bind to water just this time. After that time, increasing the salt content began to affect moisture content significantly and generally caused to decrease the moisture content, because salt could increase the water binding capacity of meat and caused the decrease of moisture content.

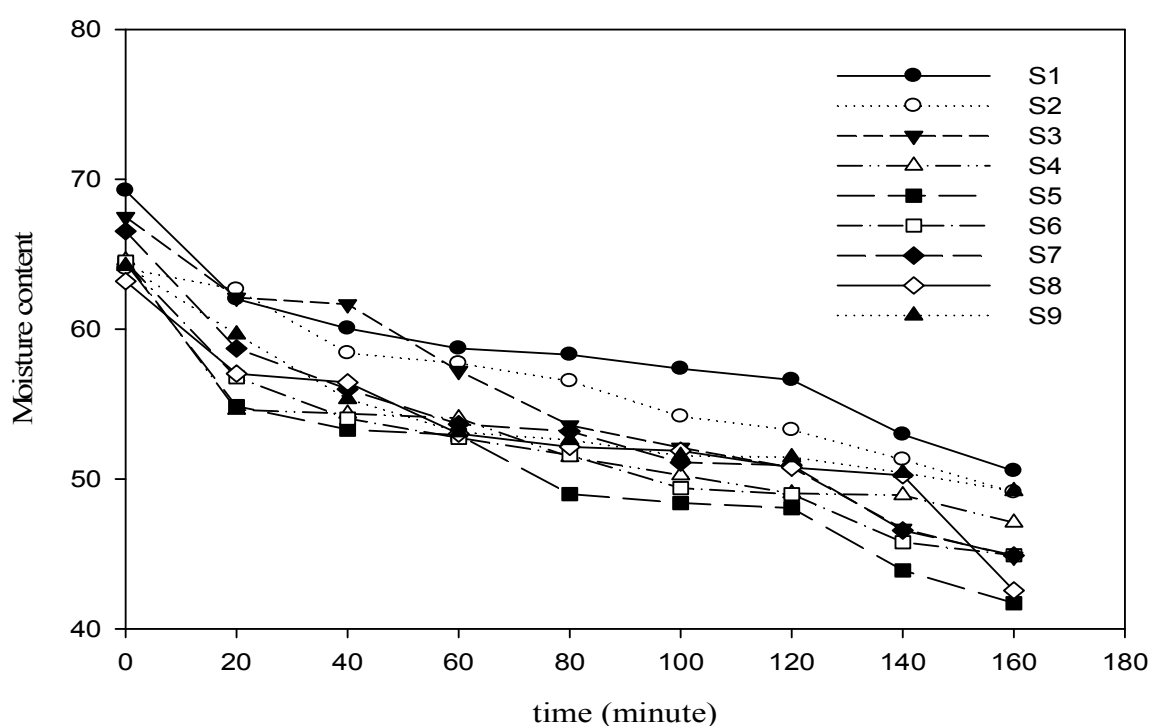


Figure 4.2 The change in moisture content values of Kavurma samples during the production

According to Turkish Standard Institute (Anonymous, 2002) the moisture content should be maximum 40% in kavurma. The optimum moisture content result was obtained in the sample of S5 among all the samples. In this sample, at the end of cooking 41.71% moisture content which was reached which close to the TSI value.

4.3. 2-Thiobarbituricacid Reactive Substance (TBARS)

TBARS values were followed for measuring the lipid oxidation in kavurma during the process (Figure 4.3) The values and the results of statistical analysis results are given in Table 4.3

Salt, fat and time caused a significant change ($P < 0.05$) on the TBARS value during the cooking process (three way ANOVA results). As a general, TBARS values decreased ($P < 0.05$) by increasing the salt content from 1.5% to 2.0%, on the other hand by the increase of salt content from 2.0% to 2.5%, their values increased ($P < 0.05$). Salt content affected TBARS values. TBARS values in 20% and 25% fat containing samples weren't significantly different ($P > 0.05$) from each other, however increasing the fat content to 30%, TBARS values increased ($P < 0.05$) to about 0.87 mg malonaldehyde/kg levels. In three way ANOVA, it was found that TBARS values significantly increased with time 0 to 160 minute during the cooking process. Tim and Watts (1958) reported that cooking increased lipid oxidation in muscle and could increase TBARS values. Moreover, Shadidi et al. (1992) and Maillard et al. (1996) indicated that lipid oxidation could decrease the nutritional value by the formation of potentially toxic products during cooking and processing.

TBARS values were found to be in the range of 0.14 – 1.94 mg malonaldehyde/kg sample during the cooking process. The TBARS values were observed at the end of cooking process varied between 0.67 and 1.94 mg malonaldehyde/kg. These results were in agreement with the previos studies. Yetim et al. (2006) also found that TBARS values of kavurma sample were in the range of 0.125 - 2.56 mg malonaldehyde/kg. Ibik et al. (2007) analysed the TBARS values in beef kavurma and they found 0.2 mg malonaldehyde/kg. Arvanitoyannis et al. (2000) studied TBARS value in many samples which were obtained from different producers in North East Greece and Attica and it was observed that the values were ranging from 0.5 to 7.3 mg malonaldehyde/kg. Wu et al. (1991) reported that if the TBARS value is higher than 1 mg/kg generally off-odours

are formed and it is considered as the beginning of organoleptic perception of lipid oxidation. Also, according to Ockerman (1976), meat products had TBARS value higher than 1 mg/kg could be considered as “rancid”. It was seen in the Table 4.5 and 4.6 that TBARS values higher than 1 mg/kg observed generally at 160 minute. However, in sample S9 (2.5% salt content, 30% fat content) TBARS values higher than 1 mg/kg had already observed after 60 minute. This means that at the high fat and salt content, lipid oxidation so off odours could be formed at the early stage of the cooking process.

According to one way ANOVA results, as in the three way ANOVA results, TBARS values increased ($P<0.05$) by the time during the cooking process. Myoglobin pigments in raw meat when subjected to heat in the presence of oxygen could become denatured and changed to hematin compounds. The ferric heme pigments formed then act as active catalysts which can initiate the oxidation of lipids after cooking. Also cooking caused to breakdown of lipoprotein complex in meat and so lipid fraction could be released and become more susceptible to oxidative attacks (Dawson and Gartner, 1983).

In the 1.5% salt containing samples, there was no difference ($P>0.05$) between the TBARS values by increasing fat content. However, for the samples containing 2% salt, the increase in fat content affected significantly ($P<0.05$) to the TBARS value and caused to increase ($P<0.05$) about 1.52 mg/kg. In the 2.5% salt containing samples, TBARS value was also affected significantly ($P<0.05$) and reaching the maximum value at the end of cooking which was 1.94 among all the samples. So, the highest TBARS value was obtained at the highest salt content (2.5%) and the highest fat content (30%). Because as the salt content increases, water activity decreases and lipid oxidation increases. As the fat content increases lipid oxidation increases. That is why the highest TBARS values were reached at these high salt and fat content.

In the samples containing 20% fat content, TBARS values were not significantly different ($P>0.05$) from each other by increasing salt content. In the 25% fat containing samples, TBARS values decreased ($P<0.05$) by increasing salt content, however, increasing salt content caused to increase in TBARS values in the 30% fat containing sample. Among all the samples, the lowest TBARS value (0.67) was

Table 4.3. Statistical results for changes of TBARS values of kavurma recipes during the production with respect to cooking time, salt and fat content

Time(min.)	Samples								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
0	0.20aAX	0.27aAX	0.28aAX	0.14aAX	0.12aAY	0.34aBX	0.21aAX	0.20aAXY	0.33aAX
20	0.32abAX	0.37aAX	0.31aAX	0.17aAY	0.22bAY	0.44abBX	0.23aAY	0.38abBX	0.89bCY
40	0.34abAXY	0.60bAX	0.47abAX	0.18aAY	0.28bBZ	0.52bcCXY	0.55aAX	0.41abcAY	0.99bcBY
60	0.68abcAX	0.70bAX	0.60abAX	0.19aAX	0.34cBY	0.51bcCX	0.67aAX	0.43abcAY	1.01bcAX
80	0.69abcAX	0.72bAX	0.64abAX	0.21aAX	0.38cBY	0.61cdCX	0.72aAX	0.44abcBY	1.11cCY
100	0.79bcAX	0.77bAX	0.77abAX	0.34bAY	0.35cAY	0.71deBX	0.72aAX	0.47abcBY	1.49dCY
120	0.85bcAX	0.98cAX	0.78abAX	0.50cAX	0.39cAY	0.80efBX	0.78aAX	0.62bcAXY	1.89eBY
140	0.87bcABX	1.14cdAX	0.81abBX	0.62dAX	0.40cBY	0.86fCX	0.87aAX	0.65bcAY	1.93eBY
160	1.15cAX	1.25dAX	1.00bAX	0.80eAX	0.67dAY	1.52gBY	1.31bAX	0.70cAY	1.94eAZ

S1: 1.5 % table salt and 20 % sheep tail fat of 1000g beef meat added recipe; S2: 1.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S3: 1.5 % table salt and 30 % sheep tail fat of 1000g beef meat added recipe; S4: 2.0 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S5: 2.0 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S6: 2.0 % table salt and 30% sheep tail fat of 1000g beef meat added recipe; S7: 2.5 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S8: 2.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe and S9: 2.5 % table salt and 30% sheep tail fat of 1000g beef meat added recipe;

Different small letters indicate statistical difference between cooking time values at $\alpha=0.05$ level in each column.

Different capital letters; A, B, C indicate statistical difference between fat content values at same salt content (S1, S2, S3; S4, S5, S6; S7, S8, S9) at $\alpha=0.05$ level among products at each time.

Different capital letters; X, Y, Z indicate statistical difference between salt content values at same fat content (S1, S4, S7; S2, S5, S8; S3, S6, S9) at $\alpha=0.05$ level among products at each time.

obtained in the sample containing 2% salt and 25% fat (S5). So, neither highest nor the lowest values of salt and fat content was valuable for reaching the optimum values which means lower TBARS values.

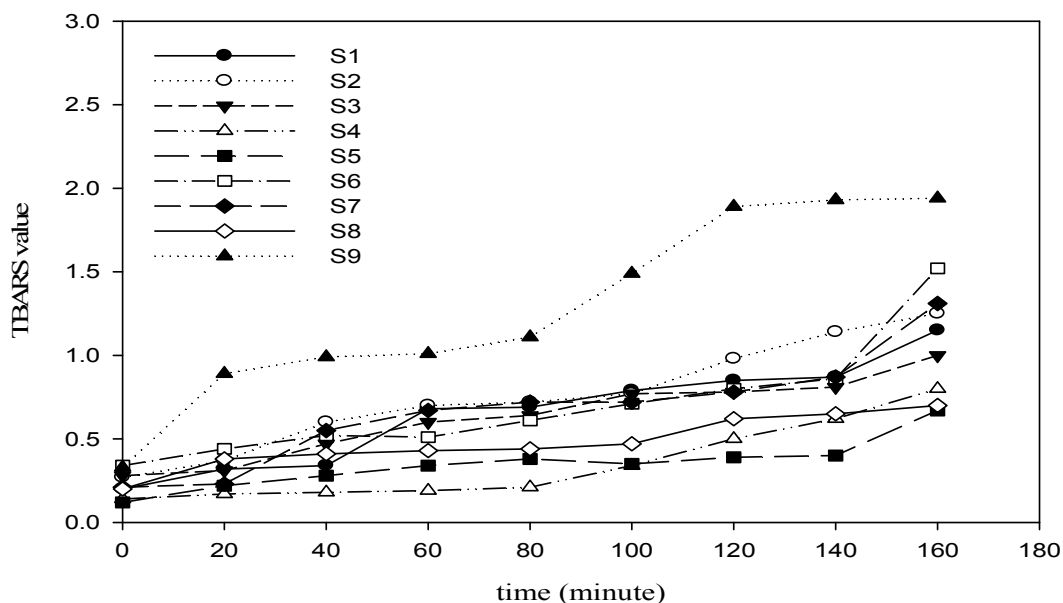


Figure 4.3 The change in TBARS values of Kavurma samples during the production

4.4. CIELAB Hunter Colour Parameters (L^* , a^* and b^*)

CIELAB colour parameters (L^* ; lightness-darkness, a^* ; redness-greenness, b^* ; yellowness-blueness) have been previously proved valuable in describing deterioration of visual colour (Garza et al., 1999; Gunawan and Barringer 2000; Tijskens et al., 2001). The study of colour change in cooked meat during the processing and the storage has been subjected by many investigators (Aksu and Kaya, 2005; Garcia- Segovia et al., 2007). It can be stated that colour of cooked meat product is an important parameter for the consumer preferences and also for the shelf life. Moreover, its measurement can provide reliable information about eating quality attributes.

Changes in Hunter colour (L^* , a^* and b^*) values were followed during the cooking process and browning index (BI) values were calculated by using Hunter L^* , a^* , and b^* values (Bayram and Bozkurt, 2007).

4.4.1. Change in L* values

Three way ANOVA results showed that lightness (Hunter L*) values were affected significantly ($P<0.05$) by increasing salt, fat content and cooking time. As a general, the increase of fat and salt content caused to decrease ($P<0.05$) in lightness value. By time, lightness value firstly increased ($P<0.05$) then decreased ($P<0.05$). The increasing of lightness value could be due to evaporation of moisture. However, the decrease of lightness value illustrated decreasing of the lightness and formation of dark color due to the browning reaction (Bayram and Bozkurt, 2007). Heat causes the breakdown of the tetrapyrrole rings of the muscle protein, myoglobin. Thus, the meat undergoes browning.

The lightness values of samples are shown in the Table 4.4 and Figure 4.4. Among all the samples, the highest ($P<0.05$) L* value was 86.4, while the lowest ($P<0.05$) was as 42.69. In the literature, Arvanitoyannis et al. (2000) found the mean lightness value 45.6 in kavurma samples. Aksu and Kaya (2005) measured lightness parameter in their control sample and reached to 44.4. İbik et al. (2007) also studied lightness value in beef kavurma and found to be 43.1.

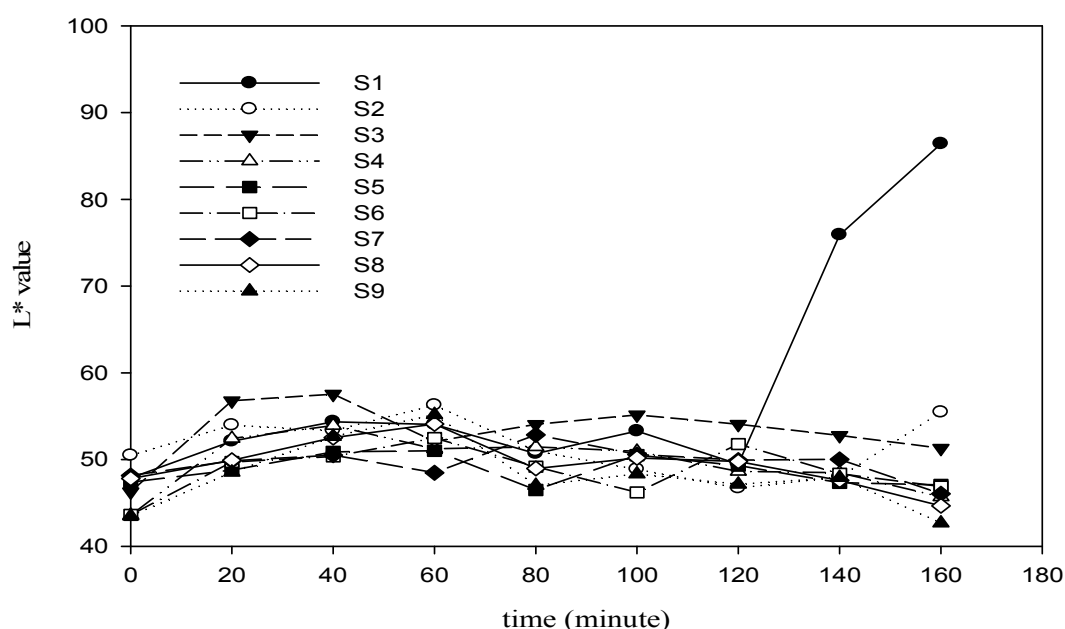


Figure 4.4 The change in L* values of Kavurma samples during the production

The results of one way ANOVA showed that lightness (Hunter L*) values were affected significantly ($P<0.05$) by cooking time. This could be due to heme pigment, myoglobin, which gives desired color to meat, could be denaturated during the cooking process. Generally, in this study, L* value increased during the first 60 min of cooking, after that its value decreased until the end of the cooking process. The increase of lightening at first could be due to an increase in reflection of light arising from light scattering due to evaporation of moisture and then, the decrease of lightening could be due to increase of brown pigments by cooking longer. Similarly, Bozkurt and Belibağlı (2008) found that the lightness value of kavurma firstly increased then decreased during the cooking process. Aksu and Kaya (2005) and Kayaardı et al. (2005) also found that Hunter L* values of kavurma decreased during the storage periods.

In this study, the lowest L* value ($P<0.05$) was found at 2.5% salt content and 30% fat content (S9) at the end of cooking. In this sample, L* value increased from 43.49 to 55.18 during the first 60 minute of cooking. After that, it decreased to 42.69 which was the lowest L* ($P<0.05$) among all the samples, at the end of 160 minute of cooking. So, at the highest fat and salt content, formation of dark color was also the highest at the end of cooking.

At each salt content, the increase of fat content from 20% either to 25% or 30% affected significantly ($P<0.05$) the lightness value. The highest lightness ($P<0.05$) values were observed at the 1.5% salt content as 86.40 at the end of cooking. However, increasing fat content decreased the L* to about 51.31. In the 2.0 % salt containing samples, the increase of fat content also caused to decrease in lightness ($P<0.05$) value during the processing. In the 2.5 % salt containing samples, the increase of fat content caused to obtain lowest lightness values ($P<0.05$) which could be related to formation of darker color. These results were close to the some scientists explanations. Berry (1998) and Berry et al. (2001) explained that fat content of meat had some effect on the final cooked color, with higher fat patties appearing less pink.

At each fat content of 20%, 25% and 30% , the increase of salt content from 1.5% to 2.5% affected the lightness value significantly ($P<0.05$). The increase of salt content

Table 4.4. Statistical results for changes of L* values of kavurma recipes during the production with respect to cooking time, salt and fat content

Time(min.)	Samples								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
0	47.88aAX	50.47abAX	46.27aAX	43.58aAX	47.40abAX	43.61aAX	48.15abAX	47.82abAX	43.49aAX
20	52.11abcAX	53.96bcAX	56.77efAX	52.42cAX	48.78bcBY	49.72cdefBY	49.84bcAX	49.92bcdAY	48.55bAY
40	54.36cAX	53.34bcAX	57.54fBX	53.91cAX	50.88dBY	50.36defBY	50.50bcAY	52.53cdABXY	52.66cBY
60	54.05bcAX	56.26cAX	52.09bcAX	51.23bcAXY	51.01dAY	52.48fBX	48.48bcAY	54.10dBXY	55.18cBY
80	50.69abcAX	50.98abAX	54.05cdBX	51.45bcAX	46.50aBY	49.17cdeABY	52.84dAX	48.96bcBXY	47.02bBZ
100	53.29bcAX	48.87aBX	55.14deCX	50.94bcAX	50.51cdAX	46.21abBY	50.60cAX	50.18bcdAX	48.34bAY
120	49.48abAX	46.72aBX	54.06cdCX	48.63bAX	49.31cdAX	51.78efBY	49.94bcAX	49.78bcAX	47.15bAZ
140	75.90dAX	47.98aBX	52.78bcCX	48.48bAY	47.33abAX	48.35bcdAY	50.02bcAY	47.59abAX	47.93bAY
160	86.40eAX	55.45cBX	51.31bBX	45.68aAY	47.07abBY	46.89bcBY	46.06aAY	44.67aABY	42.69aCZ

S1: 1.5 % table salt and 20 % sheep tail fat of 1000g beef meat added recipe; S2: 1.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S3: 1.5 % table salt and 30 % sheep tail fat of 1000g beef meat added recipe; S4: 2.0 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S5: 2.0 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S6: 2.0 % table salt and 30% sheep tail fat of 1000g beef meat added recipe; S7: 2.5 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S8: 2.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe and S9: 2.5 % table salt and 30% sheep tail fat of 1000g beef meat added recipe;

Different small letters indicate statistical difference between cooking time values at $\alpha=0.05$ level in each column.

Different capital letters; A, B, C indicate statistical difference between fat content values at same salt content (S1, S2, S3; S4, S5, S6; S7, S8, S9) at $\alpha=0.05$ level among products at each time.

Different capital letters; X, Y, Z indicate statistical difference between salt content values at same fat content (S1, S4, S7; S2, S5, S8; S3, S6, S9) at $\alpha=0.05$ level among products at each time.

caused to decrease in lightness ($P<0.05$) value. These results were also supported by some researches. Trout (1989) demonstrated in ground beef patties cooked with 0% to 3% NaCl that increasing in NaCl concentrations increased the percentage of myoglobin denaturated. Lytras et al. (1999) also found that the rate of myoglobin denaturation in ground beef with 1.5% to 3% NaCl was almost twice than that of salt free meat.

The denaturated myoglobin in cooked meat could cause to formation of brown pigments and this was the indicative of decreasing lightness value

4.4.2. Change in a^* (redness) values

Salt, fat and time caused a significant change ($P<0.05$) in Hunter a^* (redness) values during the processing of kavurma (three way ANOVA results). As a general, the increase of fat and salt content caused to decrease ($P<0.05$) in Hunter a^* values. This could be due to increase of denaturation of myoglobin. The increase of cooking time also caused to decrease of a^* values. By cooking longer, a reddish reduction (deoxymyoglobin and oxymyoglobin denaturation) and an increase in brownish-red and greenish (metmyoglobin and sulfmyoglobin species) could be obtained.

The redness values of samples are given in Table 4.5. The Hunter a^* value decreased sharply ($P<0.05$) during the first 40 minutes (Figure 4.5). This was probably due to the partial or total denaturation of myoglobin because of the heat treatment. Bayram and Bozkurt (2007) reported that the decrease in the Hunter a^* value could be due to the pigment degradation. After that time, Hunter a^* values remained constant ($P>0.05$) about in the range of 4.00-6.00 until the end of cooking except the sample of S1. In this sample, redness value increased sharply ($P<0.05$) to 39.07 and 41.54 at 140th and 160th minutes, respectively.

In the 1.5% salt containing samples, the increase of fat content from 20% to 25% caused to decrease ($P<0.05$) in redness value, while the increase of fat content from 25% to 30% didn't cause significant change ($P>0.05$) in redness value. In the 2.0% salt containing samples, redness values were not significantly different ($P>0.05$) from each other by increasing fat content. In the samples containing 2.5% salt content, with the increase of fat content, redness values generally remained constant.

Table 4.5. Statistical results for changes of a* values of kavurma recipes during the production with respect to cooking time, salt and fat content

Time (min.)	Samples								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
0	11.52aAX	10.02aAX	12.26aAX	12.24aABX	13.23aAX	11.19aCZ	11.63aAX	10.08aAX	14.07aBY
20	6.80bAX	3.08bBX	7.66bAX	10.06aAX	5.82bcAY	9.71aAX	6.67bcAX	10.22aAZ	10.22bAX
40	5.52cAX	4.22bAX	4.77cAX	6.97bAX	5.85bcAX	6.32bAY	5.70dABX	4.69bAX	6.11cCY
60	4.41cAX	3.02bBX	4.21cAX	5.74bAY	6.30bBZ	5.62bAY	5.13dAXY	5.23bAY	5.18cAY
80	4.99cAX	3.38bBX	2.87cBX	5.60bAX	4.87cBY	5.32bABY	5.51dAX	5.17bAY	5.66cAY
100	5.08cAX	3.61bBX	4.33cABX	4.63bAX	5.55bcAY	5.52bAY	5.58dAX	4.83bBY	5.46cAY
120	5.54cAX	4.33bBX	4.14cBX	5.89bAX	5.37bcAY	5.75bAY	5.44dAX	5.91bAY	5.74cAY
140	39.07dAX	4.48bBX	4.47cBX	5.60bAY	5.80bcAY	5.67bAY	5.89cdAY	6.20bAY	5.39cAXY
160	41.54eAX	4.16bBX	5.03cCX	5.82bAZ	6.19bAY	5.70bAY	6.87bAY	6.15bBY	5.98cBY

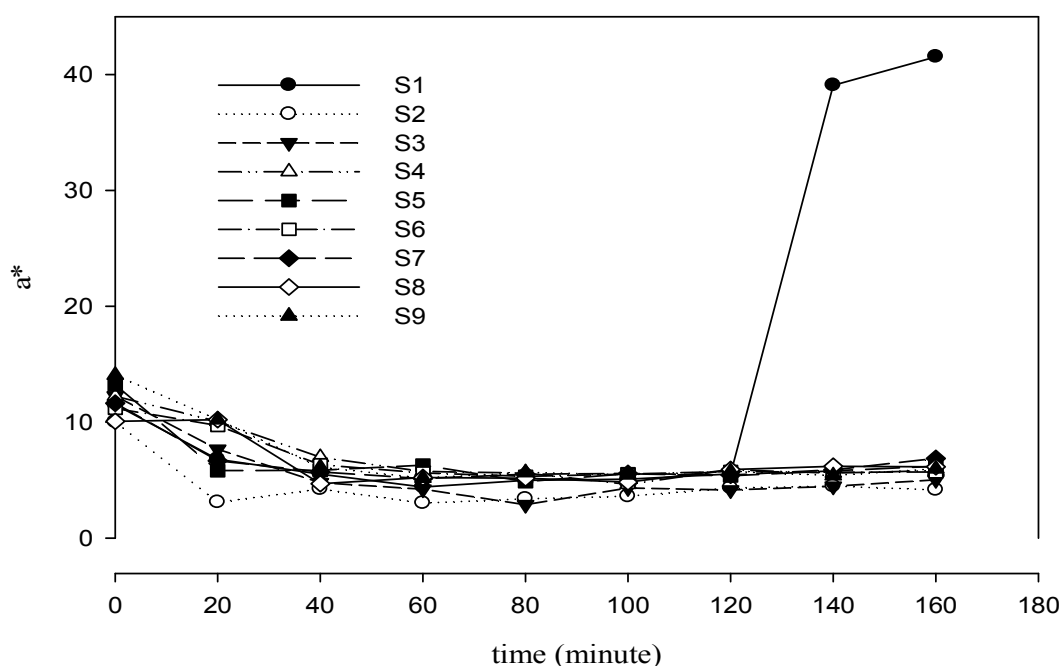
S1: 1.5 % table salt and 20 % sheep tail fat of 1000g beef meat added recipe; S2: 1.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S3: 1.5 % table salt and 30 % sheep tail fat of 1000g beef meat added recipe; S4: 2.0 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S5: 2.0 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S6: 2.0 % table salt and 30% sheep tail fat of 1000g beef meat added recipe; S7: 2.5 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S8: 2.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe and S9: 2.5 % table salt and 30% sheep tail fat of 1000g beef meat added recipe;

Different small letters indicate statistical difference between cooking time values at $\alpha=0.05$ level in each column.

Different capital letters; A, B, C indicate statistical difference between fat content values at same salt content (S1, S2, S3; S4, S5, S6; S7, S8, S9) at $\alpha=0.05$ level among products at each time.

Different capital letters; X, Y, Z indicate statistical difference between salt content values at same fat content (S1, S4, S7; S2, S5, S8; S3, S6, S9) at $\alpha=0.05$ level among products at each time.

In the 20% fat containing samples, the increase of salt content didn't cause a significant change in redness values during the first 120 minute, but at 140 and 160 minute the increase of salt content caused to decrease in redness values sharply ($P<0.05$). In the samples containing 25% and 30% fat, generally the increase of salt content caused to increase ($P<0.05$) in redness value.



Fi

Figure 4.5 The change in a^* values of Kavurma samples during the production

4.4.3. Change in b^* (yellowness) values

According to three way ANOVA results, Hunter b^* (yellowness) values affected significantly ($P<0.05$) by salt content and time but fat didn't cause a significant change ($P>0.05$) in yellowness value. The increase of salt content and cooking time caused to decrease of yellowness value which indicates that the color of kavurma turned to blue (approaching a negative b -value) rather than yellow.

The Hunter b^* values of samples are shown in Tables 4.6 and Figure 4.6. The values were changed in the range of 11.90-17.20. Arvanitoyannis et al. (2000) also found the mean b^* (yellowness) value of kavurma samples as 13.1 in their study.

Table 4.6. Statistical results for changes of b^* values of kavurma recipes during the production with respect to cooking time, salt and fat content

Time (min.)	Samples								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
0	16.63aAX	17.20aAX	15.49abAX	14.23aAY	16.58aAX	14.04aAY	14.72aAXY	15.36aAX	15.38abAXY
20	12.96eAX	14.35bcdABX	16.36aBX	17.05bAY	13.96bcBX	15.70bABX	13.83abcAX	15.51aABY	16.12bBX
40	15.84abAX	14.28bcdBX	13.14cBX	13.86aAY	13.48bcAX	14.06aAX	14.11abAXY	13.31bAX	13.24cdeAX
60	14.16cdeABX	14.44bcdAX	13.79cBX	13.84aAX	14.19bcAX	13.69aAXY	12.79cAY	13.76bAX	13.32cdAY
80	13.24eAX	13.63dAX	14.05cAX	14.23aAX	12.27cBX	14.00aAX	14.04abcAX	12.49bCX	13.39cdBY
100	13.68deAX	14.04cdAX	14.00cAX	14.15aAXY	13.52bcABX	13.08aBX	14.55aAY	13.24bBX	13.37cdABX
120	14.76bcdAX	15.26bAX	14.37bcAX	13.84aAXY	13.77bcAXY	13.96aAX	12.86bcAY	13.24bAY	12.10deAY
140	14.22cdeAX	15.03bcAX	14.46bcAX	13.45aAX	13.95bcAY	13.17aAY	14.60aAX	13.21bBZ	14.42acAX
160	15.09bcAX	14.80bcABXY	13.94cBX	12.88aAY	15.24abBY	14.22aABX	14.94aAX	12.76bBX	11.90eBY

S1: 1.5 % table salt and 20 % sheep tail fat of 1000g beef meat added recipe; S2: 1.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S3: 1.5 % table salt and 30 % sheep tail fat of 1000g beef meat added recipe; S4: 2.0 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S5: 2.0 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S6: 2.0 % table salt and 30% sheep tail fat of 1000g beef meat added recipe; S7: 2.5 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S8: 2.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe and S9: 2.5 % table salt and 30% sheep tail fat of 1000g beef meat added recipe;

Different small letters indicate statistical difference between cooking time values at $\alpha=0.05$ level in each column.

Different capital letters; A, B, C indicate statistical difference between fat content values at same salt content (S1, S2, S3; S4, S5, S6; S7, S8, S9) at $\alpha=0.05$ level among products at each time.

Different capital letters; X, Y, Z indicate statistical difference between salt content values at same fat content (S1, S4, S7; S2, S5, S8; S3, S6, S9) at $\alpha=0.05$ level among products at each time.

One way ANOVA results showed that b^* values decreased by time ($P < 0.05$) close to the end of processing. This could be due to melanoidins which have a brown colour formed by Maillard reactions during the cooking (Bozkurt and Bayram, 2006). Also, similar results were observed by Kayaardı et al. (2005) found that Hunter b^* values of kavurma decreased during the storage periods. As in the three way ANOVA results, one way ANOVA results also revealed that the increase of salt content caused to decrease in yellowness values, because by increasing salt content, myoglobin denaturation occurred and denaturated proteins enhanced the browning pigments formation. Fat didn't cause a significant change ($P > 0.05$) in yellowness value. Some publications have indicated that fat content does not influence the color of cooked meat (Trout et al., 1992b).

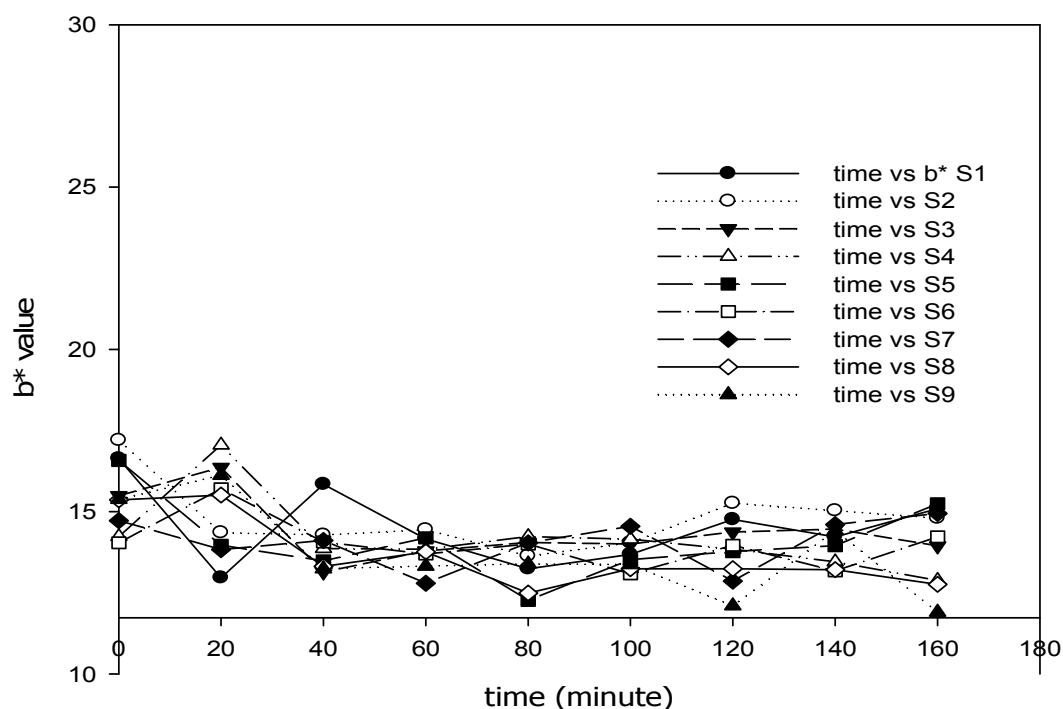


Figure 4.6 The change in b^* values of Kavurma samples during the production

4.4.4. BI Index

Browning index (BI) values of kavurma during the cooking period are shown in Figures 4.7, 4.8 and 4.9. BI values sharply decreased ($P<0.05$) within 40 min of process. This could be due to the degradation of coloured pigments such as myoglobin. After that BI values remained constant up to 100-140 minute then slightly increased ($P<0.05$) until the end of the cooking process because of the formation of brown pigments. This increase was expected because application of heat caused browning reactions such as Maillard reactions.

Browning index (BI) values were changed in the range of 66.41 to 33.04. Bozkurt and Belibağlı (2008) found that BI values of Kavurma gradually increased ($P<0.05$) to about 55. Bayram and Bozkurt (2006) studied browning index (BI) in sucuk during ripening and found 58 to 53 at the beginning and end of ripening.

As it was seen in the Figure 4.7, 4.8 and 4.9, the increase of fat content caused to decrease in browning index. This could be due to increase in fat content decreased the moisture content which was related to obtain lower browning index values. In our study, the lowest browning index values were obtained as 38.38 at the end of processing in S3, the sample which have the lowest salt content and highest fat content. At low salt content due to lower pigment degradation and at high fat content due to lower moisture content, browning index could be lower.

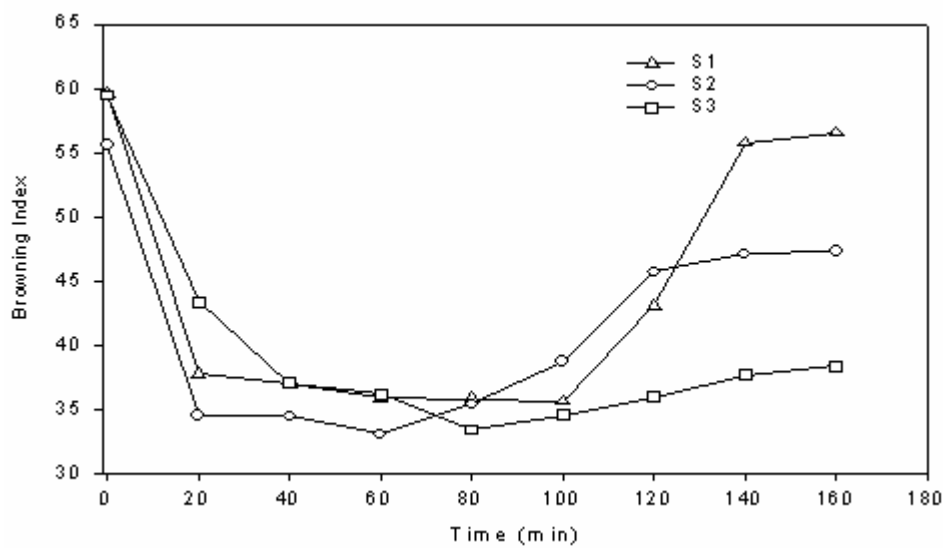


Figure 4.7 BI values of S1, S2, S3 kavurma samples during the processing

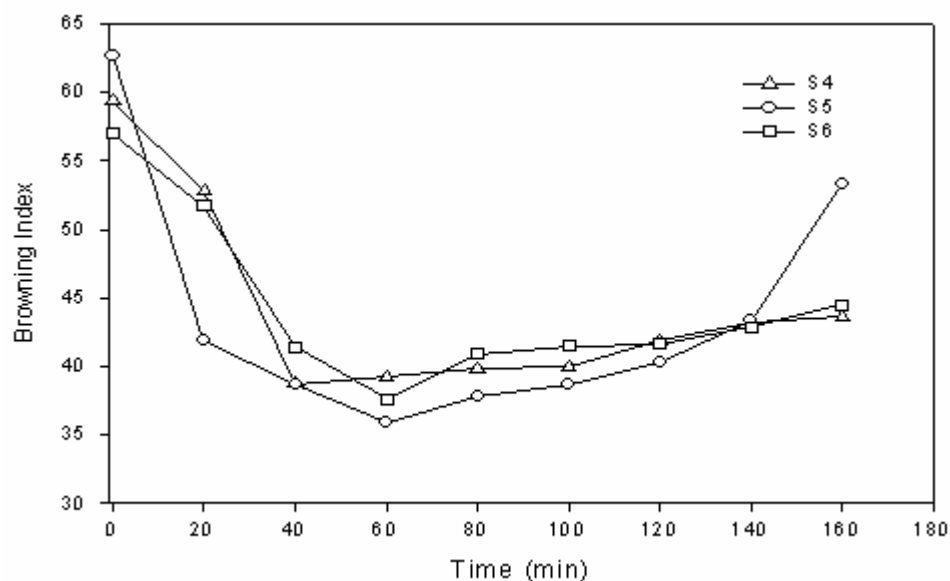


Figure 4.8 BI values of S4, S5, S6 kavurma samples during the processing

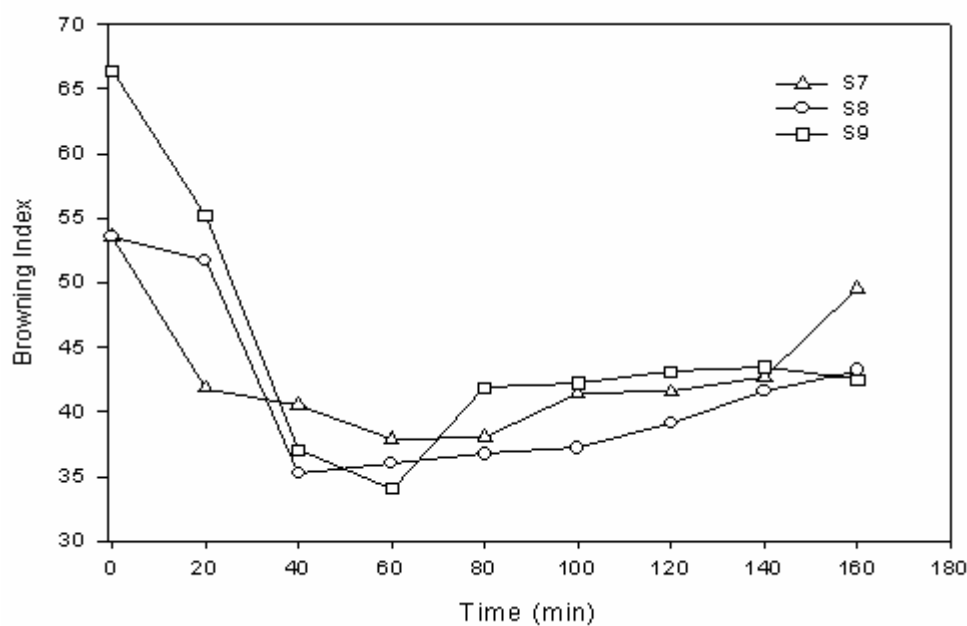


Figure 4.9 BI values of S7, S8, S9 kavurma samples during the processing

4.5. Flavour

Changes in flavouring compounds were followed during the processing and their results are given in Tables 4.7-4.15. About 25 flavouring compounds were identified in samples by headspace technique. The major identified compounds were n-butane, n-heptane, n-hexane, n-octane, n-butanal, 3-methylbutanal, n-pentanal, 2,3-pentadione, n-hexanal, heptanal, 3-methyl-1-butanol, and n-octanal. Similar results were obtained by

Raes et al. (2003); Wood et al. (2003); Rhee et al. (2005); Flores et al. (2007); and reported by Calkins and Hodgen (2007) and Pérez-Juan et al. (2008). Wettasinghe et al. (2001) explained that beef flavor was one of the most thoroughly investigated areas in flavor chemistry and in their study they identified totally 61 volatile compounds in cooked beef. Also, Raes et al. (2003) reported that about 67 volatiles were identified in grilled meat samples.

In all samples, while the concentration of n-heptane, n-octane, n-butane and heptanal was very low in raw state, their concentration was very high at 0 minute. Since, raw state had little flavoring compound of their own, by heating, flavoring compound were formed. After 0 minute, their concentration decreased due to evaporation. Also, it was found that some of the flavoring compounds like 2-heptanone, 2,5-dihydro furandione, were identified in raw meat but not observed in kavurma samples, this could be due to decomposition of these compounds during the cooking process. Similarly, 1-undecanol and 2-ethylfuran identified in melted tail fat but not observed in kavurma samples. However, saturated aldehydes such as; n-butanal, branched aldehydes (3-methyl butanal) and hydrocarbons such as n-hexane and n-butane were not identified in raw meat and melted tail fat but observed in kavurma samples. These were produced during the cooking process. Wood et al. (2003) and Rhee et al. (2005) reported that aldehydes formed during the lipid oxidation were the dominant volatile compounds gave aroma to cooked beef. Aro et al. (2003) also indicated that especially the branched aldehydes, 2-methyl butanal and 3-methyl butanal, were the most abundant volatiles in cooked beef. These explanations were in agreement with the result in this study. Machiels et al. (2004) declared that Maillard reaction between amino acids and sugars and lipid thermal degradation were the main sources of volatiles in cooked meat. Unsaturated aldehydes and ketones could be derived from lipid oxidation while sulphur and nitrogen containing compound derived from Maillard reaction (Machiels et al., 2004). Baek (2007) and Flores et al. (2007) reported that major aromatic compounds detected in cooked meat are 3-methylbutanal, hexanal, 2,3-butanedione, 1-octen-3-one and some furan derivatives. Calkins and Hodgen (2007) reported that hexanal contribute positively to beef flavor but could produce undesirable flavors at higher concentrations. According to this, the samples in our study which contain 1.5% salt content (S1, S2, S3) could have undesirable flavors. Elmore et al. (2004) stated that heptanal was an important contributor of flavour to cooked lamb and beef. Also, they informed that heptanal was

formed from the decomposition of α -linolenic acid. Beef is rich with respect to α -linolenic acid content (Enser et al., 1996). The characteristic aroma of the heptanal is oily and fatty as indicated in Table 2.2. In our study, highest concentration of heptanal was observed in S1 (1.5% Salt, 20% Fat) at 0 minute and S8 (2.5% Salt, 25% Fat) at 60 minute as 140.970 and 78.205 respectively.

Concentrations of the identified compounds in all samples were generally decreased with time as it was seen in the Tables 4.7- 4.15. This could be due to the evaporation of these compounds increased as the time past. The lowest concentration values of identified compounds at the end of cooking time were reached at the samples which had 20% fat content (S1, S4, S7). This indicated that evaporation of the compounds was higher at low fat content.

As indicated before, salt caused to form free iron ions by promoting the displacement of iron from binding sites of heme compounds and so catalyze the lipid peroxidation that leads to develop flavoring compounds. The amount of fat in meat also important since it influences flavor due to lipid oxidation leads to rancidity. The oxidation of lipids gives a wide range of hydrocarbon, aldehydes, alcohols, ketones. In this study, the increase of salt and fat content caused to formation of these compounds stayed along the end of processing even if in lower concentrations especially hexanal and heptanal which were the major lipid oxidation products.

Table 4.7. Changes in flavouring compounds of S1, mg/kg, of kavurma during the processing.

Compound	Retention time (min)	Raw Meat	Melted tail fat	Process Time (min)								
				0	20	40	60	80	100	120	140	160
n-hexane	1.746±0.008	ND	ND	378.655	74.8458	11.8834	ND	40.4494	5.00738	ND	2.6592	0.35328
ethanal	1.837±0.014	ND	ND	28.809	ND	ND	ND	ND	ND	ND	ND	ND
n-heptane	1.962±0.010	178.146	172.782	973.115	401.704	62.0601	136.644	82.4080	5.00738	9.91880	4.50549	1.32122
2-methyl-1-hexane	2.079±0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-pentanol	2.118±0.011	42.818	76.895	95.3564	ND	ND	ND	ND	ND	ND	ND	ND
2-heptanone	2.255±0.007	47.663	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-octane	2.365±0.030	7.392	17.781	543.712	107.809	14.2098	26.1001	35.6677	ND	8.88607	ND	ND
2,4-dimethyl pentanal	2.452±0.000	ND	28.515	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-butane	2.535±0.009	ND	ND	92.224	30.1542	13.2705	24.2546	18.4631	2.35719	24.4561	16.7037	0.25679
(s)-3-4-dimethyl pentanol	2.719±0.005	ND	ND	66.0315	ND	ND	ND	ND	ND	ND	ND	ND
2,5-dihydro furandione	2.850±0.000	3.378	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-methyl tetrahydrofuran	2.978±0.008	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-butanal	3.102±0.042	5.530	ND	212.605	26.9446	7.58648	7.19046	7.95284	ND	ND	ND	ND
propane (pentane)	3.375±0.021	ND	7.945	ND	ND	ND	7.4690	ND	ND	4.61622	ND	0.27361
2-methylbutanal	3.541±0.000	ND	ND	ND	ND	ND	ND	ND	ND	4.77727	ND	ND
3-methylbutanal	3.606±0.004	ND	ND	63.2351	ND	9.05692	10.6287	ND	1.95681	7.52651	ND	0.62564
cyclohexan-1,4,5-triol-3-one	3.771±0.004	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-Undecanol	3.926±0.021	64.635	13.832	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-ethylfuran	4.163±0.002	8.164	17.487	ND	ND	ND	ND	ND	ND	ND	ND	ND
n--pentanal	4.631±0.005	ND	ND	375.622	59.5163	21.8668	23.6461	13.7104	ND	ND	ND	ND
2,3-pentanedione	5.911±0.032	24.656	12.991	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-hexanal	6.888±0.008	ND	ND	355.334	65.0200	29.5105	30.6614	13.0808	2.97860	ND	ND	ND
heptanal	9.664±0.012	3.490	3.421	140.970	23.4118	8.43170	7.642067	0.28674	ND	ND	ND	ND
3-methyl-1-butanol	11.626±0.121	2.800	ND	39.6022	ND	ND	ND	0.18327	ND	ND	ND	ND
n-Octanal	12.576±0.230	0.704	ND	40.3764	4.82136	ND	ND	0.15836	ND	ND	ND	ND

S1: 1.5 % table salt and 20 % sheep tail fat of 1000g beef meat added recipe.

ND: Not Detected

Table 4.8. Changes in flavouring compounds of S2, mg/kg, of kavurma during the processing.

Compound	Retention time (min)	Raw Meat	Melted tail fat	Process Time (min)								
				0	20	40	60	80	100	120	140	160
n-hexane	1.746±0.008	ND	ND	ND	ND	ND	12.2568	ND	33.25592	22.59299	17.313029	9.415842
ethanal	1.837±0.014	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-heptane	1.962±0.010	178.146	172.782	443.401	186.470	296.178	221.495	82.45214	218.17343	144.4625	224.72829	35.47092
2-methyl-1-hexane	2.079±0.005	ND	ND		4.77411	10.4917	6.72859	4.868471	8.9746748	5.709983	6.6230361	ND
1-pentanol	2.118±0.011	42.818	76.895	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-heptanone	2.255±0.007	47.663	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-octane	2.365±0.030	7.392	17.781	32.0989	11.4248	24.6219	44.2017	ND	60.09383	52.91739	38.359822	18.19777
2,4-dimethyl pentanal	2.452±0.000	ND	28.515	ND	ND	ND	ND	2.146581	ND	ND	ND	ND
n-butane	2.535±0.009	ND	ND	98.5043	32.4237	67.8991	28.0081	41.62779	21.58877	26.74719	31.42739	8.608493
(s)-3-4-dimehtyl pentanol	2.719±0.005	ND	ND	ND	ND	ND	ND	ND	ND	5.804391	ND	ND
2,5-dihydro furandione	2.850±0.000	3.378	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-methyl tetrahydrofuran	2.978±0.008	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-butanal	3.102±0.042	5.530	ND	22.5967	4.26946	15.162	9.53197	2.220289	10.183057	25.19644	8.6955675	8.367982
propane (pentane)	3.375±0.021	ND	7.945	23.6708	5.62061	14.1819	ND	11.50005	2.6625459	15.63557	4.1739066	5.865847
2-methylbutanal	3.541±0.000	ND	ND	ND	ND	ND	ND	11.78966	ND	2.729938	ND	ND
3-methylbutanal	3.606±0.004	ND	ND	27.0736	4.88535	19.5344	4.40617	79.30316	ND	9.762067	6.073005	4.709794
cyclohexan-1,4,5-triol-3-one	3.771±0.004	ND	ND	10.3102	ND	ND	3.01751	4.583190	ND	ND	ND	ND
1-Undecanol	3.926±0.021	64.635	13.832	ND	ND	ND	ND	ND	ND	14.56731	ND	9.912362
2-ethylfuran	4.163±0.002	8.164	17.487	ND	ND	ND	3.28899	ND	6.1251028	13.59444	ND	
n--pentanal	4.631±0.005	ND	ND	ND	24.0501	66.04158	25.1947	22.40222	23.108282	80.63290	17.143091	27.67704
2,3-pentanedione	5.911±0.032	24.656	12.991	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-hexanal	6.888±0.008	ND	ND	134.958	56.1683	71.1857	33.0760	29.36453	32.764758	98.55330	25.787949	38.03068
heptanal	9.664±0.012	3.490	3.421	40.2448	10.7977	21.2446	7.07196	3.902512	6.5855253	38.43457	5.6942613	7.187848
3-methyl-1-butanol	11.626±0.121	2.800	ND	ND	ND	ND	ND	1.169227	ND	8.494530	ND	ND
n-Octanal	12.576±0.230	0.704	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

S2: 1.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe.

ND: Not Detected

Table 4.9. Changes in flavouring compounds of S3, mg/kg, of kavurma during the processing.

Compound	Retention time (min)	Raw Meat	Melted tail fat	Process Time (min)								
				0	20	40	60	80	100	120	140	160
n-hexane	1.746±0.008	ND	ND	ND	22.072262	48.890161	ND	5.3882713	0.0675614	ND	ND	ND
ethanal	1.837±0.014	ND	ND	467.18955	3.8329961	6.4904836	ND	ND	ND	ND	ND	ND
n-heptane	1.962±0.010	178.146	172.782	10.99861	313.52096	179.55019	14.486826	98.223902	51.841045	7.3391006	44.91473	27.748972
2-methyl-1-hexane	2.079±0.005	ND	ND	ND	5.7545192	ND	ND	ND	ND	ND	ND	ND
1-pentanol	2.118±0.011	42.818	76.895	65.949227	8.0939744	11.345414	ND	ND	ND	ND	ND	ND
2-heptanone	2.255±0.007	47.663	ND	89.759022	ND	ND	ND	ND	ND	ND	ND	ND
n-octane	2.365±0.030	7.392	17.781	6.8193363	79.60289	62.228905	2.2235798	22.939855	2.4404125	ND	10.219678	6.9173763
2,4-dimethyl pentanal	2.452±0.000	ND	28.515	ND	ND	ND	ND	ND	1.4858344	ND	ND	ND
n-butane	2.535±0.009	ND	ND	ND	72.141968	20.882824	3.4791662	16.567982	2.797284	1.8646237	19.743413	10.966192
(s)-3-4-dimehtyl pentanol	2.719±0.005	ND	ND	ND	8.7205447	5.592229	ND	0	0.9765153	ND	ND	ND
2,5-dihydro furandione	2.850±0.000	3.378	ND	6.3022201	ND	ND	ND	ND	ND	ND	ND	ND
2-methyl tetrahydrofuran	2.978±0.008	ND	ND	ND	ND	2.6884491	ND	ND	ND	ND	ND	ND
n-butanal	3.102±0.042	5.530	ND	17.586604	48.34597	12.235131	ND	4.049383	ND	0.7616808	1.8634464	1.9840245
propane (pentane)	3.375±0.021	ND	7.945	10.366273	25.393552	5.2929294	ND	10.439878	ND	ND	3.3173763	2.2410339
2-methylbutanal	3.541±0.000	ND	ND	109.43778	ND	ND	ND	ND	ND	ND	2.5589661	ND
3-methylbutanal	3.606±0.004	ND	ND	ND	18.242802	2.1866148	ND	5.0824458	2.2545548	ND	10.590928	2.4286826
cyclohexan-1,4,5-triol-3-one	3.771±0.004	ND	ND	ND	14.578432	ND	ND	ND	ND	ND	ND	ND
1-Undecanol	3.926±0.021	64.635	13.832	ND	8.9753974	3.0796554	ND	6.2349528	ND	ND	ND	0.85203
2-ethlyfuran	4.163±0.002	8.164	17.487	ND	6.3014119	3.3374208	ND	ND	ND	ND	ND	ND
n--pentanal	4.631±0.005	ND	ND	ND	173.50817	33.99433	3.4533074	29.844691	3.2181034	1.0083141	10.910995	1.4717399
2,3-pentanedione	5.911±0.032	24.656	12.991	8.7778911	ND	1.1192663	ND	ND	ND	ND	ND	ND
n-hexanal	6.888±0.008	ND	ND	ND	93.787549	40.658699	7.6528182	47.267482	10.45583	3.1978332	16.112729	2.7522957
heptanal	9.664±0.012	3.490	3.421	14.658788	28.468149	8.5537632	ND	6.9263813	ND	ND	ND	ND
3-methyl-1-butanol	11.626±0.121	2.800	ND	3.9755998	6.3780434	1.2262924	ND	ND	ND	ND	ND	ND
n-Octanal	12.576±0.230	0.704	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

S3: 1.5 % table salt and 30 % sheep tail fat of 1000g beef meat added recipe.

ND: Not Detected

Table 4.10. Changes in flavouring compounds of S4, mg/kg, of kavurma during the processing.

Compound	Retention time (min)	Raw Meat	Melted tail fat	Process Time (min)								
				0	20	40	60	80	100	120	140	160
n-hexane	1.746±0.008	ND	ND	1.429772	ND	2.1010895	2.3576098	2.817343	1.6139967	ND	2.4588994	0.5693296
ethanal	1.837±0.014	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-heptane	1.962±0.010	178.146	172.782	16.69727	4.361512	12.493496	16.247804	14.42279	11.127404	2.1807671	17.274819	2.3062479
2-methyl-1-hexane	2.079±0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-pentanol	2.118±0.011	42.818	76.895	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-heptanone	2.255±0.007	47.663	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-octane	2.365±0.030	7.392	17.781	4.073196	ND	2.6269038	3.5807893	4.0162201	3.274786	0.6864625	3.7106281	ND
2,4-dimethyl pentanal	2.452±0.000	ND	28.515	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-butane	2.535±0.009	ND	ND	4.397042	1.1325737	2.7181879	2.3249472	2.1379433	2.7772874	ND	3.5039244	0.3748927
(s)-3-4-dimehtyl pentanol	2.719±0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,5-dihydro furandione	2.850±0.000	3.378	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-methyl tetrahydrofuran	2.978±0.008	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-butanal	3.102±0.042	5.530	ND	1.756687	ND	1.1108949	1.2972985	1.1446137	0.6005814	0.3329394	1.216398	ND
propane (pentane)	3.375±0.021	ND	7.945	0.601706	ND	0.5864614	0.3709072	ND	ND	ND	ND	ND
2-methylbutanal	3.541±0.000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3-methylbutanal	3.606±0.004	ND	ND	1.343768	0.7246804	0.8230806	1.3976987	0.5978588	0.8290617	0.268179	1.8095831	0.4420667
cyclohexan-1,4,5-triol-3-one	3.771±0.004	ND	ND	ND	ND	0.6293952	ND	ND	ND	ND	ND	ND
1-Undecanol	3.926±0.021	64.635	13.832	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-ethylfuran	4.163±0.002	8.164	17.487	ND	ND	ND	ND	ND	ND	ND	ND	ND
n--pentanal	4.631±0.005	ND	ND	5.9507949	0.4083558	3.2579099	3.1791217	2.5230573	2.3067927	0.5617621	3.0689161	0.3760534
2,3-pentanedione	5.911±0.032	24.656	12.991	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-hexanal	6.888±0.008	ND	ND	3.8875931	0.4208071	2.2324514	4.2767982	3.9328182	2.391373	1.3290606	2.3315953	1.0341712
heptanal	9.664±0.012	3.490	3.421	1.0036109	0.214627	0.2031451	0.7423802	0.6363791	0.2471551	ND	0.3832462	ND
3-methyl-1-butanol	11.626±0.121	2.800	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Octanal	12.576±0.230	0.704	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

S4: 2.0 % table salt and 20% sheep tail fat of 1000g beef meat added recipe.

ND: Not Detected

Table 4.11. Changes in flavouring compounds of S5, mg/kg, of kavurma during the processing.

Compound	Retention time (min)	Raw Meat	Melted tail fat	Process Time (min)								
				0	20	40	60	80	100	120	140	160
n-hexane	1.746±0.008	ND	ND	ND	2.0116176	4.9852251	2.2645359	ND	1.1748527	0.9639867	0.7704503	ND
ethanal	1.837±0.014	ND	ND	253.17899	ND	ND	ND	ND	ND	ND	ND	ND
n-heptane	1.962±0.010	178.146	172.782	ND	18.355309	23.840133	14.960645	ND	8.5776098	8.4467593	6.655453	2.2357643
2-methyl-1-hexane	2.079±0.005	ND	ND	93.210228	ND	ND	ND	ND	ND	ND	ND	ND
1-pentanol	2.118±0.011	42.818	76.895	43.578432	ND	ND	ND	ND	ND	ND	ND	ND
2-heptanone	2.255±0.007	47.663	ND	8.4688382	ND	ND	ND	ND	ND	ND	ND	ND
n-octane	2.365±0.030	7.392	17.781	ND	4.3934074	5.9553974	2.3653808	ND	1.1613341	1.2542635	0.5602968	ND
2,4-dimethyl pentanal	2.452±0.000	ND	28.515	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-butane	2.535±0.009	ND	ND	88.115397	2.2519066	3.5288494	2.2815564	ND	1.674219	3.0622346	2.5406893	1.7667927
(s)-3-4-dimehtyl pentanol	2.719±0.005	ND	ND	9.6467593	ND	ND	ND	ND	ND	ND	ND	ND
2,5-dihydro furandione	2.850±0.000	3.378	ND	54.965092	ND	ND	ND	ND	ND	ND	ND	ND
2-methyl tetrahydrofuran	2.978±0.008	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-butanal	3.102±0.042	5.530	ND	ND	1.1199555	2.0628683	1.098577	ND	ND	0.4240934	ND	ND
propane (pentane)	3.375±0.021	ND	7.945	ND	ND	0.6263457	ND	ND	ND	0.5391718	ND	ND
2-methylbutanal	3.541±0.000	ND	ND	181.88293	ND	0.6470917	ND	ND	ND	ND	ND	ND
3-methylbutanal	3.606±0.004	ND	ND	ND	ND	1.182657	0.7966648	ND	0.8401123	1.0669672	1.4225347	1.3310283
cyclohexan-1,4,5-triol-3-one	3.771±0.004	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-Undecanol	3.926±0.021	64.635	13.832	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-ethylfuran	4.163±0.002	8.164	17.487	ND	ND	ND	ND	ND	ND	ND	ND	ND
n--pentanal	4.631±0.005	ND	ND	14.607893	4.3999889	4.3240133	3.0170873	ND	0.9568594	1.0928182	0.5074619	ND
2,3-pentanedione	5.911±0.032	24.656	12.991	193.11006	ND	ND	ND	ND	ND	ND	ND	ND
n-hexanal	6.888±0.008	ND	ND	ND	3.9875598	3.9599555	2.7829794	ND	0.8650806	0.802189	0.7001123	ND
heptanal	9.664±0.012	3.490	3.421	ND	0.9170472	0.8055731	0.5231406	ND	ND	ND	ND	ND
3-methyl-1-butanol	11.626±0.121	2.800	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-Octanal	12.576±0.230	0.704	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

S5: 2.0 % table salt and 25% sheep tail fat of 1000g beef meat added recipe.

ND: Not Detected

Table 4.12. Changes in flavouring compounds of S6, mg/kg, of kavurma during the processing.

Compound	Retention time (min)	Raw Meat	Melted tail fat	Process Time (min)								
				0	20	40	60	80	100	120	140	160
n-hexane	1.746±0.008	ND	ND	1.401234	8.477587	ND	ND	ND	29.335742	ND	ND	ND
ethanal	1.837±0.014	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-heptane	1.962±0.010	178.146	172.782	14.792551	42.905503	180.95586	109.93296	80.956087	138.41201	178.65926	249.63524	377.93241
2-methyl-1-hexane	2.079±0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-pentanol	2.118±0.011	42.818	76.895	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-heptanone	2.255±0.007	47.663	ND	4.0156976	ND	7.6163202	ND	ND	ND	ND	ND	ND
n-octane	2.365±0.030	7.392	17.781	ND	7.4507949	ND	7.9600778	9.8518955	49.490606	16.914063	35.404113	52.785103
2,4-dimethyl pentanal	2.452±0.000	ND	28.515	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-butane	2.535±0.009	ND	ND	4.3372429	7.9475931	18.93552	18.307393	17.17154	18.322735	40.131406	58.670261	196.58043
(s)-3-4-dimehtyl pentanol	2.719±0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,5-dihydro furandione	2.850±0.000	3.378	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-methyl tetrahydrofuran	2.978±0.008	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-butanal	3.102±0.042	5.530	ND	1.6195664	2.900289	ND	ND	ND	14.052251	ND	ND	10.729483
propane (pentane)	3.375±0.021	ND	7.945	1.1863591	2.2071151	ND	4.415264	4.7493941	5.6363758	ND	ND	19.001334
2-methylbutanal	3.541±0.000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3-methylbutanal	3.606±0.004	ND	ND	ND	2.712229	8.8116398	8.7274041	6.9248694	6.5761979	27.525069	39.673374	149.91306
cyclohexan-1,4,5-triol-3-one	3.771±0.004	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-Undecanol	3.926±0.021	64.635	13.832	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-ethylfuran	4.163±0.002	8.164	17.487	ND	ND	ND	ND	ND	ND	ND	ND	ND
n--pentanal	4.631±0.005	ND	ND	11.204558	15.705503	21.576543	8.1089383	10.259855	26.998888	9.887204	14.838466	24.404558
2,3-pentanedione	5.911±0.032	24.656	12.991	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-hexanal	6.888±0.008	ND	ND	6.9940967	15.635798	20.683936	7.4797221	12.373541	17.609783	9.8583435	9.0387215	10.917476
heptanal	9.664±0.012	3.490	3.421	2.6716509	3.9023013	2.4393663	ND	ND	ND	ND	ND	ND
3-methyl-1-butanol	11.626±0.121	2.800	ND	1.3987215	2.1565759	ND	ND	ND	ND	ND	ND	ND
n-Octanal	12.576±0.230	0.704	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

S6: 2.0 % table salt and 30% sheep tail fat of 1000g beef meat added recipe.

ND: Not Detected

Table 4.13. Changes in flavouring compounds of S7, mg/kg, of kavurma during the processing.

Compound	Retention time (min)	Raw Meat	Melted tail fat	Process Time (min)								
				0	20	40	60	80	100	120	140	160
n-hexane	1.746±0.008	ND	ND	ND	12.595442	ND	ND	9.0545414	ND	ND	ND	ND
ethanal	1.837±0.014	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-heptane	1.962±0.010	178.146	172.782	452.57977	230.04236	234.03835	27.370984	127.26014	133.43313	81.688049	69.029016	ND
2-methyl-1-hexane	2.079±0.005	ND	ND	4.9873819	ND	ND	ND	ND	ND	ND	ND	ND
1-pentanol	2.118±0.011	42.818	76.895	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-heptanone	2.255±0.007	47.663	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-octane	2.365±0.030	7.392	17.781	22.353641	27.023013	13.325625	2.6991773	21.504836	5.7504058	12.17154	3.467771	0.85073
2,4-dimethyl pentanal	2.452±0.000	ND	28.515	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-butane	2.535±0.009	ND	ND	82.926848	49.995108	29.052474	5.5015675	27.539522	33.523402	33.52129	29.447471	
(s)-3-4-dimehtyl pentanol	2.719±0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,5-dihydro furandione	2.850±0.000	3.378	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-methyl tetrahydrofuran	2.978±0.008	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-butanal	3.102±0.042	5.530	ND	4.8815675	5.7105948	4.1513174	ND	17.218232	ND	ND	ND	ND
propane (pentane)	3.375±0.021	ND	7.945	15.355197	5.7986103	2.0181101	1.0825737	11.530072	4.9015342	4.3547526	4.9524402	ND
2-methylbutanal	3.541±0.000	ND	ND	ND	ND	3.2235019	ND	ND	5.0471484	6.7411562	3.6122068	ND
3-methylbutanal	3.606±0.004	ND	ND	17.321623	4.5825347	ND	2.3168872	20.565425	16.463146	16.694386	12.243802	ND
cyclohexan-1,4,5-triol-3-one	3.771±0.004	ND	ND	11.142635	ND	ND	ND	ND	ND	ND	ND	ND
1-Undecanol	3.926±0.021	64.635	13.832	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-ethylfuran	4.163±0.002	8.164	17.487	ND	ND	ND	ND	6.6950195	ND	ND	ND	ND
n--pentanal	4.631±0.005	ND	ND	113.2587	13.788216	14.043469	9.1952196	66.332518	11.4607	7.8117065	10.762135	ND
2,3-pentanedione	5.911±0.032	24.656	12.991	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-hexanal	6.888±0.008	ND	ND	15.974319	11.45025	12.877932	9.1691051	61.361201	10.99791	13.984547	12.162201	ND
heptanal	9.664±0.012	3.490	3.421	5.3619011	3.7684714	2.2857254	3.20806	15.133741	1.2499389	ND	ND	ND
3-methyl-1-butanol	11.626±0.121	2.800	ND	2.683035	3.2251918	ND	ND	2.910617	ND	ND	ND	ND
n-Octanal	12.576±0.230	0.704	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

S7: 2.5 % table salt and 20% sheep tail fat of 1000g beef meat added recipe.

ND: Not Detected

Table 4.14. Changes in flavouring compounds of S8, mg/kg, of kavurma during the processing.

Compound	Retention time (min)	Raw Meat	Melted tail fat	Process Time (min)								
				0	20	40	60	80	100	120	140	160
n-hexane	1.746±0.008	ND	ND	ND	28.466	65.774	362.662	13.113	56.388	22.183	65.143	42.427
ethanal	1.837±0.014	ND	ND	ND	ND	7.079	26.541	ND	ND	1.690	ND	ND
n-heptane	1.962±0.010	178.146	172.782	388.331	565.117	426.285	844.572	71.727	325.405	108.377	452.471	353.640
2-methyl-1-hexane	2.079±0.005	ND	ND	ND	15.989	10.613	ND	ND	ND	ND	ND	8.845
1-pentanol	2.118±0.011	42.818	76.895	12.993	ND	4.839	70.828	ND	ND	8.535	ND	ND
2-heptanone	2.255±0.007	47.663	ND	36.075	ND	ND	ND	ND	ND	ND	ND	ND
n-octane	2.365±0.030	7.392	17.781	3.257	68.251	117.391	450.714	24.834	86.876	52.988	107.647	73.580
2,4-dimethyl pentanal	2.452±0.000	ND	28.515	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-butane	2.535±0.009	ND	ND	ND	111.055	53.767	88.196	21.938	62.067	25.243	130.288	151.309
(s)-3-4-dimehtyl pentanol	2.719±0.005	ND	ND	ND	ND	10.361	42.518	ND	ND	6.970	ND	ND
2,5-dihydro furandione	2.850±0.000	3.378	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-methyl tetrahydrofuran	2.978±0.008	ND	ND	ND	ND	9.958	23.608	ND	ND	4.054	ND	ND
n-butanal	3.102±0.042	5.530	ND	4.474	22.977	37.486	147.961	10.608	27.971	20.560	35.156	22.223
propane (pentane)	3.375±0.021	ND	7.945	ND	25.575	18.926	31.519	5.690	16.349	9.730	17.040	22.840
2-methylbutanal	3.541±0.000	ND	ND	ND	ND	ND	ND	ND	8.586	2.454	19.053	23.788
3-methylbutanal	3.606±0.004	ND	ND	ND	21.775	17.780	31.845	7.391	28.619	8.537	64.915	83.711
cyclohexan-1,4,5-triol-3-one	3.771±0.004	ND	ND	ND	9.839	ND	ND	ND	ND	8.875	ND	ND
1-Undecanol	3.926±0.021	64.635	13.832	21.018	ND	18.833	55.488	6.276	ND	14.148	ND	ND
2-ethylfuran	4.163±0.002	8.164	17.487	ND	12.900	17.223	18.955	ND	ND	ND	7.928	ND
n--pentanal	4.631±0.005	ND	ND	ND	124.266	103.723	249.890	39.408	74.231	55.628	71.120	72.860
2,3-pentanedione	5.911±0.032	24.656	12.991	14.982	48.177	17.164	52.203	8.780	15.688	10.899	7.793	15.357
n-hexanal	6.888±0.008	ND	ND	ND	63.557	89.182	238.950	40.769	69.463	57.748	67.506	52.678
heptanal	9.664±0.012	3.490	3.421	2.878	16.360	27.338	78.205	10.889	17.038	17.966	22.481	18.145
3-methyl-1-butanol	11.626±0.121	2.800	ND	1.334	13.765	8.826	38.298	3.256	5.896	6.448	5.821	4.929
n-Octanal	12.576±0.230	0.704	ND	ND	3.564	6.031	28.618	2.806	4.373	3.732	7.056	5.613

S8: 2.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe.

ND: Not Detected

Table 4.15. Changes in flavouring compounds of S9, mg/kg, of kavurma during the processing.

Compound	Retention time	Raw Meat	Melted	Process Time (min)								
	(min)		tail fat	0	20	40	60	80	100	120	140	160
n-hexane	1.746±0.008	ND	ND	1.401234	8.477587	ND	ND	ND	29.335742	ND	ND	ND
ethanal	1.837±0.014	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-heptane	1.962±0.010	178.146	172.782	14.792551	42.905503	180.95586	109.93296	80.956087	138.41201	178.65926	249.63524	377.93241
2-methyl-1-hexane	2.079±0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-pentanol	2.118±0.011	42.818	76.895	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-heptanone	2.255±0.007	47.663	ND	4.0156976	ND	7.6163202	ND	ND	ND	ND	ND	ND
n-octane	2.365±0.030	7.392	17.781	ND	7.4507949	ND	7.9600778	9.8518955	49.490606	16.914063	35.404113	52.785103
2,4-dimethyl pentanal	2.452±0.000	ND	28.515	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-butane	2.535±0.009	ND	ND	4.3372429	7.9475931	18.93552	18.307393	17.17154	18.322735	40.131406	58.670261	196.58043
(s)-3-4-dimehtyl pentanol	2.719±0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,5-dihydro furandione	2.850±0.000	3.378	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-methyl tetrahydrofuran	2.978±0.008	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-butanal	3.102±0.042	5.530	ND	1.6195664	2.900289	ND	ND	ND	14.052251	ND	ND	10.729483
propane (pentane)	3.375±0.021	ND	7.945	1.1863591	2.2071151	ND	4.415264	4.7493941	5.6363758	ND	ND	19.001334
2-methylbutanal	3.541±0.000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3-methylbutanal	3.606±0.004	ND	ND	ND	2.712229	8.8116398	8.7274041	6.9248694	6.5761979	27.525069	39.673374	149.91306
cyclohexan-1,4,5-triol-3-one	3.771±0.004	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-Undecanol	3.926±0.021	64.635	13.832	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-ethylfuran	4.163±0.002	8.164	17.487	ND	ND	ND	ND	ND	ND	ND	ND	ND
n--pentanal	4.631±0.005	ND	ND	11.204558	15.705503	21.576543	8.1089383	10.259855	26.998888	9.887204	14.838466	24.404558
2,3-pentanedione	5.911±0.032	24.656	12.991	ND	ND	ND	ND	ND	ND	ND	ND	ND
n-hexanal	6.888±0.008	ND	ND	6.9940967	15.635798	20.683936	7.4797221	12.373541	17.609783	9.8583435	9.0387215	10.917476
heptanal	9.664±0.012	3.490	3.421	2.6716509	3.9023013	2.4393663	ND	ND	ND	ND	ND	ND
3-methyl-1-butanol	11.626±0.121	2.800	ND	1.3987215	2.1565759	ND	ND	ND	ND	ND	ND	ND
n-Octanal	12.576±0.230	0.704	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

S9: 2.5 % table salt and 30% sheep tail fat of 1000g beef meat added recipe.

ND: Not Detected

4.6. Texture

Texture profile of kavurma (hardness, adhesiveness, springiness, cohesiveness, gumminess, chewiness, and resilience) was followed during the processing (Figure 4.10- 4.16) and their statistical results are shown in Tables 4.16-4.22.

4.6.1. Hardness

According to three way ANOVA results; time, salt content and fat content didn't cause a significant change ($P>0.05$) in hardness values.

According to one way ANOVA results, time didn't cause a significant change in hardness values in most of the samples. However, the samples of S1, S6, S8 and S9 were affected by the time significantly. In these samples hardness value firstly increased ($P<0.05$) sharply, and then decreased ($P<0.05$) close through the end of cooking. Huidobro et al. (2005) found that hardness increased with cooking about 4 times. Hardness value increased because the protein (myosin) in meat could be coagulate, so water was squeezed around the groups of myosin and the protein could coagulate even more, cells could form into more solid groups, so the meat became firmer and larger pockets of liquid made it juicer. As the time passes, the collagen could be denaturated in the connective tissue and put more pressure on the water. As a result, the meat could shrink and release much of its juice and became tougher. By time, close through the end of cooking hardness value decreased. This could be due to collagen changed in to soft gelatin and meat released it tight texture. This was desirable for kavurma texture.

The increase of salt content didn't cause a significant change in hardness value during the processing of kavurma. However, at the end of cooking, in the samples containing 25% and 30% fat content, the increase of salt content caused to increase in hardness value. Claus et al. (1994) reported that addition of salt into meats helps to extract NaCl soluble proteins and increases gel strength. So, increasing protein content could lead to formation of a more dense gel matrix and as a result the higher hardness value was obtained (Pietrasika and Shand, 2005).

There was no difference between the hardness ($P>0.05$) values in most of the samples by increasing fat content. This was also supported by some researches. According to Olkku et al. (1979) the relation between fatness and hardness was low.

4.6.2. Chewiness

Chewiness values of the samples didn't affected significantly by time as in the hardness values. The samples as indicated before in hardness (S1, S6, S8 and S9) affected significantly by time. In these samples, chewiness values firstly increased and then decreased until the end of processing (Table 4.17). Chewiness is the force required to bite through the chewed sample. Increase in chewiness values indicated that kavurma became tougher during the processing (Szczesniak, 2002).

Huidobro et al. (2005) found that chewiness value of raw meat was about 307 and increased with cooking to about 3127 N. Decrease in chewiness value indicated that meat releases its tight texture. At the end of processing, kavurma shouldn't be too hard. So, decrease in hardness and chewiness value in the kavurma was desirable.

The increase of fat content didn't has a significant effect ($P>0.05$) in the chewiness values except the samples at 140-160 minute that contain 2.5% of salt content. The increase of fat content caused to increase in chewiness values of these samples. There was a direct relation between the chewiness and fat content. Similarly, Pietrasik and Shand (2005) found that fat reduction on sausages resulted in a decrease in chewiness of final product.

The increase of salt content also didn't cause a significant change in chewiness values except the samples at the end of cooking that had 25 and 30 % fat content. Chewiness value of kavurma increased by increasing salt content at these fat contents. This could be due to salt might solubilize the proteins to increase water-holding capacity and with cooking, the proteins had been denatured, the resulting mushy texture could allowed for moisture release, resulting in tough, chewy meat.

Table 4.16. Statistical results for changes of hardness values of kavurma recipes during the production with respect to time of cooking and salt content

Time(min.)	Samples								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
0	1.3245aAX	2.4450aAX	0.7880aAX	1.5870aAX	3.5905aAX	1.7555aAX	1.7235aAX	2.1195aAX	2.3470aAX
20	20.8355abcAX	7.3690aABX	2.7365aBX	2.9050aAY	7.0080aBX	2.4355aAX	3.4910aAY	3.1625aAY	6.1620abAY
40	28.9382bcAX	9.5230aBX	8.1990aBX	14.3295aAX	8.1155aAX	13.8510aAX	11.7000aAX	10.0000aAX	9.0700abAX
60	37.0410cAX	12.3715aBX	11.6130aBX	25.7515aAX	16.1060aAX	26.296abAX	19.9725aAX	16.9620abAX	19.4000abAX
80	30.4500bcAX	17.0980aAX	11.4235aAX	23.6480aAX	19.1515aAX	28.148abAX	18.6800aAX	24.8365abAX	29.8455abAX
100	23.8645abcAX	17.7955aAX	11.5200aAX	18.4925aAX	19.8875aAX	43.8125bcAX	17.4005aAX	34.4895bAX	31.2990bAX
120	11.9535abcAX	4.3420aAX	11.6255aAX	18.8485aAX	20.6195aAXY	54.9975cBX	5.6610aAX	34.8000bAY	47.2515abAX
140	10.1655abAX	4.3145aAX	8.6205aAX	9.7335aAX	23.4400aAX	46.9810bcAY	4.3175aAX	35.1505bAX	34.0610abAXY
160	8.1990abAX	3.7140aAX	7.0895aAX	8.3795bAX	21.0475aBY	26.5430abBY	2.4500aAX	20.9075abAY	27.3900abAY

S1: 1.5 % table salt and 20 % sheep tail fat of 1000g beef meat added recipe; S2: 1.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S3: 1.5 % table salt and 30 % sheep tail fat of 1000g beef meat added recipe; S4: 2.0 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S5: 2.0 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S6: 2.0 % table salt and 30% sheep tail fat of 1000g beef meat added recipe; S7: 2.5 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S8: 2.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe and S9: 2.5 % table salt and 30% sheep tail fat of 1000g beef meat added recipe.

Different small letters indicate statistical difference between cooking time values at $\alpha=0.05$ level in each column.

Different capital letters; A, B, C indicate statistical difference between fat content values at same salt content (S1, S2, S3; S4, S5, S6; S7, S8, S9) at $\alpha=0.05$ level among products at each time.

Different capital letters; X, Y, Z indicate statistical difference between salt content values at same fat content (S1, S4, S7; S2, S5, S8; S3, S6, S9) at $\alpha=0.05$ level among products at each time.

Table 4.17. Statistical results for changes of chewiness values of kavurma recipes during the production with respect to cooking time, salt and fat content

Time (min.)	Samples								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
0	0.7610aAX	1.3135aAX	0.3805aAX	1.0665aAX	2.1025aAX	1.1370aAX	2.1850aAX	1.2650aAX	1.1495aAX
20	10.7145abAX	4.6435aAX	1.4675abAX	1.6960aAY	4.1060aAX	1.4350aAX	2.0105aAY	1.7420aAX	3.4235abAX
40	16.5430abAX	5.2905aBX	5.3620abBX	9.1585aAX	4.6355aAX	9.1595aAX	3.4570aAY	9.9470abAX	5.1085abAX
60	20.5495bAX	7.3730aAX	9.4475bAX	13.8945aAX	10.0220aAX	14.9120abAX	10.9305aAX	11.8960abAX	16.3085abcAX
80	13.6375abAX	11.8180aAX	7.5475abAX	11.5390aAX	11.2280aAX	16.2600abAX	9.7670aAX	12.5295bAX	17.0650abcAX
100	12.8165abAX	15.8910aAX	6.4935abAX	9.8360aAX	11.4470aAX	27.8935bcAX	9.7190aAX	12.9255bAX	28.2425cAX
120	8.4590abAX	2.2260aAX	6.4715abAX	9.6280aAX	13.4190aAY	28.0115cBY	2.6790aAY	13.3115bAY	29.9300cAY
140	4.9765abAX	2.5750aAX	4.1475abAX	6.5240aAX	16.2935aAY	28.3265bcAY	2.2635aAX	12.6915bBY	25.1500bcCY
160	3.0960abAX	2.8070aAX	4.4195abAX	5.9455bAX	11.0595aAY	15.8300abAXY	2.9270aAX	11.9555abABY	23.2585bcBY

S1: 1.5 % table salt and 20 % sheep tail fat of 1000g beef meat added recipe; S2: 1.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S3: 1.5 % table salt and 30 % sheep tail fat of 1000g beef meat added recipe; S4: 2.0 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S5: 2.0 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S6: 2.0 % table salt and 30% sheep tail fat of 1000g beef meat added recipe; S7: 2.5 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S8: 2.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe and S9: 2.5 % table salt and 30% sheep tail fat of 1000g beef meat added recipe.

Different small letters indicate statistical difference between cooking time values at $\alpha=0.05$ level in each column.

Different capital letters; A, B, C indicate statistical difference between fat content values at same salt content (S1, S2, S3; S4, S5, S6; S7, S8, S9) at $\alpha=0.05$ level among products at each time.

Different capital letters; X, Y, Z indicate statistical difference between salt content values at same fat content (S1, S4, S7; S2, S5, S8; S3, S6, S9) at $\alpha=0.05$ level among products at each time.

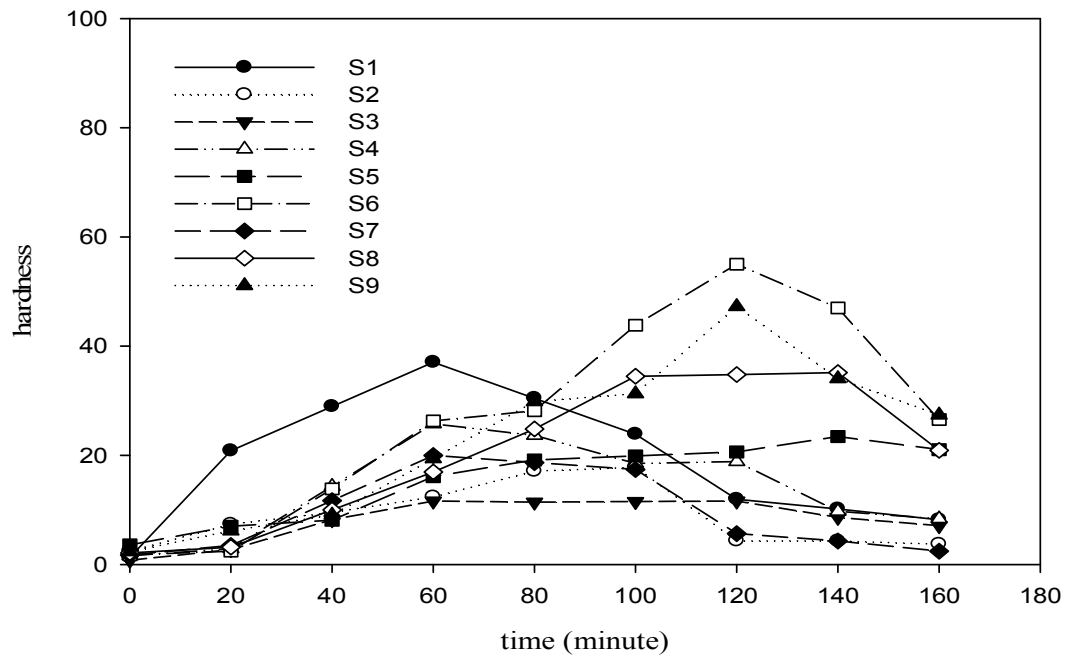


Figure 4.10 The change in hardness values of Kavurma samples during the production

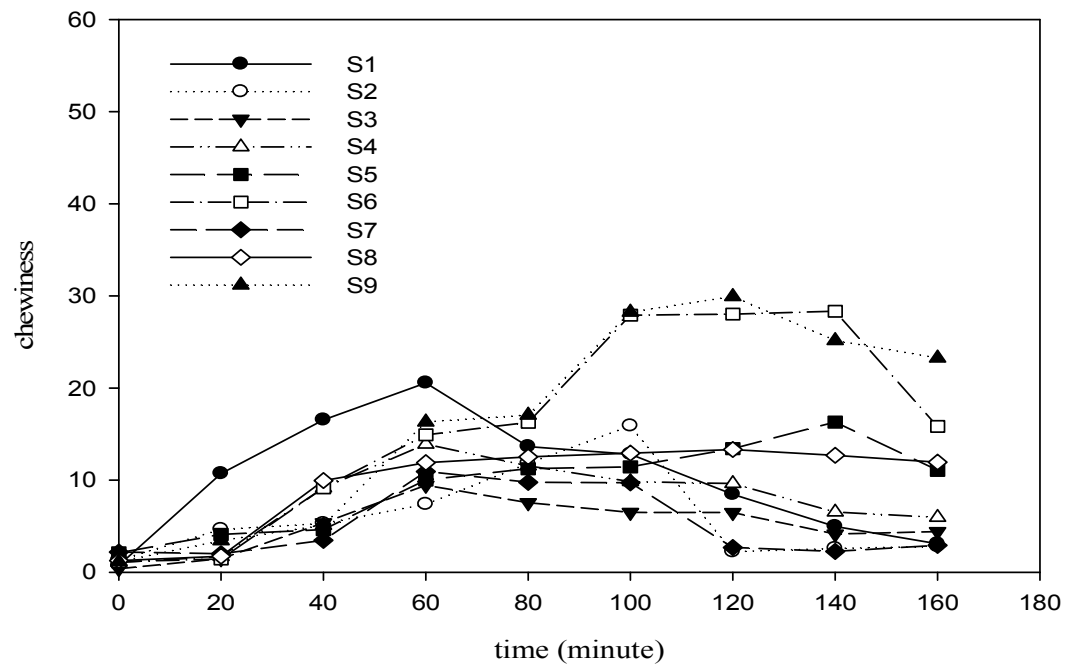


Figure 4.11 The change in chewiness values of Kavurma samples during the production

4.6.3. Other Textural Attributes

Adhesiveness values sharply increased ($P < 0.05$) in the samples of S1, S3, S4, S6 within the first 20 min of processing and then become constant ($P > 0.05$) until the end of the process (Table 4.18). In the rest of the samples, time didn't have a significant effect ($P > 0.05$) in adhesiveness values. Adhesiveness is related to the presence of liquid fat on the surface of the meat and for this reason, increasing of the fat could lead to an increase in adhesiveness values. However, there was no difference in the adhesiveness values by increasing fat content. This could be due to the values used for the fat content wasn't satisfactory to obtain higher adhesiveness values which was expected. The increase of salt content also didn't cause a significant change ($P > 0.05$) in the adhesiveness values.

Springiness and cohesiveness values did not change significantly ($P > 0.05$) by increasing cooking time, fat and salt content that was used for the processing. Springiness values were varied between 0.7 and 0.9 (Table 4.19) while cohesiveness ranged between 0.7 and 0.8 during the processing (Table 4.20). Springiness values were related to the elastic properties of kavurma. Huidobro et al. (2005) found that springiness value of cooked meat was about 2 times higher than that of raw meat.

Gumminess, values increased with time during cooking (Table 4.21), after that remain constant until the end of the processing. Szczesniak (2002) reported that gumminess values change from short to pasty gummy. Therefore pasty gummy kavurma were formed as gumminess increased.

Resilience values changed significantly ($P < 0.05$) in the samples which have 25% and 30% fat content and increased with time during the processing (Table 4.22). The increase of salt and fat content also caused to increase of resilience values at the end of cooking time.

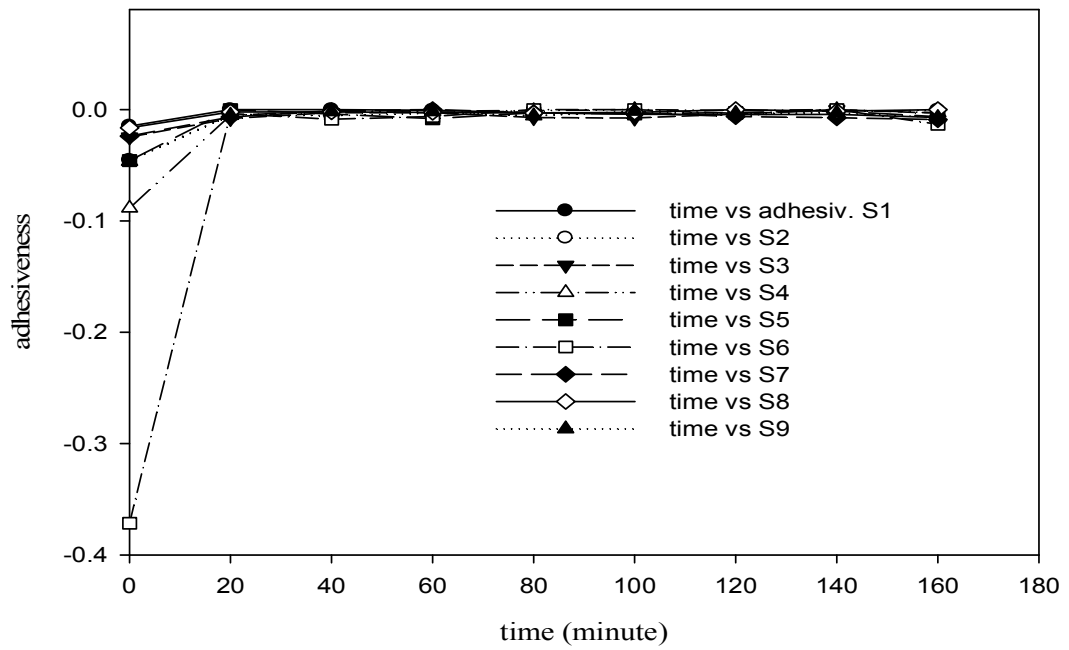


Figure 4.12 The change in adhesiveness values of Kavurma samples during the production

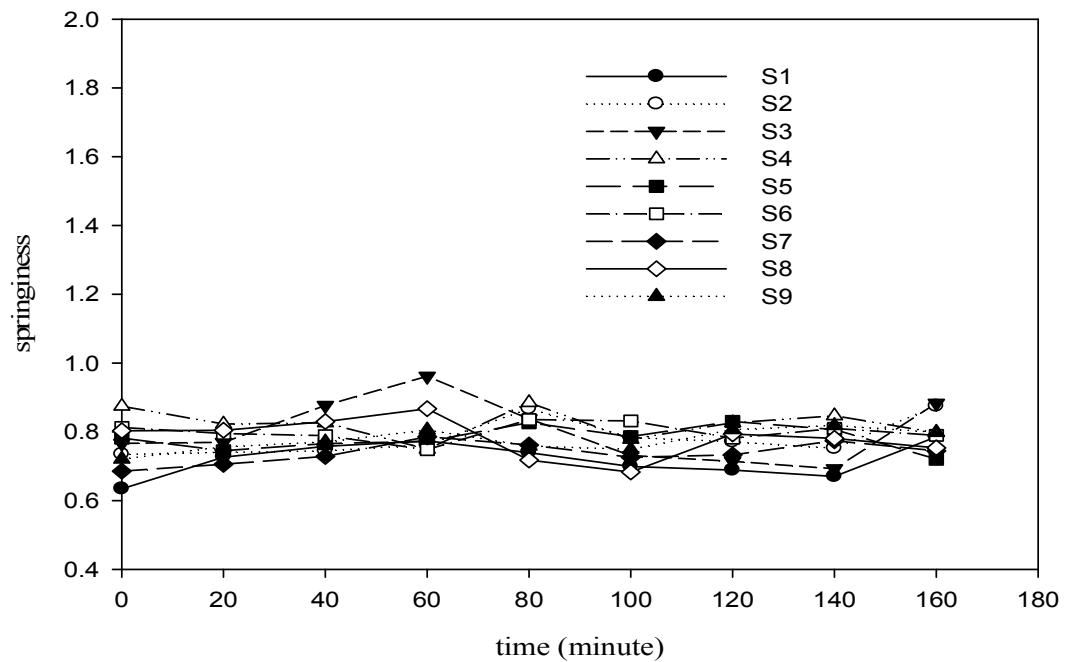


Figure 4.13 The change in springiness values of Kavurma samples during the production

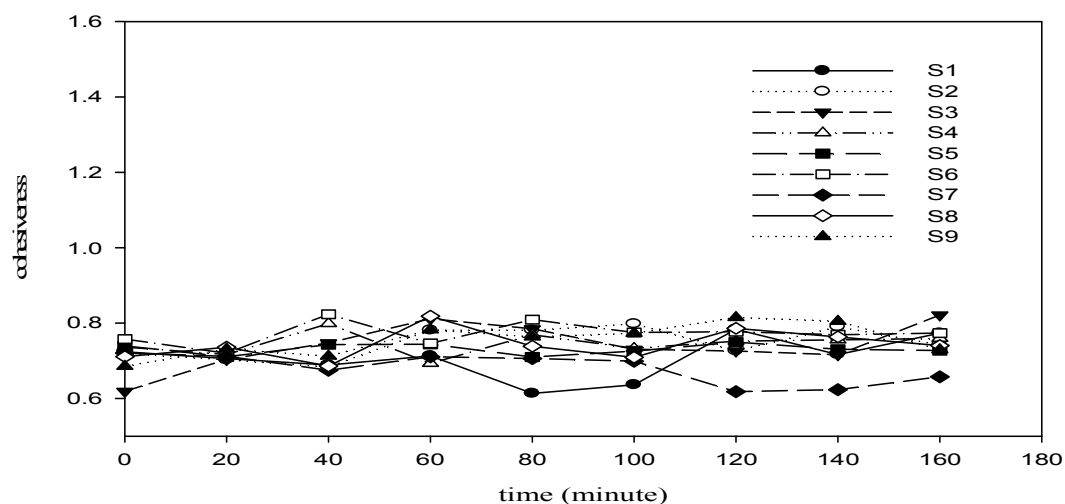


Figure 4.14 The changes in cohesiveness values of Kavurma samples during the production

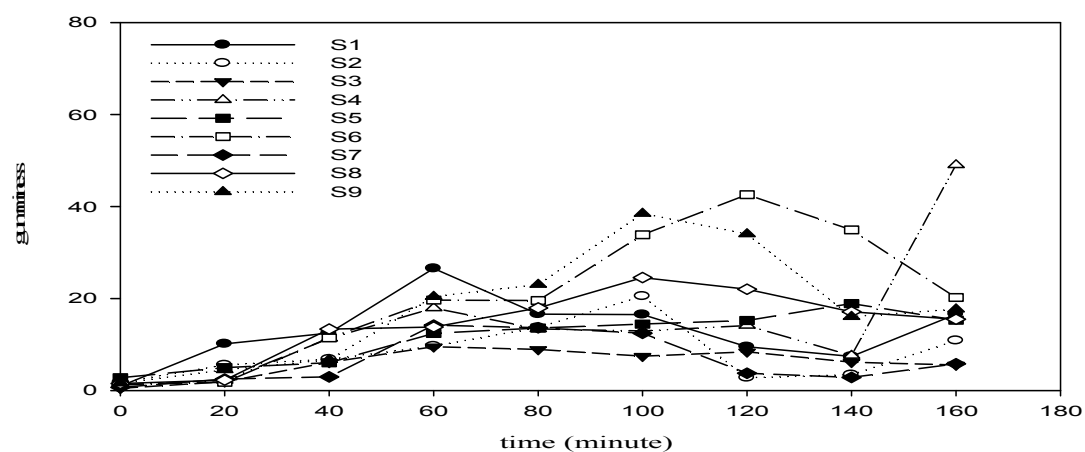


Figure 4.15 The changes in gumminess values of Kavurma samples during the production

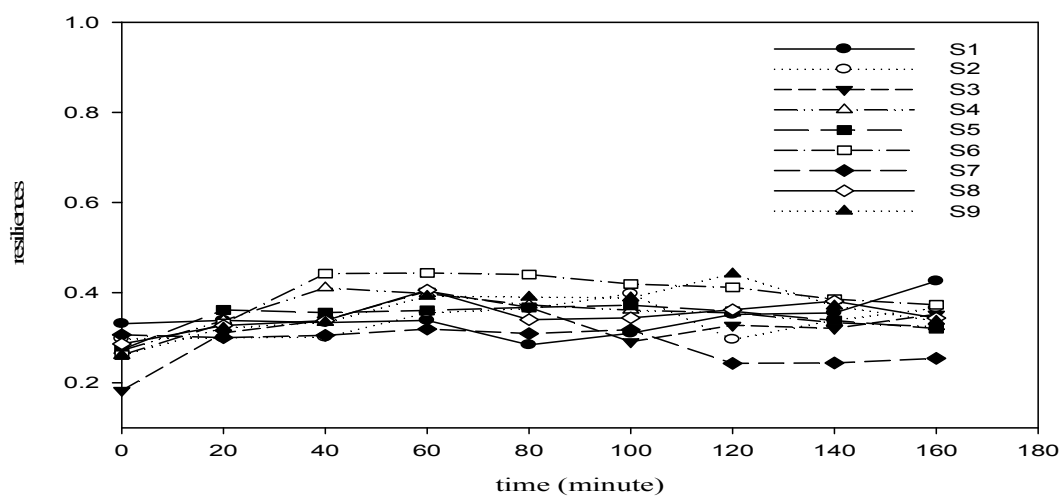


Figure 4.16 The changes in resilience values of Kavurma samples during the production

Table 4.18. Statistical results for changes of adhesiveness values of kavurma recipes during the production with respect to cooking time, salt and fat content

Time (min.)	Samples								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
0	-0.0147aAX	-0.0454aAX	-0.0246aAX	-0.0885aAX	-0.0457aAX	-0.3716aAX	-0.0238aAX	-0.0163aAX	-0.0464aAX
20	0.0000bAX	-0.0045aAX	-0.0080bAX	-0.0052bAX	0.0000aAX	-0.0035bAX	-0.0066aAX	-0.0021aAX	-0.0050aAX
40	0.0000bAX	-0.0055aAX	-0.0027bAX	-0.0012bAX	-0.0040aXY	-0.0087bAX	-0.0012aAX	-0.0020aAY	-0.0018aAX
60	-0.0005bAX	-0.0033aAX	-0.0027bAX	-0.0012bAX	-0.0081aAX	-0.0062bAX	0.0000aAX	-0.0025aAX	-0.0018aAX
80	-0.0027bAX	-0.0057aAX	-0.0071bAX	-0.0009bAX	-0.0028aAX	0.0000bAX	-0.0027aAX	-0.0030aAX	-0.0055aAX
100	-0.0041abAX	-0.0019aAX	-0.0076bAX	0.0000bAX	-0.0038aAX	0.0000bAX	-0.0032aAX	-0.0024aAX	-0.0013aAX
120	-0.0044abAX	-0.0053aAX	-0.0040bAX	-0.0008bAX	-0.0026aAX	-0.0034bAX	-0.0062aAX	0.0000aAX	-0.0033aAX
140	-0.0043abAX	-0.0018aAX	-0.0001bAX	-0.0000bAX	-0.0012aAX	0.0000bAX	-0.0073aAX	-0.0014aAX	-0.0029aAX
160	-0.0070abAX	-0.0005aAX	-0.0031bAX	-0.0028bAX	-0.0064aAX	-0.0133bAX	-0.0089aAX	0.0000aAX	-0.0070aAX

S1: 1.5 % table salt and 20 % sheep tail fat of 1000g beef meat added recipe; S2: 1.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S3: 1.5 % table salt and 30 % sheep tail fat of 1000g beef meat added recipe; S4: 2.0 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S5: 2.0 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S6: 2.0 % table salt and 30% sheep tail fat of 1000g beef meat added recipe; S7: 2.5 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S8: 2.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe and S9: 2.5 % table salt and 30% sheep tail fat of 1000g beef meat added recipe.

Different small letters indicate statistical difference between cooking time values at $\alpha=0.05$ level in each column.

Different capital letters; A, B, C indicate statistical difference between fat content values at same salt content (S1, S2, S3; S4, S5, S6; S7, S8, S9) at $\alpha=0.05$ level among products at each time.

Different capital letters; X, Y, Z indicate statistical difference between salt content values at same fat content (S1, S4, S7; S2, S5, S8; S3, S6, S9) at $\alpha=0.05$ level among products at each time.

Table 4.19. Statistical results for changes springiness values of kavurma recipes during the production with respect to cooking time, salt and fat content

Time (min.)	Samples								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
0	0.6340aAX	0.7345aAX	0.7665abAX	0.8745aAX	0.7820aAX	0.8125aAX	0.6855aAX	0.8030abAX	0.7210aAX
20	0.7265aAX	0.7405aAX	0.7690abAX	0.8225aAX	0.7450aAX	0.7950aAX	0.7055aAX	0.8045abAY	0.7560aAX
40	0.7580aAX	0.7445aAX	0.8765abAX	0.8260aAX	0.7655aAX	0.7885aAX	0.7285aAX	0.8295abAX	0.7705aAX
60	0.7735aAX	0.7630aAX	0.9615bAX	0.7495aAX	0.7720aAX	0.7480aAX	0.7855aAX	0.8670aAY	0.8055aAX
80	0.7395aAX	0.8670bBX	0.8375abBX	0.8850aAX	0.8265aAX	0.8355aAX	0.7615aAX	0.7175abAX	0.7590aAX
100	0.6990aAX	0.7835abAX	0.7310aAX	0.7780aAX	0.7860aAX	0.8315aAX	0.7260aAX	0.6830bAX	0.7490aAX
120	0.6890aAX	0.7710aBX	0.7140aAX	0.8260aAX	0.8300aAX	0.7815aAX	0.7325aAX	0.7935abAX	0.8065aAX
140	0.6705aAX	0.7520aAX	0.6925aAX	0.8465aAY	0.8060aAX	0.8100aAX	0.7740aAXY	0.7810abAX	0.8185aAX
160	0.7855aAX	0.8750bAX	0.8830abAX	0.7975aAX	0.7205aAX	0.7895aAX	0.7445aAX	0.7535abAX	0.7985aAX

S1: 1.5 % table salt and 20 % sheep tail fat of 1000g beef meat added recipe; S2: 1.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S3: 1.5 % table salt and 30 % sheep tail fat of 1000g beef meat added recipe; S4: 2.0 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S5: 2.0 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S6: 2.0 % table salt and 30% sheep tail fat of 1000g beef meat added recipe; S7: 2.5 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S8: 2.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe and S9: 2.5 % table salt and 30% sheep tail fat of 1000g beef meat added recipe.

Different small letters indicate statistical difference between cooking time values at $\alpha=0.05$ level in each column.

Different capital letters; A, B, C indicate statistical difference between fat content values at same salt content (S1, S2, S3; S4, S5, S6; S7, S8, S9) at $\alpha=0.05$ level among products at each time.

Different capital letters; X, Y, Z indicate statistical difference between salt content values at same fat content (S1, S4, S7; S2, S5, S8; S3, S6, S9) at $\alpha=0.05$ level among products at each time.

Table 4.20. Statistical results for changes of cohesiveness values of kavurma recipes during the production with respect to cooking time, salt and fat content

Time (min.)	Samples								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
0	0.7240aAX	0.7200abAX	0.6190aBX	0.7365aAX	0.7395aAX	0.7575aAY	0.7205aAX	0.7110aAX	0.6855aAXY
20	0.7060aAX	0.7025abAX	0.7035abAX	0.7165aAX	0.7105aAX	0.7200aAX	0.7120aAX	0.7360abAX	0.7310abcAX
40	0.6890aAX	0.6840aAX	0.7475bAX	0.7985aAX	0.7430aBX	0.8235aAX	0.6750aAX	0.6860aAX	0.7125abAX
60	0.7130aAX	0.7815abABXY	0.8115bBX	0.6930aAX	0.7440aBX	0.7460aBX	0.7105aAX	0.8185bBY	0.7825bcdBX
80	0.6135aAX	0.7810abBX	0.7850bBX	0.7690aAX	0.7100aAX	0.8090aAX	0.7060aAX	0.7385abAX	0.7635abcdAX
100	0.6365aAX	0.7980bAX	0.7305abAX	0.7330aAX	0.7255aAX	0.7750aAX	0.6990aAX	0.7090aABX	0.7730bcdBX
120	0.7835aAX	0.7265abAX	0.7260abAX	0.7520aAXY	0.7495aAX	0.7770aAXY	0.6180aAY	0.7860abBX	0.8150dBY
140	0.7165aAX	0.7900abAX	0.7160abAX	0.7555aAX	0.7305aAX	0.7690aAXY	0.6235aAX	0.7635abAX	0.8050cdAY
160	0.7735aAX	0.7420abAX	0.8215bAX	0.7595aAX	0.7270aAX	0.7735aAX	0.6575aAX	0.7405abAX	0.7295abcAX

S1: 1.5 % table salt and 20 % sheep tail fat of 1000g beef meat added recipe; S2: 1.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S3: 1.5 % table salt and 30 % sheep tail fat of 1000g beef meat added recipe; S4: 2.0 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S5: 2.0 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S6: 2.0 % table salt and 30% sheep tail fat of 1000g beef meat added recipe; S7: 2.5 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S8: 2.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe and S9: 2.5 % table salt and 30% sheep tail fat of 1000g beef meat added recipe.

Different small letters indicate statistical difference between cooking time values at $\alpha=0.05$ level in each column.

Different capital letters; A, B, C indicate statistical difference between fat content values at same salt content (S1, S2, S3; S4, S5, S6; S7, S8, S9) at $\alpha=0.05$ level among products at each time.

Different capital letters; X, Y, Z indicate statistical difference between salt content values at same fat content (S1, S4, S7; S2, S5, S8; S3, S6, S9) at $\alpha=0.05$ level among products at each time.

Table 4.21. Statistical results for changes of gumminess values of kavurma recipes during the production with respect to cooking time, salt and fat content

Time (min.)	Samples								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
0	0.9570aAX	1.7645aAX	0.4895aAX	1.1915aAX	2.7910aAX	1.3640aAX	0.6895aAX	1.5320aAX	1.6105aAX
20	10.1605abAX	5.5715aBX	1.9115abCX	2.2090aAY	4.9715aAX	1.7755aAX	2.4930aAY	2.2800abAY	4.5065aAY
40	12.5025abAX	6.8415aAX	6.1250abAX	11.3300aAX	6.0380aAX	11.4290aAX	2.9755aAX	13.3665abcAX	6.7145aAX
60	26.5535bAX	9.6685aBX	9.5125bBX	17.9245aAX	12.4240aAX	19.6520abAX	14.2095aAX	13.8030abcAX	20.4255aAX
80	16.5990abAX	13.7175aAX	8.9250abAX	13.3880aAX	13.5770aAX	19.5585abAX	13.6435aAX	17.9640cAX	23.0425aAX
100	16.5135abAX	20.5120aAX	7.4530abAX	12.9410aAX	14.4450aAX	33.8585bcAX	12.4460aAX	24.5500cAX	38.4850aAX
120	9.5280abAX	2.7835aAX	8.4170abAX	14.1285aAX	15.2320aAY	42.5815cBX	3.7615aAX	22.0325cAY	34.0460aAX
140	7.4115abAX	3.4345aAX	6.1615abAX	7.5925aAX	18.9150aAX	34.9115bcAY	2.8575aAX	17.1275cAX	16.0660aAXY
160	16.5940abAXY	10.8695aAX	5.5430abAX	49.0245bAX	15.2895aBX	20.2195abBX	5.8085aAY	15.5090bcAX	17.6905aAX

S1: 1.5 % table salt and 20 % sheep tail fat of 1000g beef meat added recipe; S2: 1.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S3: 1.5 % table salt and 30 % sheep tail fat of 1000g beef meat added recipe; S4: 2.0 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S5: 2.0 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S6: 2.0 % table salt and 30% sheep tail fat of 1000g beef meat added recipe; S7: 2.5 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S8: 2.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe and S9: 2.5 % table salt and 30% sheep tail fat of 1000g beef meat added recipe.

Different small letters indicate statistical difference between cooking time values at $\alpha=0.05$ level in each column.

Different capital letters; A, B, C indicate statistical difference between fat content values at same salt content (S1, S2, S3; S4, S5, S6; S7, S8, S9) at $\alpha=0.05$ level among products at each time.

Different capital letters; X, Y, Z indicate statistical difference between salt content values at same fat content (S1, S4, S7; S2, S5, S8; S3, S6, S9) at $\alpha=0.05$ level among products at each time.

Table 4.22. Statistical results for changes of resiliences values of kavurma recipes during the production with respect to cooking time, salt and fat content

Time (min.)	Samples								
	S1	S2	S3	S4	S5	S6	S7	S8	S9
0	0.3310aAX	0.2975aAX	0.1830aBX	0.2715aAX	0.2735aAX	0.2615aAX	0.3065aAX	0.2860aAX	0.2605aAX
20	0.3385aAX	0.2995aAX	0.3105bcAX	0.3380aAX	0.3615aAX	0.3315abAX	0.3000aAX	0.3270abAX	0.3215abAX
40	0.3335aAX	0.3010aAX	0.3390bcAX	0.4105aABX	0.3555aAX	0.4420bBX	0.3050aAX	0.3380abAX	0.3340abAX
60	0.3385aAX	0.3550abAX	0.4030cAX	0.3975aAY	0.3605aAX	0.4435bAX	0.3190aAXY	0.4055bBX	0.3920bcBX
80	0.2840aAX	0.3645abAX	0.3670bcAX	0.3725aAX	0.3670aAX	0.4400bAY	0.3090aAX	0.3400abABX	0.3900bcBXY
100	0.3100aAX	0.3975abAX	0.2910bAX	0.3610aAX	0.3720aAX	0.4190bAY	0.3175aAX	0.3440abAX	0.3885bcAY
120	0.3515aAX	0.2960aAX	0.3275bcAX	0.3550aAX	0.3585aAY	0.4115bAXY	0.2430aAX	0.3620abABY	0.4415cBY
140	0.3550aAX	0.3390abAX	0.3205bcAX	0.3330aAX	0.3380aAX	0.3855bAX	0.2440aAX	0.3810bAX	0.3705bcAX
160	0.4255aAX	0.3655abAX	0.3520bcAX	0.3245aAY	0.3200aAX	0.3730bAX	0.2540aAY	0.3435abBX	0.3365abBX

S1: 1.5 % table salt and 20 % sheep tail fat of 1000g beef meat added recipe; S2: 1.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S3: 1.5 % table salt and 30 % sheep tail fat of 1000g beef meat added recipe; S4: 2.0 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S5: 2.0 % table salt and 25% sheep tail fat of 1000g beef meat added recipe; S6: 2.0 % table salt and 30% sheep tail fat of 1000g beef meat added recipe; S7: 2.5 % table salt and 20% sheep tail fat of 1000g beef meat added recipe; S8: 2.5 % table salt and 25% sheep tail fat of 1000g beef meat added recipe and S9: 2.5 % table salt and 30% sheep tail fat of 1000g beef meat added recipe.

Different small letters indicate statistical difference between cooking time values at $\alpha=0.05$ level in each column.

Different capital letters; A, B, C indicate statistical difference between fat content values at same salt content (S1, S2, S3; S4, S5, S6; S7, S8, S9) at $\alpha=0.05$ level among products at each time.

Different capital letters; X, Y, Z indicate statistical difference between salt content values at same fat content (S1, S4, S7; S2, S5, S8; S3, S6, S9) at $\alpha=0.05$ level among products at each time.

CHAPTER V

CONCLUSION

In this study, effects of different salt, fat contents and cooking times on changes in pH, moisture content, TBARS value, Hunter L*, a* and b* values, BI values, flavour and texture attributes of Kavurma were investigated during the processing.

The following results were obtained during the production of Kavurma;

Moisture Content:

- Salt, fat and time had a significant effect on the moisture content value.
- The increase of salt content caused to a decrease in the moisture content.
- Increasing fat content decreased the moisture content.
- Moisture content values of samples decreased regularly by the time.
- The optimum moisture content obtained as 41.71% in the sample of 2% salt content and at 25% fat content (S5) among all the samples.

pH Values:

- Salt, fat and time had a significant effect on the pH value.
- Increase in salt and fat content caused to decrease in pH value.
- By time, pH value increased.

TBARS Values:

- TBARS values of the samples were in the range of 0.14 – 1.94 mg/kg.
- Salt, fat and time caused a significant change in the TBARS value.
- TBARS values increased by the time during the cooking process.
- TBARS values decreased by increasing the salt content from 1.5% to 2%, on the other hand by the increase of salt content from 2% to 2.5%, TBARS values increased.

- TBARS values of 20% and 25% fat containing samples weren't significantly different from each other, however increasing the fat content to 30%, TBARS values increased to about 0.87 mg malonaldehyde/kg.
- At the end of cooking, the lowest TBARS value (0.67) was obtained in the sample containing 2% salt content and 25% fat content (S5).

Hunter Colour Values

L* (Lightness)

- The increase of salt and fat content caused to decrease in lightness value.
- Lightness value firstly increased then decreased during the cooking.
- The highest L* value was observed at the 1.5% salt, 20% fat content (S1) as 86.4, while the lowest was at the 2.5% salt content and 30% fat content as 42.69 (S9) at the end of cooking.

a* (redness)

- Salt, fat and time caused a significant change ($P < 0.05$) in Hunter a* values.
- The increase of salt, fat content and cooking time caused to a decrease in redness values.

b* (yellowness)

- Hunter b* values affected significantly by salt content and time but fat didn't cause a significant change in yellowness value.
- The increase of salt content during the cooking caused to a decrease in yellowness value which indicated that the color of Kavurma turned to blue (approaching a negative b-value) rather than yellow.

BI (Browning Index)

- BI values sharply decreased within the 40 minute of process. After that, BI values remained constant up to 100-140 minute then slightly increased.
- Until the end of cooking process the increase of fat content caused to a decrease in browning index however the increase of salt content caused to an increase in browning index.

Flavour

- About 25 flavouring compounds were identified in samples
- The major identified compounds were n-butane, n-heptane, n-hexane, n-octane, n-butanal, 3-methylbutanal, n-pentanal, 2,3-pentadione, n-hexanal, heptanal, 3-methyl-1-butanol, and n-octanal.
- 2-heptanone, 2,5-dihydro furandione, cyclohexan-1,4,5-triol-3-one were identified in raw meat but not observed in Kavurma samples.
- 1-undecanol and 2-ethylfuran were identified in melted tail fat but not observed in Kavurma samples.
- Saturated aldehydes such as n-octanal, n-butanal, branched aldehydes (3-methyl butanal) and hydrocarbons such as n-hexane were not identified in raw meat and melted tail fat but observed in Kavurma samples.
- Concentrations of the identified compounds in all samples were generally decreased with time.
- The lowest concentration of identified compounds were observed in the samples containing 20% fat content (S1, S4, S7) at the end of cooking.
- The increase of salt and fat content caused to formation of compounds like hydrocarbons, aldehydes, alcohols and ketones stayed along the end of processing even if in lower concentrations especially hexanal and heptanal which were the major lipid oxidation products.

Textural Attributes

- Time didn't cause a significant change in hardness and chewiness values in most of the samples except the samples of S1, S6, S8 and S9. In these samples hardness and chewiness values firstly increased sharply and then decreased until the end of cooking.
- The increase of salt content didn't cause a significant change in hardness and chewiness values during the processing of Kavurma at 20% fat content. However, increase of salt content at 25% and 30% fat content caused to increase in the hardness and chewiness values.
- There was no difference between the hardness values in most of the samples by increasing fat content.

- The increase of fat content didn't have a significant effect on the chewiness values of the samples. Only, at the salt content of 2.5%, at 140 and 160 minute, the increase of fat content caused to increase of chewiness values.
- Adhesiveness values sharply increased in the samples of S1, S3, S4, S6 within the first 20 min of processing and then become constant until the end of the process. In the rest of the samples, time didn't have a significant change in adhesiveness values.
- The increase of salt and fat content also didn't cause a significant change in the adhesiveness values.
- Springiness and cohesiveness values did not change significantly by increasing cooking time, fat and salt content that was used for the processing.
- Springiness values were varied between 0.7 and 0.9 while cohesiveness ranged between 0.7 and 0.8 during the processing.
- Gumminess, values increased with time during cooking , after that remain constant until end of the processing. The increase of salt and fat content didnt cause a significant change in gumminess
- Resilience values changed significantly in the samples which have 25% and 30% fat content and increased with time during the processing. The increase of salt and fat content also caused to increase in resilience values of Kavurma.

Consequently, **a standard method** for kavurma process was developed with the sample containing 2.0% salt content and 25% fat content (S5) at 160 minutes of cooking. Among all the samples, S5 had optimum conditions with considering quality attributes.

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