



*Sudan University of science and technology*

*College of graduate studies*

**Effect of partially Substituting Beef by Chicken Liver  
and Heart on Quality Attributes of Beef Sausage**

**تأثير الإحلال الجزئى للحوم الابقار بأكباد وقلوب الدواجن على  
خصائص الجودة للسجوك البقرى**

Complementary Dissertation submitted in Partial Fulfillment of  
the Requirement for the Degree of M.Sc. In Tropical Animal  
Production.

By:

Aisha Malik Mohammed Ali

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Supervisor:

Dr. Maha Mubarak Mohammed Ahmmed

Department of Meat science and technology – College of Animal  
Production Science and Technology.

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## الاستهلال

قال تعالى :

(والانعام خلقها لكم فيها دفء ومنافع ومنها تأكلون )

صدق الله العظيم

سورة النحل الايه (5)

## ***Dedication***

*To my lovely family*

*To my father's soul*

*To my colleagues*

*I dedicate this work*

## ***Acknowledgement***

First of all I am indebted to Allah who helped me to complete this research.

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## ABSTRACT

This study was conducted to investigate the effect of substitution of chicken liver for beef sausage production at levels (30%,15%) and chicken heart for beef sausage production at levels (30%,15%) on chemical, physical and microbial characteristics, sensory evaluation and financial cost of sausage. The formulation of sausage was done with five treatments as A control (100% beef), B (30% chicken liver + 70%beef), (C) (15% chicken liver + 85% beef) ,D (30% chicken heart+ 70% beef), and E (15% chicken heart + 85%beef ).

The proximate analysis of the sausage showed significant differences among the treatments in the protein, fat, moisture, and ash contents.

The sensory evaluation results showed no significant differences among the treatments in color, texture, flavor , juiciness, and overall acceptability. On the other hand the physical and microbial characteristics results showed that, there were no significant differences among the treatments in water holding capacity, shrinkage, cooking loss and total bacterial count .

For the financial cost the study revealed that beef sausage incorporated with chicken liver or chicken heart has lower cost than beef sausages.

## المستخلص

أجريت هذه الدراسة لمعرفة تأثير إحلال أكباد وقلوب الدواجن للحوم الأبقار عند مستويات (15% , 30%) أكباد و(15% , 30%) قلوب على الخواص الكيميائية، الفيزيائية، المايكروبايولوجية، التقييم الحسى والتكلفة المالية للسجك المنتج. وقد تم تقسيم التجربة الى خمسة معاملات A الشاهد ( 100% لحوم ابقار) ، B (30% أكباد دواجن + 70% لحوم ابقار) ، C ( 15% أكباد دواجن + 85% لحوم ابقار) ، D (30% قلوب دواجن + 70% لحوم ابقار) ، E (15% قلوب دواجن + 85% لحوم ابقار).

أظهرت نتائج التحليل التقريبي للسجك المنتج وجود فروق معنوية بين المعاملات فى كمية البروتين والدهون والرطوبة والرماد .

وأظهرت نتائج التقييم الحسى عدم وجود فروق معنوية بين المعاملات فى اللون و القوام والنكهة و العصيرية و درجة القبول الكلية. كما أظهرت نتائج الخصائص الفيزيائية والمايكروبايولوجية وجود فرق معنوى بين المعاملات فى القدرة على الاحتفاظ بالماء ، و لكن لم يكن هناك فروق معنوية بين المعاملات فى النسبة المئوية للانكماش و فاقد الطبخ و العد الكلى للبكتيريا.

أما بالنسبة للتكاليف المالية، أظهرت الدراسة أن السجك المصنع من أكباد وقلوب الدواجن مع اللحم البقرى أقل تكلفة من سجك لحوم الأبقار .

## CHAPTER ONE

### INTRODUCTION

Sudan has the largest population of animals in Africa and among Arabic countries. Recently Ministry of Animal Resources Fisheries and Ranges (MARFR, 2016) estimated animal population to be around 107 million heads. Although Sudan is rich in animal resources, it confronts many problems which lead to continuous increase in animal and meat prices. These include poor natural pastures, high cost of feed ingredients and processed feed, diseases, inefficient management of stocks, government taxes, steep and high transportation costs.

Sudan, due to its location, vast area, and variety of climates, is endowed with huge animal resources. They were judged to be around 107,555 head in 2016, with details as 30,632 head of cattle, 40,612 sheep, 31,481 goats and 4,830 camels, MARFR (2016).

In spite of all this great resource and availability of good quality red meat which has been estimated as 167.2 million tons (A.O.A.D, 2005).

Although Sudan is rich in animal resources, it confronts many problems which lead to continuous increase in animal and meat prices. These include poor natural pastures, high cost of feed ingredients and processed feed, diseases,

inefficient management of stocks and high transportation costs.

Meat factories are concentrated in Khartoum state. There are about 16 factories but actually about 15 active factories distributed in three localities . Khartoum locality 8 factories, Omdurman 3 factories and Bahri 5 factories (Asama, 2014).

There are many different types of processing including size reduction, freezing curing, tenderizing and forming (*Acton et al., 1983; Foegeding and Ramsey, 1986*)(*Barbut, 1995*). During processing ,meat is mixed with ingredients, common salt phosphate and protein or carbohydrate binders that will bind the particles back together. Directly or indirectly the mixture is formed to desired shape include various sausages frankfurter, bologna and some meat loaves and formed shape will be maintained after freezing and cooling(*Barbut, 1995*).

Meat and meat products are considered as an excellent source of high quality animal protein, vitamins especially B complex, and certain minerals especially iron (*Gracey et al.,1986*)

Skeletal muscle meats from slaughtered animals are the principal ingredients used in sausage production . However, the different skeletal muscles vary not only in their contents of fat, water and proteins , but also in their water binding and emulsifying properties ,

color , etc. This is the reason why all skeletal muscle meats, such as different cuts of carcasses, including cheek and head meats and trimmings, as well as other muscle meats, such as hearts, weasand meat (muscular part of oesophagus) and gibleet meat (fleshy portion of diaphragm), are regularly subdivided according to their fat-to-lean ratios and their water binding properties (*Wilson, ( 1981)*)

Most sausages are made from only skeletal muscles, a few varieties of sausage can also be made with variety of meats, such as liver or tongue Food Safety and Inspection Service (*FSIS./D.A).* (2000).

Meat quality, especially in relation to bacteriological load, isof special importance in the production of fresh sausages

Beef sausage is also manufactured from cheaper cuts of forequarterssuch as clod(*Savic, 1985*). For desirable color, meat from older animals which contains more myoglobin is preferred(*Toldra, 2002*)

It is difficult to fit sausages into one single definition since they are many and varied. Attempts, however, have been made to define sausage either by shape type or meat content. Characteristically sausages are comminuted processed meat products made from red meat poultry, fish or a combination of these with water, binders and seasoning. They are usually stuffed into a casing and may be cured , smoked or cooked.

Food and Agriculture Organization of the United Nations (FAO ,1985)views sausages as one of the oldest forms of meat processing in which meats go through various modification processes to acquire desirable organoleptic properties. Increasing costs of conventional animal protein foods , have encouraged researchers to study alternative protein sources, particularly chicken livers and hearts that are commonly used in direct consumption without processing.

The problem of this study is that there were no more previous researches carried in this subject .

The reason which guide to this study is the continues increase in red meat price.

The objectives of this study are:

- To study the effect of substituting chicken livers and chicken hearts for beef on quality attributes of sausages product.
- To study the effect of substituting and financial cost of sausage.
- To evaluate the consumer acceptability of new product.
- Creation of good recipe and marketing for chicken livers and chicken hearts..

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Meat nutritive value and human consumption:-

Meat is the post-mortem aspect of a complicated biological muscle tissue. Chemical and biological constitution of the muscle are affected by a large number of intrinsic factors. The most important of these factors are animal species, breed, sex, age and anatomical location of muscle, training or exercise, plane of nutrition and interracial variability. In addition to various extrinsic factors, such as food, fatigue, fear, pre slaughter, manipulation and environmental condition before, during and after slaughter, In broad sense the composition of meat can be approximate to 75% water, 18% protein, 3.5% soluble non-protein substance and 3% fat (*Lawrie, 1991*). Meat is consumed by human for variety reasons including taste, nutrient, prestige, tradition and availability (*Rogowski, 1980*). Meat in diet is an important source of protein which is not only of high biological value but for its amino acids composition and components. The most important taste active components of meat are amino acids, peptides, organic acids, nucleotides and other flavor enhancer (*Shahidi, 1989*). Also it is a good source of iron and zinc (*Bender 1992*). Meat consists primarily of muscular tissue with amounts of fatty tissue varying not only with breed, age,

sex, and diet of the animal but also with anatomical location (*Lawrie . 1991*) Regarded nutritionally, meat is a very good source of essential amino acids, and to a lesser extent, of certain mineral. Although vitamins and essential fatty acids are also present, meat is not usually relied upon for these components in a well-balanced diet (*Lawrie , 1990*) . Also meat provides calories from proteins, fats and limited quantities of carbohydrates present (*Judge et al, 1991*). Since connective tissue proteins, have a lower content of essential amino acids than those of contractile tissue , meat having a high percentage of collagen or elastine will also have relatively lower intrinsic nutritive value (*Lawrie , 1991*)

In respect of the essential amino acids, beef would appear to have a somewhat higher content of leucine , lysine and valine than lamb, and lower content of threonine. More significant difference may exist between specific muscle locations, or that breed, and animal age, have important effect. The amino acids content may be affected by processing e.g.heat.ionizing radiation, but unless processing conditions are both severe and prolonged, such destruction is minimal. Rather more important is the possibility that certain amino acids may become unavailable, (*Bender , 1966*) Thus (*Dvorak and Vognarova 19650*) have found that after heating beef for 3 hours at a series of temperatures, 90% of the available lysine was retained at 70c and only 50% at 160c Meat is generally a good source of all



minerals except calcium, calcium of the meat is present in bones and teeth (*Judge et al , 1990*). Meat is also an important source of iron, the concentration of it is markedly higher in the liver than in the muscular tissue (*Lawrie , 1991*). Meat is an excellent source of water soluble B complex group but, is very poor source of the water soluble vitamin C, and of the fat soluble vitamin A,D,E and K that are found primarily in the body fat and the variety meat (*liver, kidney, heart etc ...*) All meat is a very poor source of water – soluble vitamin C except when ascorbate has been added to processed meat products (*Judge et al ,1990*).

## **2.2:Products of Meat Industry:**

*Judge et al.* (1989) defined animal by-products as everything of economic value, other than carcasses, obtained from animals during slaughter and processing. Meat by-products are commonly classified as edible or inedible (*Olivero et al., 1982*). It has been reported that meat by-products have been avoided in meat processing due to their undesirable sensory quality, low biological value of their proteins and high microbial loads contaminating the by-products (*Gorska et al., 1988*). The increasing price of lean meat and processed meat products caused the food industry to evaluate the utilization of all protein sources, including by-products (*Gorska et al., 1988*). Sausage ingredients are classified as either binder or filler meats. Binder meats are further subdivided into high, medium and low categories depending on

their ability to bind water and emulsify fat, meats with very poor binding properties are referred to as filler meats(*Gorska et al., 1988*).

### **2.3:Chicken livers:**

While chicken is one of the most commonly eaten meats, the liver is often overlooked as an undesirable part of the bird. Chicken liver does contain a large amount of cholesterol, but it also supplies healthy doses of many essential vitamins and minerals. (American Society for Parenteral and Enteral Nutrition(ASPEN,) 2018).

**Fat and Cholesterol :**One chicken liver contains 2.86 grams of total fat, with 0.9 grams being saturated. The same chicken liver has 248 milligrams of cholesterol. The cholesterol content makes chicken liver only an occasional part of your diet.( American Society for Parenteral and Enteral Nutrition(ASPEN), 2018).

**Iron and Zinc :**chicken liver provides a healthy dose of iron and zinc. Iron enables your body to use oxygen efficiently and to make new red blood cells. This mineral also plays a role in cell division and the health of your immune system. An iron deficiency can cause fatigue, A. Chicken liver has 72% iron which contributes for preventing anemia and also keeps the immune system healthy in condition and this kind of liver is a great source of the essential minerals, zinc, phosphorus and

magnesium. Mineral become an important requirement for the healthy body

Vitamins: Chicken liver is a nutritious source of vitamins. One chicken liver contains 7.41 micrograms of vitamin B12, which is significantly more than the 2.4 milligrams you need each day. You need vitamin B12 for the healthy function of your brain and nervous system and to replenish your blood supply. One chicken liver supplies 254 micrograms of the 400 micrograms of folic acid reduces your risk of certain birth defects. The same chicken liver contains 5,864 international units of vitamin A.

One serving supplies more than 100 percent of the DRI for vitamins A and four of B vitamins- foliate , pantothenic acid riboflavin and B12. One serving also provides more than 50 percent of the DRI for choline, vitamins B6 and niacin, which are also water-soluble B vitamins . Vitamins A supports the eyes and immune system. B vitamins assist in the health of the nervous system, liver, brain and muscles.

Protein : Chicken liver contains 172 calories, more than 100 of which come from protein. One serving of chicken liver contains 25.8g of protein, which provides more 40 percent of the DRI for protein.(ASPEN, 2018).

Chicken livers can be good source of nutrition to human , chicken livers are high in protein and a rich store of floate, which is important for fertility and helps prevent certain birth defects .

Livers are also loaded with iron to give you energy and a trove of certain B vitamins, most notably B12. This nutritional profile makes them a good choice for anyone prone to anemia. Chicken livers are also one of top sources of vitamin A, which helps eye health. Chicken livers are healthy meat organs which contains high cholesterol. According to database of USDA, chicken liver has 5.61 mg/g. Choosing the most safe food in high cholesterol is important. The health benefits in eating chicken liver might help to sway out mind since they contain amount of protein. Furthermore is rich in iron and vitamin (American Society for Parenteral and Enteral Nutrition(ASPEN,) 2018).

#### **2.4:Chicken Heart:**

There are numerous health benefits to eating hearts. They are a good source of high quality proteins and provide all the essential amino acids which carry out all sorts of crucial functions throughout the body. They are high in iron which is needed to produce hemoglobin to transport oxygen through the blood, and zinc which boosts the immune system and helps heal cuts. (American Society for Parenteral and Enteral Nutrition (ASPEN,) 2018).

Chicken hearts are also high in B vitamins which help with stress, fatigue and problems with the heart and blood vessels. So eating hearts is actually good for your heart. Chicken heart is

a very good source of protein. and provide foliate, phosphorus zinc iron etc... ( American Society for Parenteral and Enteral Nutrition..( ASPEN) 2018).

## **2.5:Sausage as meat product:**

### **2.5.1:Sausage manufacturing:**

Sausage making and manufacturing is a continuous sequence of events. Each step in proper sequence is important to successful operation in studying sausage processing, it is convenient to separate the process in to four basic processing: selecting ingredient, grinding, mixing and thermal processing (*Pearson and Gillett, 1996*).

### **2.5.2:Sausage classification:**

Sausage can be classified according to degree of combinations to coarsely and emulsified sausage . As stated by (*Boyle, 1994*).There are five basic classification of sausage these are fresh sausage, uncooked smoked sausage, cooked smoked sausage, and cooked sausage, dry and semi-dry sausages. Classification of sausage is commonly based on the type of the meat ingredients and processing methods used in their manufacture. Some products may be made from meat of only one specie, however it is very common to use two or three types of red meat and poultry ingredients in many sausage formulations.

### **2.5.3:Types of sausage:**

Sausage is made from beef, veal, pork, lamb, poultry and wild game or from any combination of these meats. Sausage making has become a unique blend of old procedures and new scientific, highly mechanized processes, Traditionally, sausage was formed into asymmetrical shapes, but it now can be found in variety of shapes and sizes to meet consumers needs. Many sausage products are vacuum packed, freshness dated and 100% edible. Sausage can be classified in a variety of ways, but probably the most useful is by how they are processed Fresh sausage, Uncooked thoroughly smoked sausage, Cooked smoked (Frankfurter) sausage, Dry sausage, semi-dry (bologna) sausage and cooked meat (Loaves, head ) specialties(*Martin and Julie, 1998*).

Emulsion type sausage is technologically dependent upon the protein and their water binding and emulsifying properties. Muscle protein can be divided into three groups, based on their solubility characteristics, sarcoplasmic (water-soluble), myofibril (salt-soluble) and stromal (insoluble) protein (*Xiong, 1997*). Myofibril protein, of which myosin and actin are the most abundant, are most important during meat processing because of their ability to produce three-dimensional gels upon heating and subsequent cooling, which has a high influence on the yield and texture properties of processed meat product (*Smith, 1988*),(*vega-wamer et, al, 1999*).

## **2.6:Sausage ingredients:**

### **2.6.1:Meat:**

Meat can be defined as the whole or part of the carcass of any cattle, sheep, goat, camel, buffalo, deer, hare, poultry, or rabbit, (*Williams, 2007*). Most sausage are made from only skeletal that is taken off the bones. A few varieties of sausage can also be made with variety meats, such as liver or tongue(*FSIS/USDA.1995*). Meat quality, especially in relation to its bacteriological load, is of special importance in the production of fresh sausage. Beef sausage is also manufactured from cheaper cuts of forequarters such as clod (*Savic1985*). For desirable color, meat from older animals which contains more myoglobin is preferred (*Toldra, 2002*).

### **2.6.2:Casings:**

Casings are used as containers for sausage to give them shape and to hold them together during further processing. There are two types of casing natural and manufactured. The natural casings are derived from gastro-intestinal tract of sheep, goats, swine and cattle. The manufactured casings have four classes edible classes, edible collagen, cellulose and plastic (*Judge et al., 1990*)

### **2.6.3:Non meat ingredients (additives):**

Food additives are used to accomplish certain functions such as coloring, antimicrobial, ant oxidative, preservation,

improved nutrition, increased emulsification and altered flavor(*Jihad et al., 2009*).

### **2.6.3.1:Salt:**

Salt is the most common and most important non meat ingredient of sausage. Its function includes flavoring, preservation and production of proper texture by solubilization of meat protein. Maintaining color stability and minimizing bacterial growth can be achieved satisfactorily by using alternatives binders to salt, that don't accelerates the of hemoglobin, bacterial growth can be minimizing by using sodium bisulphate(*Savic, 1985, Bender, 1992, Judge et al., 2001, Kerry et al., 2002*). Salt is powerful preservative at high concentration, but at low concentration it develops a desirable flavor in the processed meat products. Salt is added for flavoring function at concentration between 2-3% Fresh sausage generally have a lower salt level due to detrimental color and effects,1.5% salt in finished sausage works out satisfactorily for color and flavor .

### **2.6.3.2:Nitrate and Nitrite**

As discussed by *Aberleet al. (2001)* nitrite, either as a potassium or sodium salt, is used to preserve desirable meaty flavor, prevent warmed- over flavor, fix a bright reddish pink color and inhibit microbial growth, particularly out growth of *C. botulinum* spores. Sodium or potassium nitrates were the first compounds used for



this purpose. However, it was discovered that nitrate reduced to nitrite by microorganisms and that direct nitrite addition results in the desired flavor.

#### **2.6.3.3:Ice or cold water:**

Water or ice added to the meat mixture provides considerable functional qualities. It chills the meat during the chopping or mixing operations, which give longer and more efficient churning of meat mass without mechanical overheating. It aids in dissolving sodium chloride and curing salts to give better distribution in the mixture. Also it imparts fluidity to the meat mixture or emulsion that aids in proper filling of the casings. Moreover, the added water content markedly affects texture and tenderness of finished sausages (*Pearson and Gillett, 1996*). According to Sudanese Standards and Metrology Organization, (*SSMO, 2008*) the level of added water should not exceed than 10% in the fresh sausage.

#### **2.6.3.4:Binders and extenders:**

Non-meat proteins are widely used in meat processing. Non-meat proteins used in meat processing technology are divided into two groups: (1) plant proteins such as soy isolates, soy concentrates and flours (2) protein of animal origin such as milk proteins. Soy products have been used in meat processing to improve functional properties such as water binding and textural properties, they are hydrophilic (absorb and

retain water ( and have adhesive properties (*Giесе, 1992; Dexter et al., 1993*);(*Mittal and Barbut, 1993*) ; *pietrasik and Duha , 2000; porcella et al.,2001*);Meltem and Meltem, (2003). Milk proteins can act both as emulsifier and as water and fat binders in foods Sebranek , (1996).

#### **2.6.3.5: Seasonings:**

Seasonings influence the flavor, appearance or shelf-life of the product; they are classified further as spices, herbs, aromatic vegetables, flavoring enhancers and stimulated meat flavors. Certain spices such as black pepper, ginger and mace have antioxidant properties and will help extend the shelf-life of sausages (*Komarik et al., 1978; Pearson and Gillett, 1996*). The characteristic flavor of a given type of sausage depends to a large extent on the spices used in its formulation(*Toldra, 2002*)

#### **2.7:Meat quality attributes:**

Meat quality includes tenderness, palatability, aroma, flavor, color and juiciness. Species, sex, breed, age and post-mortem handling are known to influence these factors. It is also possible that diet or some components of diet may exert some effects on the factors mentioned above. It may lead to reduce meat quality leading to low pricing Dikeman( 1990) ; Koohmaraie, 1992; Glitsch 2000; Kerry et al., 2002; Egena and Ocheme 2008).

The effect of temperature of comminuting on stability and eating quality of "English" sausage. It was found that increasing temperature of comminuting lead to increase cooking loss, softening in texture and at darkening in color and subjective assessment indicated that at least up to comminuting temperature of 25c the sausage were acceptable and at temperature above 30c off flavor developed, (*Sally Brown and Ledward, 1984*).

### **2.7.1:Color:**

Color is an important criterion of raw or cooked meat and meat products. It reflects the proper composition of the products, in particularly relation of meat to other compounds, freshness of raw materials, texture, taste and proper conditions of storage(*Klak et al., 2001, Alberti et al., 2002*).

The presence of muscle pigments, myoglobin and haemoglobin is the main limiting factor of the meat color. Discoloration can be related to the amount of these pigments in the meat, the chemical state of the pigments and the way in which light is reflected off the meat (*Adegoke and Falade, 2005*).Color loss in sausage is caused partly by oxidation of meat pigment myoglobin to metmyoglobin (Wilson, 1981). Goat meat was darker red in color than lamb (*Babiker et al., 1990*)

### **2.7.2 Tenderness and texture**

Of all the attributes of eating quality, the average consumer presently rates texture and tenderness most important (Koochmaraie *Mukasa*, (1981) defined texture of meat as the sensory manifestation of the structure of the meat and the manner in which the structure reacts to the force applied during biting.

stated that meat tenderness and flavor are the most important components that determine meat quality . *McMillin*, (2005) reported that there are two main components of meat tenderness, myofibrillar and connective tissue .

The degree of tenderness was related to three categories of protein in muscle, those of the connective tissue, the myofibril and the sarcoplasmic proteins. Age, breed, and diet influence tenderness, juiciness, and flavor (*Morgan*, 1992) considers tenderness as the single most important component of meat quality. (*Kadim et al.*, 2006) stated that, younger animals yield more tender meat than older ones.

### **2.7.3: Juiciness**

Juiciness is important to meat texture and palatability. It has two major components; the first is the impression of wetness produced by the more release of fluid from the meat during chewing, the second is the sustained juiciness that apparently results from the stimulating effect of fat on the

production of the saliva (Lawrie, 1991), and (Moloney, 1999) stated that juiciness reaches a minimum when the pH level of the meat is about six reported that the sensation of juiciness in chevon is directly related to the quantity and composition of intramuscular fat. (Lawrie, 1991) stated that Juiciness of meat and meat products is affected by the storage.

#### **2.7.4 Flavor and Aroma**

(Shahidi, 1994) stated that flavor has a great influence on the (Sensory quality of meat, consequently on its overall acceptability. Milton, 1990 and Moloney, 1999) reported that the flavor of meat is associated with either moisture or fat contents of meat. Therefore, meat from older animals is more intense in flavor than meat from younger animals. Calkins and Hodgens, (2007) reported that flavor is a complex attribute of meat palatability and was determined by the chemical senses of taste and smell. (Muchenje et al., 2009) reported that flavor depends on the quantity and composition of fat in meat. (Lawrie, 1991) stated that flavor is a complex sensation that involves odor, taste, texture temperature and pH. (Angelo et al., 1987) reported that the factors that influence the flavor of meat products include animal feed, processing methods, storage condition and sanitation. (Mottram, 2002) stated that meat aroma develops from the interaction of non-volatile precursors including free

amino acids , peptides , reducing sugars, vitamins nucleotides and unsaturated fatty acids, during cooking.( *Ellard, 2002*)

### **2.7.5 Water holding capacity**

Water holding capacity is the ability of meat to retain its own or added water during application of external forces such as cutting, heating grinding, or pressing (*Judge et al., 1989*) .(*Trout, 1988*) reported that the WHC of meat or meat product was determined the amount of product that can be sold and influence the sensory properties of the product such as juiciness, texture, and flavor . Thomsen and stated that the WHC is strongly dependent on the pH of meat and it's minimum at pH 5, corresponding to the iso-electric point of actomyosin. Thomosion ,andZeuthen (1988).

### **2.7.6 Cooking loss:**

Cooking loss is one of the most important properties of sausage products as it is related to water holding capacity. There is variation in water holding capacity among different types of meat from different animal and muscles (*Lawrie, (1991)*). (*Kannan et al.,(2001)*) stated that cooking loss was highest in leg cuts, intermediate in shoulder/arm cuts and lowest in loin/rib cuts.(*Siham 2008*) reported that cooking loss was lower in camel meat compared to beef. (*Babiekr et al., 1990*) reported that chevon had lower cooking loss compared to lamb.*Kannan,( 2004)*

stated that cooking loss% was lower in chevon sausages compared to beef

An evaluation of overall organoleptic properties depends upon the sensory evaluation of physical characteristics and mainly upon

### **2.7.7:Meat microbiology:**

Contamination of carcass come from different sources including environment and equipments with which meat comes in contact during slaughtering and processing, but hides remain an important source of contamination of carcass (*Striger et al., 1969.*)

The total viable bacterial count of perishable foods is used to evaluate its contamination level because the bacterial load determines the shelf-life(*Angelloti, 1964*). Recently many vegetable proteins have been blended with different meat products. However, many research workers have reported that bacterial numbers increase with the increase with the increase of the percentage of vegetable protein blended in meat products(*Tibin and Melton 1990*) .

Ground beef is one of the most economical and popular choice of meat product that offer consumer variety and convenience. However, it providesan excellent environment for microbial growth and becomes contaminated as result of grinding and mixing during fabrication process When examined for microbiological quality and shelf-life at higher temperature was found to have significantly higher total plate counts.

(*Narasimhaand Ramesh, 1988*)reported that for fresh sausage the total aerobic plate count should not exceed than  $5.25 \times 10^5$ CFU/ml. (SSMO 2008).

Keeping quality of meat and meat products depend on the number of the contaminating bacteria and their metabolism and rate of growth. It also depends on the physical and chemical environment(*Brownile,1966*)., however the hygienic level of the methods of killing, preparing and subsequent processing meat determines the bacteriological quality of the finished product. The deterioration of food usually manifested by alternations in the appearance, texture, color, odor and flavor or by slime formation. Degradation of food results in the formation of compounds which have odors and flavors different from those of fresh food (*Jadge,1970*).



## **CHAPTER THREE**

### **MATERIALS AND METHODS**

This experiment was conducted at the laboratory of Meat Science and Technology, College of Animal Production Science and Technology Sudan University of Science and Technology in 4/10/2017.

#### **3.1-Beef meat preparation:-**

A total of 9.30kg fresh deboned beef meat was obtained from Meat Technology Department in Kuku Animal Production Research Center.

The beef meat was ground through 0.25 in plate of an electrical meat grinder . The whole bulk of mixed meat was thoroughly hand mixed and divided in to five batches a 1 kg ,0.70kg, 0.85kg,0.70kg, and 0.85kg (one batch for each treatment).

#### **3.2:Chicken liver and heart preparation:-**

A total of 1.135kg fresh chicken liver and 1.135kg fresh chicken heart were obtained fromKhartoum meat market . They were washed cleaned and ground through 0.25in plate of an electrical meat grinder then the bulk was divided in to four samples treatment (B) contained (0.30kg) chicken liver, treatment(C) contained (0.15kg), chicken liver , treatment(D) contained (0.30kg) chicken heart , and treatment(E)

contained(0.15kg)chicken heart While thefivth treatment(A) was formulated without chicken liver and heart (control ).(Three replication were done for each treatment).

### **3.4:Ingredients:**

All ingredients were added equally to all treatments.

Table (1); Ingredients based on total mixed base

<b>No</b>	<b>Ingredient</b>	<b>%</b>
1	Salt	1.8
2	Coriander	0.3
3	Cinnamon	0.3
4	Garlic	0.3
5	Skimmed milk powder	4
6	Potatoes	10
7	Ice water	20
8	Dry bread	10

All ingredient are percentage from the formulated products

### **3.3 : Casings:**

Natural casings from (sheep intestines )were obtained from the local market at Khartoum north in clean scraped ready form.They were salted and kept in a freezer at  $-18c^0$ ).

### **3.5:Treatments formulation:**

Ground chicken liver and chicken heart were added to the ground beef meat to formulate five treatments:

(A)100%beef (control),0% chicken liver and heart.

(B)70%beef, 30% chicken liver.

(C)85% beef, 15% chicken liver.

(D)70% beef, 30% chicken heart .

(E)85% beef, 15% chicken heart.

### **3.6:Preparation of sausage:**

All ingredients (shown in table1) were added equally to all treatments .

Each batch was chopped separately , after formulation using the ingredients in table (1) The chopper was started after the minced meat was introduced, half the recommended ice water were added together and uniformly dispersed . Then , the binder and seasoning were added together, with the remainder of the recommended ice water.The entire mass for each batch was chopped about 5 minutes . The batter for each batch was then stuffed into natural casing and linked at length about 7cm .The sausage were packed in polyethylene bags and stored in freezer waiting different tests.

### **3.7:Sensory evaluation:**

Ten(10) semi-trained panelists were asked to evaluate the treatments effect on color, tenderness, juiciness, flavor, and overall acceptability .

Samples in each treatment were taken after they had been cooked in apan using vegetable oil at (90c) for 5minutes then placed in a dish which was divided into 5 portions Every treatment was given random five code numbers which were changed in each session .Every panelist had one dish to evaluate in each session under natural light. Using 8-points(hedonic scale ) card (Cross et al., 1987), in which the highest score of 8 being extremely desirable and 1 being extremely undesirable, tap water was available for use between testing samples for washing hands and mouth cleaning(Appendix 1).

### **3.8 Proximate analyses**

Five sausage samples were taken at random from each treatment and then approximately 50 grams portions were taken from different places and mixed well to assure a representative sample for proximate analyses, and were sent to the Central Laboratory for Veterinary Research Department of Biochemistry Soba for the Proximate chemical analysis, moisture, crude protein (CP), ether extract (EE) and ash of the sausage sample were determined according to Association of Official Analytical Chemists (AOAC 1995) methods.

### **3.8.1: Moisture determination**

Moisture content determination was based on weight loss of 2.5gm sample, dried overnight in a drying oven at 102°C. The sample was cooled in a desiccator, weighed and moisture loss was calculated as percentage of fresh sample weight.

$$\text{Moisture \%} = \frac{\text{weight loss}}{\text{Original weight}} \times 100$$

$$\text{Dry matter\%} = 100 - \text{moisture\%}$$

### **3.8.2: Ash determination**

Samples were placed in crucibles and dried overnight in a drying oven at 102°C, then ashed in muffle furnace at 550°C for 18 hrs. Samples were cooled in a desiccator and weighed.

$$\text{Ash \%} = \frac{\text{wt. of ash}}{\text{Wt. of sample}} \times 100$$

### **3.8.3: Fat determination**

Fat was determined by ether extract method. Two gms from the sample were taken to Soxhlet apparatus. The sample were subjected to continuous extract with ether for 6 hours. The sample then removed from the extractor and allowed to dry for 2 hours at 100°C in a drying oven till no traces of ether remained. The sample was then cooled and weighed for the extraction percentage was calculated as follows :-

$$\text{Fat \%} = \frac{\text{fat weight}}{\text{Sample weight}} \times 100$$

### 3.8.4: Crude protein determination

The Kjeldahl method was used to determine the total nitrogen. Crude protein was calculated 6.25 times Kjeldahl nitrogen. 0.2gm sample was weighed in Kjeldahl flask. Half tablet of catalyst mixture (10 part of  $K_2SO_4$  to 1 part of  $CuSO_4$ ) was added. Ten mls conc.  $H_2SO_4$  was added. The content of the flask was digested under boiling at maximum heat for about 2 hours. The flask was cooled and transferred to the distillation unit. The sample was distilled using 40% Na OH solution and received in 4% boric acid. The content titrated against 0.1 N HCL.

$$\text{Crude protein \%} = \frac{(\text{ml HCL for sample} - \text{ml HCL for blank}) \times 0.1 \times 14 \times 6.25}{\text{Wt. of sample} \times 1000}$$

$$\text{Wt. of sample} \times 1000$$

### 3.8.5: Cooking losses:

The frozen sausage samples were thawed in a refrigerator for overnight then cooked in a pan using vegetable oil at constant temperature (90c) for 5 minutes with continues turning of the samples. The cooked samples were dried of the oil using absorbent kitchen paper and allowed to cool and weighed. The difference in weight of samples before and after cooked was recorded as the total cooking loss and expressed as a percentage of weight before cooking.

$$\text{Cooking loss \%} = \frac{\text{wt. before cooking} - \text{wt. after cooking}}{\text{weight before cooked}} \times 100$$

### **3.8.6: Shrinkage determination:**

The frozen sausage samples of almost the same diameter were thawed in a refrigerator for overnight. The length of the samples were measured using a measuring tape then cooked in a pan using vegetable oil at constant temperature (90c) for 5 minutes with continuous turning of the samples . The cooked samples were dried of the oil using absorbent kitchen paper and allowed to cool and remeasured. The difference in the total length of samples before and after cooking was recorded as the shrinkage and expressed as a percentage of length before cooking (*Nour 2003*) .

$$\text{Shrinkage\%} = \frac{\text{length before cooking} - \text{length after cooking}}{\text{length before cooking}} \times 100$$

### **3.8.7: Water holding capacity:**

Water holding capacity was calculated according to *Alaswad (1984)*. The meat samples from each rib section about 0.3g were ground and placed on a humidified filter paper (what man no 40) of known weight then the samples were pressed between two Plexiglas plates for 10 min at 1kg load. Each filter paper was reweighed and the difference between the two weights was obtained. The water holding capacity then calculated using the following equation:

$$\text{WHC (\%)} = \text{Actual moisture(\%)} - \text{Free water in sample(\%)}$$

### **3.8.8: Total bacterial count:**

Standard plate count agar media was used to determine the total bacterial count. Samples were prepared according to the technique described by (ICMSF 1974). Briefly, 1g from each sample was transferred under aseptic condition to glass tube containing 9ml of sterile normal saline. The content of the tube was homogenized by dipping and shaking the sample to have a dilution of  $10^{-1}$ . About  $10^{-15}$  ml of plate count agar media poured aseptically into sterile petri-dishes. One ml from dilutions added to each petri – dish, and they were transferred to an incubator at  $37^{\circ}\text{C}$  for 48 hours. A colony count was used for counting colonies grown in the incubated petri – dishes. Such homogenate was used for all bacterial investigation. Further, 5 fold serial dilutions were prepared up to  $10^{-5}$ .

### **3.9: Financial cost determination:**

As shown in table (8) Figure (4), to determine the financial cost of each treatment calculated the price of all additives and materials involved in each treatment .Table 2 which represents the (A) treatment (control 100% beef meat ) the financial cost 1.470kg from sausage processed reached (96 SDG) this mean(1kg cost 65.31 Sudanese pound). treatment (B)30% chicken liver with 70%beef meat, the financial cost 1.470kg from sausage processed recorded( 81SDG) this mean (1kg cost 55.10Sudanese pound). In the treatment (C) 15% chicken liver with 85%beef meat, the financial cost 1.470 kg from sausage processed recorded



(88.5SDG) this mean (1kg cost 60.20Sudanese pound).In the treatment (D)30% chicken heart with 70% beef meat, the financial cost 1.470kg from sausage processed recorded (81SDG)this mean (1kg55.10Sudanese pound ).In the treatment(E)15% chicken heart with 85% beef meat, the financial cost 1.470kg from sausage processed recorded(88.5SDG)this mean (1kg =60.20Sudanese pound)

Table (2): Sausage processed from(100% beef + 0% chicken liver and heart)

NO	Ingredient	Quantity/gram	Price
1	Additives	470	16
2	Meat	1000	80
3	Liver and Heart	-	-
4	Total	1470	96

Table (3):Sausage processed from/(70% Beef + 30% chicken liver )

NO	Ingredient	Quantity/gram	Price
1	Additives	470	16
2	Meat	700	56
3	Liver	300	09
4	Total	1470	81

Table (4): Sausage processed from/( 85% beef + 15% chicken liver )

NO	Ingredient	Quantity/gram	Price
1	Additives	470	16
2	Meat	850	68
3	Liver	150	4.5
4	Total	1470	88.5

Table (5):Sausage processed from/(70%Beef + 30% chicken heart)

NO	Ingredient	Quantity/gram	Price
1	Additives	470	16
2	Meat	700	56
3	Heart	300	09
4	Total	1470	81

Table (6):Sausage processed from(85%Beef + 15% chicken heart)

NO	Ingredient	Quantity/gram	Price
1	Additives	470	16
2	Meat	850	68
3	Heart	150	4.5
4	Total	1470	88.5

# Chapter Four

## Results and Discussion

### 4.1: Proximate Analysis:

Mean values of the effect of different substitution levels of chicken livers and heart for beef on chemical composition in table (7) showed there were significant differences among the treatments in crude protein % while there was high significant differences ( $p \leq 0.05$ ) among the treatments in Ash% ,Fat% and Moisture%.

Crude protein% content was higher in the sausage sample (B) which contained from (30% chicken liver+70%beef ) and recorded(19.50) sausage sample (D) (30%chicken heart +70%beef)),sausage sample (C) (15%chicken liver+85%beef) The sausage sample (E) (15%chicken heart +85% beef) recorded respectively(19.25),(18.81),(18.25),while sample(A) the control(100%beef) had the lowerst score (18.25).

Table (7) indicated that, there were significant differences ( $P \leq 0.05$ ) in fat content among the treatments, where the sample (D)has higher fat (3.37%) compared to the sausage sample (E) (2.90%), sausage sample (B) recorded (2.50%),sausage sample (C) recorded (2.49%) and sausage sample (A) the control which has the lowest score (2.43%).

As for ash content table (5) showed that, there were significant differences ( $p \leq 0.05$ ) among the treatments, the sample (A) as (1.92%) had higher percentage compared with sausage sample (D) (1.89%), sausage sample (B) recorded (1.84%), sausage sample (C) (1.70%) and sausage sample (E) which was (1.62%).

The results of moisture content as shown in table (7) and indicated that, there were significant differences ( $p \leq 0.00$ ) among the treatments, the sausage sample (A) the control contained the highest moisture content which recorded (70.63%) followed by that sausage sample (E) which reached (69.61%) sausage sample (C) (69.22%), sausage sample (D) recorded (68.55%) and sample (B) which recorded (67.76%).

These findings were in agreement with that observed by Reddy and Vijayalakshmi (1998) who reported a gradual increase in the protein and fat content with increased incorporation of heart and gizzard in sausage formulation. Similar trend was observed by Raut, et al (2015), who revealed that, protein and fat content increased gradually with increased incorporation of heart and gizzard. Also **Mohamed Elkhatim**, et al (2013) reported that, there were no significant differences ( $p \leq 0.05$ ) in fat content among the different samples in their study of the effect of incorporation of chicken gizzard on the fresh and stored sausage. On the other hand, Sudheer, et al (2011) mentioned that, the

protein increased significantly, whereas, the fat content decreased significantly ( $p \leq 0.05$ ) as the level of incorporation of gizzards increased which may be due to the low fat content in the raw gizzard

Crude protein, fat, ash, and moisture content were in agreement with that reported by Ali (2012) who studied the effect of storage period on quality of chevon and beef sausage with percentage 50% chevon+50%beef due to different types of meat with his finding significant differences ( $p \leq 0.00$ ) in moisture and ash content.

As for crude protein and fat content, although the results disagree with those found by (Hassan ,2014) who studied the effect of partial substituting beef by chicken gizzard on quality attributes of beef sausage with percentage 50%chicken gizzard+50%beef and 25% chicken gizzard+75% beef, but also agree with his finding significant differences ( $p \leq 0.05$ ) in moisture and ash content.Reddy and Vijayalakshmi (1998) also reported gradual reduction in moisture content of sausage made with incorporation of skin, gizzard and heart which agree with Mohamed Elkhatim, et al (2013) who observed decrease in moisture content with increased percentage of chicken gizzard incorporated in sausage . Similar trend was reported with Raute, et al (2015) who incorporated heart and gizzard in chicken pickle.

Table7: Mean values and their standard deviation (SD) for Crude protein, Fat, Ash and Moisture content of various treatments

Treatments Parameters	A	B	C	D	E	Significant
Moisture	70.63±0.02 <sup>a</sup>	67.76±0.02 <sup>b</sup>	69.22±0.02 <sup>c</sup>	68.55±0.02 <sup>d</sup>	69.61±0.01	**
Crude protein	18.25±0.03	19.50±0.03	18.81±0.01	19.25±0.02	18.55±0.02	**
Fat	2.43±0.03	2.50±0.02	2.49±0.02	3.37±0.53	2.90±0.02	*
Ash	1.92±0.02	1.84±0.02	1.70±0.02	1.89±0.02	1.62±0.02	**

\*:significant at (p<0.05)

\*\* :significant at(p<0.01).

A:Control(100% beef)

B:(30%chicken livers+70% beef)

C:(15%chicken livers+85% beef)

D:(30%chicken heart+70% beef)

E:(15%chicken heart+85% beef)

#### 4.2:Sensory evaluation:

As shown in table (8) There was no significant difference among the treatments in color, texture , flavor, juiciness, and overall acceptability.

The color values for all the sausage samples indicated that there was no significant difference among the treatments table(6) and Figure (2) However the sausage sample(A) ,(D) and(E) had equal scores (7.09), while sausage sample (C)reached (6.98) and the sausage sample (B) less than other treatment (6.97).

As for texture there were no significant difference ( $p \geq 0.05$ ) among the treatments in texture as shown in table (8).The sausage sample (D)and (E) had equal scores (6.93), sausage sample (A) which recorded (6.90),sausage sample (C) reached (6.87), and the sausage sample (B) had lowest score(6.85).

Table (8) Figure (2) revealed that there was no significant difference among the treatments in flavor. However, the sample (B)which had the highest score (6.86), sample (D) which recorded (6.82), while sausage sample (E) reached (6.70)and sample (C)which recorded (6.62) which lower score then the (A) control 100% beef (6.67).

As for the juiciness therewas no significant difference among the treatments, where sausage sample (B) had the lowest juiciness score (6.42), followed by sausage sample (C)which recorded (6.55), The sausage sample (D)and(E) had the same score (6.80), while the sample (A) control had a higher score reached (6.92).

For the overall acceptability in table (8) Figure (2) there was no significant difference among the treatments, The sample (B) had the highest score (6.82) The sausage sample (A) and (E) had



the same score (6.69), followed by sausage sample (C) which recorded (6.68), and the sausage sample (D) had the lowest score (6.67).

These results agree with Mohamed Elkhatim et al, (2013) who did not find any significant difference in sensory attributes such as appearance, tenderness and overall acceptance among the different types of sausage formulation, and also agree with Raut et al (2015) who found that, the incorporation of heart and gizzard up to 10% level had no significant effect on flavor and texture compared to control. On the other hand the sensory scores in the present study did not agree with Sudheer et al, (2011) who reported that the sensory scores of the product increased significantly ( $p \leq 0.05$ ) for all the parameters up to 40% level of gizzard incorporation, and also the results disagree with the findings of Malik and Pands (1994) and Reddy and Vijayalakshmi (1998) who reported higher acceptability scores of mutton blocks incorporated with 25% gizzard and 5% heart and chicken sausages incorporated with skin, heart, gizzard and yolk at levels of 15 and 18%, respectively.

The results showed that the scores for the juiciness decreased with increasing the poultry heart and liver which nearly agree with Raute et al, (2015) who reported in their study, since there was further increase in gizzard level, scores for flavor, texture and juiciness declined significantly. Similar trend was reported

by Hassan( 2014) for sausage made with incorporation of 25% gizzard .

Table8: Mean values and their standard deviation (SD) for sensory evaluation.

Treatments Parameters	A	B	C	D	E	Significance level
Color	7.09±0.30	6.77±0.29	6.99±0.11	6.57±0.44	6.57±0.19	NS
Texture	6.77±0.10	6.55±0.04	6.77±0.02	6.98±0.10	6.98±0.21	NS
Flavor	6.67±0.30	6.86±0.09	6.62±0.02	6.82±0.19	6.70±0.09	NS
Juiciness	6.82±0.16	6.66±0.07	6.55±0.09	6.80±0.11	6.80±0.09	NS
Overall acceptance	6.79±0.16	6.89±0.14	6.68±0.04	6.69±0.07	6.68±0.07	NS

NS : Not significant

A:Control(100%beef).

B:(30%chicken livers +70%beef).

C:(15%chicken livers +85%beef).

D:(30%chicken heart+70%beef).

E:(15%chicken heart +85%beef).

#### **4.3:Physical properties and total bacterial count:**

Table (9) showed that, there were not significant differences among the treatments in water holding capacity, The sausage sample (A) had a higher percentage (1.79%) followed by sausage sample (C)which recorded(1.77%), sausage sample (D) recorded(1.70%) , sausage sample (E)reached (1.64%)

and the sausage sample (B) which recorded(1.56%).

With regard to shrinkage, table (9) Figure (3) the results revealed that, the sausage were not significantly different, The sausage sample (B) had the higher score (21.65%), while the sausage sample (C) recorded (21.24%), The sausage sample (D) reached (20.97%) , sausage sample (E) recorded (20.80%), and in addition the sausage sample (A) had lower score reached(20.64%).

As shown in table (9) the results of cooking loss were not significantly different ( $p \geq 0.05$ ) .The sausage sample (A) recorded higher score (20.72%), followed by the sausage sample (E)which recorded (20.62%) , The sausage sample (D) reached (20.42%) , sausage sample (C) recorded (20.34%) and at last the sausage sample (B) which recorded (19.92%).

There was no significant difference among the treatments in total bacterial count (TBC). Addition of chicken liver and heart slightly increased Total Bacterial Count of sausage sample (B)and (D) as shown in table (9)

The result in table (9) Figure (3) cleared that there were no significant differences among the treatments in total bacterial count which agree with Smith and Berranq (2006) , who found crop and gizzard increased over all bacterial count of per chill broilers carcasses .( Hassan 2014) and(Ali 2012) These reported no significant differences among the treatments.

These results agree with that stated by (Hassan 2014) who fund no significant differences in shrinkage, but disagreed with (Ali 2012) who studied the effect of storage period on quality of chevon and beef sausage and reported significant differences this disagreement may be attributed to different cooking methods used.

For cooking loss% the results agree with Hassan (2014) who reported no significant differences in his study, but disagreed withMahassin(2008) and (Ali 2012)who reported significant differences in their studies .

As for the W.H.C the results in table (9) showed no significant differences among the treatments which **disagreed** with that reported by (Ali 2012) and (Hassan 2014) who found the same result in their studies.

On the other hand the beef sausage (control) was lower in total bacterial count compared to (chicken liver and chicken heart with beef) as in table 9 in the treatment which agree with Ali 2012) and (Hassan 2014)

Table 9 Mean values and their standard deviation SD for water holding capacity, shrinkage, cooking loss, total bacterial count.

<b>Treatments</b> <b>Parameters</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>Significant level</b>
W.H.C%	1.79±0.03	1.56±0.02	1.77±0.02	1.70±0.02	1.64±0.01	NS
Shrinkage%	20.64±0.12	21±0.02	21.24±0.01	20.97±0.02	20.80±0.02	NS
Cooking loss%	20.72±0.02	19.92±0.02	20.34±0.03	20.42±0.02	20.62±0.02	NS
TBC CFU 10 <sup>-5</sup> ml <sup>-1</sup>	3.60±1.88	4.52±1.44	3.98±1.63	5.68±2.32	4.54±1.88	NS

W.H.C= water holding capacity .

TBC=Total Bacterial Count.

NS=Not significant.

Different letter with in the same row means significant different at (p<0.05).

(A)Control (100%beef).

(B)(30%chicken liver+70%beef).

(C)(15%chicken liver+85%beef).

(D)(30%chicken heart+70%beef).

(E)(15%chicken heart+ 85% beef).

#### 4.4: Recipe cost:

As shown in table (10) the economical cost for the five samples (A), (B),(C), (D). and (E) is 96, 81, 88.5, 81, 88.5 Sudanese pound respectively. The additives costs are equal in all treatments.

The calculation of the financial cost of sample A (100%beef) (1kg)which costs (65.31)SDP, sample (B)(30%chicken liver+70%beef) (1kg) costs(55.10)SDP, while the sample(C) (15% liver +85%beef) (1kg) costs(60.20)SDP, sample (D) (30% chicken liver +70%beef) (1kg) costs (55.10)SDP, and sample (E) (15%chicken heart+85%beef) (1kg) costs (60.20)SDP, that reflects the lower price of chicken liver and heart compared with prevalent market prices of sausage marketed

Table10: Recipe cost of sausage treatments

No	Samples	Quantity/kg	Cost/SDG
1	A	1.47	96.00
		1.00	63.31
2	B	1.47	81.00
		1.00	55.10
3	C	1.47	88.50
		1.00	60.20
4	D	1.47	81.00
		1.00	55.10
5	E	1.47	88.50
		1.00	60.20

**SDG**= Sudanese pound.

**A** Control(100%beef).

**B**:(30%chicken liver+ 70%beef).

**C**:(15%chicken liver+ 85%beef).

**D**:(30%chicken heart+70%beef).

**E**:(15%chicken heart+85%beef).

## Chapter Five

### Conclusions and Recommendation

#### 5.1: CONCLUSIONS:

.The study has concluded the followings:

.sausage incorporated with chicken liver and chicken heart are nearly similar, in proximate analysis, physical properties and sensory evaluation to beef sausage.

. Chicken liver and heart sausage has good recipe and low financial cost compared with beef sausage. With excellent acceptability of new product .

.The flavor and aroma of chicken liver and heart could be improved with providing seasonings .

. The contamination level was generally higher in chicken liver and heart –beef sausage in comparison with beef sausage.

#### 5.2: RECOMMENDATIONS:

This study has recommended the following :

. To encourage the researchers to investigate other chicken meat alternatives for beef in sausage processing:

. Recommended continuation of the research in this issue.

. To explore more about chicken liver and heart and other chicken by- products such as gizzard.

. Chicken liver and heart must be regarded as high quality meat in processed meat industry.

. Improve aroma and reduce softness of chicken liver and heart meat and improve processing techniques and mixing ratios.

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