Sudan University of Science and Technology

College of Graduate Studies

Effect of Adding Gum Arabic Powder on Quality Properties of Beef and Camel Meat Sausages

أثر اضافة بدرة الصمغ العربي على خصائص جودة سجغ البقر والابل.

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الآية

قال الله تعالى :-

{ومن الإبلِ اثنينِ ومن البقرِ اثنينِ قل ءالذكرين حرم أم الانثيين أما اشتملت عليه أرحامُ الأنثيين أم كنتم شهداء إذ وصاكم الله بهذا فمن أظلم ممن افترى على الله كذباً ليضل الناسَ بغيرِ علمٍ إنّ اللهَ لا يهدِى القومَ الظالمينْ}۝

سورة الأنعام (144)

DEDICATION

To
The souls of my father and mother.

My uncles, aunts, brother and sisters.

My lovely family. Husband, son and daughter.

Geihan

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My praise to Allah, the cherisher and sustainer of the words, who gave me the knowledge and the power to complete this research.

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ABSTRACT

This study was conducted in Meat Science and Technology Laboratory, College of Animal Production and Technology, Sudan University of Science and Technology, in September 2020 to investigate the effect of adding gum Arabic powder to beef and camel meat sausage, on proximate analysis, physiochemical properties and sensory properties. Three kg of meat (2 kg of beef and 1kg of camel meat), were minced through 30 mm plate and divided into three treatments [(control (0% Gum Arabic powder), beef (3% GA powder) and camel (3% GA powder)] after mixed with non-meat ingredients and stuffs in natural sheep casing. Samples were sent to the laboratory for analysis and the obtained results were subjected to analysis of variance followed Duncan's multiple range test. The results revealed significant differences in all chemical composition parameters. Camel sausage with 3% GA powder was the higher in moisture content followed by beef sausage 3% GA powder. While control beef sausage (0% GA powder) showed the highest percentage of protein, fat and ash. Also it revealed significant differences in the pH and cooking loss %. pH was the highest in 3% GA powder beef sausage and lowest in control sausage. 3% of GA powder camel and control beef sausage showed the highest values of cooking loss with significant differences. Camel sausage with 3% GA powder showed significant differences ($p<0.05$) in texture and overall acceptability lower than control sausage. It could be concluded that adding GA powder had significant effect on some physiochemical properties of camel sausage (pH and cooking loss) and also; camel sausage had less significant differences in some sensory evaluation traits. (Texture and overall acceptability).

Adding GA to camel meat sausage doesn't affect the eating quality.

الخلاصة

أجريت هذه الدراسة في معمل علوم وتكنولوجيا اللحوم، كلية علوم وتكنولوجيا الانتاج الحيواني، جامعة السودان للعلوم والتكنولوجيا في سبتمبر 2020م. للتحقق من أثر إضافة بدرة الصمغ العربي على التحليل الكيميائي، الخواص الفيزيوكيميائية و الخصائص الحسية. تم فرم ثلاث كيلوجرام لحم (2كجم بقر و 1كجم أبل) بمفرمة 3.5 ملم وقسم اللحم لتصنيع ثلاثة أنواع من السجك [سجك التحكم (0%)، سجك البقر (3% بدرة صمغ عربي) وسجك لحم الإبل (3% بدرة صمغ عربي)] بعد خلطها بالإضافات غير اللحمية وتعبئة الخلطة في إمعاء ضأن. أُرسلت العينات إلى المعمل لإجراء التحاليل. خضعت العينات لتحليل التباين متبوعا بإختبار المدى العديد Duncan. أثبتت النتائج وجود فروق معنوية في كل قياسات التركيب الكيميائي. وكان سجك لحم الإبل بـ3% بدرة صمغ عربي هو الأعلى في محتوى الرطوبة يليه السجك البقري بـ3% بدرة صمغ عربي. بينما كان السجك البقري (التحكم) هو الأعلى في محتوى البروتين، الدهون والرماد. كما أثبتت النتائج وجود فروق معنوية في فاقد الطبخ والأس الهيدروجيني حيث كان السجك البقري بـ3% بدرة صمغ عربي هو الأعلى في الأس الهيدروجيني وكان السجك البقري (التحكم) هو الأدنى. سجل سجك لحم الإبل بـ3% بدرة صمغ عربي والسجك البقري (التحكم) أعلى قيم لفاقد الطبخ من غير فروق معنوية بينهما. أظهر سجك لحم الإبل بـ3% بدرة صمغ عربي وجود فرق معنوي في القوام والقبول العام وكان أقل من السجك البقري (التحكم). يمكن أن نخلص من هذه الدراسة أن إضافة بدرة الصمغ العربي تؤثر على بعض الخصائص الفيزيوكيميائية لسجك لحم الإبل كذلك وجود فرق معنوي طفيف في بعض صفات التقييم الحسي لسجك لحم الإبل.

ان اضافة الصمغ العربي لا تؤثر على الجودة الغذائية لسجك لحم الابل.

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CHAPTER ONE

1. INTRODUCTION

Sudan is the second largest livestock rich country in Africa, with about 31 million cattle, 41 million sheep, 32 million goats and 4.9 million camels. Most of the country is Arid- Semi Arid and the animals are raised in extensive pastoral and agro-pastoral production systems across the country's agro-climatic zones. Export of meat sheep, goats, cattle and camel is increasing from 2014 to 2018. **(Mamo, 2019; Food and Agriculture Organization FAO, 2020)**.

Meat consumption in developing countries has been continuously increasing from a modest average annual per capita consumption of 10 kg in the 1960s to 26 kg in 2000 and will reach 37 kg around the year 2030 according to FAO projections. **(Heinz and Hautzinger, 2007; Mohammed, 2019)**. In recent years there has been an increase demand for convenience meat and meat products requiring minimal home preparation. Meat processing is the manufacture of meat products from meat, animal fat and certain non meat additives. **(Faye, 2014)**. The additives are used to enhance product flavor, appearance and to increase product volume. The contribution of camel meat to world meat production is rather marginal due to the less significant place of camel among the herbivores. Compared to all meat producing types (except fish), camel meat represents 0.13% of the total meat produced in the world and 0.51% of red meat from herbivorous. **(Faye, 2014)**.

The sausage is the oldest food industries for keeping meat by salting and drying, it is a minced meaty product laced with salt and spices and some water association and extended, in addition to preservatives and packed in casings has shapes and different types. **(Al-Hilphy *et al*., 2013)**.

Gum Arabic (GA) is edible, dried, gummy exudates from the stems and branches of *Acacia senegal* and *Acacia seyal*. These trees are abundant in the central Sudan, central Africa and in West Africa. **(Dauqan and Abdullah, 2013; Ahmed *et al*., 2018)**. It grows predominantly in the African region of Sahel in Sudan. Gum Arabic (GA) is one of the world's major natural commodities of commerce and constitutes an important export commodity in countries such as Niger, Chad, Senegal, Nigeria, and especially Sudan which controls about 85% of the world's export of GA. Chemically, GA is a complex mixture of macromolecules of different sizes and composition -mainly carbohydrates and proteins. It is rich in non-viscous soluble fibers with high dietary value, and also contains minerals like potassium, magnesium and calcium. **(Ahmed *et al*., 2018)**. Gum Arabic is commonly used in the pharmaceutical and food industries as emulsifier and stabilizer as suspending agent for insoluble drugs. **(Dauqan and Abdullah, 2013)**, is widely sought after in industrialized countries for use in confectionary and beverages, artistic materials, photography, lithography, printing and pesticides. **(Barbier, 1992)**.

The objective of this study is to evaluate the effect of adding gum Arabic powder on chemical, physical and organoleptic properties of beef and camel sausages from beef and camel meat.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Meat definition

Meat is defined as those animal tissues, which are suitable for use as food. All processed or manufactured product, which might be prepared from tissues, are included in this definition. **(AbdelKareem, 2010)**. Also, **Heinz and Hautzinger (2007),** defined meat as "the muscle tissue of slaughter animals".

2.2. Meat products and processing

Meat products are mainly consisting of meat, different quantities of animal fat, common salt and spices for flavor. Other non-meat ingredients are added in small amounts to improve flavor and binding attributes. They are also added in large quantities to extend the volume particularly in low-cost products such products as sausages, burgers, frankfurter, kebab, etc. **(Heinz and Hautzinger, 2007)**.The processed meat products are defined as those in which properties of fresh meat have been modified by use of one or more procedures, such as grinding or chopping, addition of seasoning, alteration of color or heat treatment. Generally, meat processing developed soon after people become hunter. **(AbdelKareem, 2010)**. Meat and meat products can be modified by adding ingredients considered beneficial for health or by eliminating or reducing components that are considered harmful. The use of these ingredients in meat products offers processors the opportunity to improve the nutritional and health qualities of their products. **(Andres *et al*., 2009)**. Processing of camel meat such drying, curing and smoking have taken place in Arabia for many years. Suggested that the acceptability of camel meat products increases with an increase in the duration of smoking, frying and cooking, indicating that such products should be fully processed to gain

acceptability. Recently Australian processed camel meat has been accepted as an international traded meat product. It is now exported to Saudi Arabia, throughout Asia, Canada, United States and Europe. Camel is available in carcass form or as fresh or frozen vacuum-packed cuts. Recently, more attention has been paid to the nutritional value of camel meat, with the aim of creating additional value for various camel meat products. (**AbdelKareem, 2010**).

2.3. Camel meat production in Sudan

World production of camel meat has been regularly increasing, mainly in the Central African sub-region doubling during the past two decades. **(Kimassoum *et al*., 2016)**. Even if these data did not cover the entire reality, it is obvious that camel production in Sudan is insufficiently valorized. **(Faye *et al*., 2011)**. According to FAO statistics, camel population in Sudan ranks the second in the world after Somalia. This population is quite important while the camel production appears at least officially very low. With a meat production of 49,880 tons, camel production is far away from the potential. In spite of the increase in local camel meat consumption to 63,000 tons in 2009, yet camel meat is common in some parts of the country. The camel meat production is a traditional speculation of the camel farming systems in Sudan. The slaughtering rate 1961-2009 in this country increased from 3 to 5%. **(Faye *et al*., 2011)**. The camel breeds in Sudan have heavy conformation with heavy carcass. However, the mean carcass weight did not change (225 kg) between 1961 and 2009, underlining that the meat productivity did not increase contrary at the world level where the mean carcass weight increased from 183 to 203 kg at the same time. **(Faye *et al*., 2011)**. Consequently the increase in camel meat production in Sudan is linked only to the increasing of camel population and of the slaughtering rate. Compared to the world statistics, the meat production growth is

more important in Sudan, especially since the years 2000. The production in 2009 (50,000 tons) was four fold the production reported in 1961 (12,000 tons), **(Faye *et al*., 2011)**. Recently, more attention has been paid to the nutritional value of camel meat, with the aim of creating additional value for various camel meat products. Camel meat is used for human consumption in several countries. The acceptability of camel meat products increases with an increase in the duration of processing (smoking, frying and cooking) indicating that the products should be fully processed to gain maximum acceptability. **(Alamin *et al*., 2015)**.

2.4. Benefits of camel meat

Camels are used for many purposes such as meat and/or milk production, and for physical labor as well as racing. **(Kimassoum *et al*., 2016)**, it can be used for wool, transport, races, tourism, agricultural work and beauty contests. **(Faye, 2014)**. The nutrient content of camel meat can be affected by age, sex, carcass weight, fatness, packaging and storage conditions, and time. (**AbdelKareem, 2010**). Meat production is the only one of these purposes that requires the camel to be slaughtered. Consequently, meat production is linked to proper herd management in terms of the selection of animals to be slaughtered, such as young males that are not kept for reproduction or other activities and culled female or males, and to market organization at a local and regional level. **(Faye, 2014)**. The invariable adulteration/substitution of camel meat with other meat species is common in minced meat products in some countries in Middle East particularly in Egypt due to low cost and easy availability of camel meat. However, detection of camel meat is difficult due to a lack of rapid and sound technique to differentiate them from other meat species especially in low percentage. **(El-Morshedy *et al*., 2011).** The camel is a good source of meat, especially in harsh arid and semi-arid areas where climate adversely affects the production efficiency of other animals. The

camel meat is rich in animal protein and is an important meat source in many African and Asian countries. In some regions, particularly Arabian countries, camel meat is preferred over meat from other animals, especially in the traditional dishes, due their presumed medicinal benefits, as well as for being a good source of minerals, vitamins, bioactive compounds, and essential fatty acids such as n-3 fatty acids. There is a common opinion that camel meat is harder, coarser, and more watery than meats from other animals; however, this may be largely due to the fact that camel meat is mostly obtained from old animals that have become less effective in their primary roles of transportation, dairy production, or breeding females. **(Suliman *et al*., 2020)**. Camel meat is believed by Somali and Indian people to have remedial effects for as many as 13 different diseases, including hyperacidity, hypertension, pneumonia and respiratory diseases and also to be an aphrodisiac. **(Kadim *et al*., 2008; AbdelKareem, 2010)**. Camel meat is known to be more beneficial for health because it contains lower fat and cholesterol levels than other red meats. **(Kimassoum *et al*., 2016)**. It was rich in mono and polyunsaturated acids and calcium **(Kadim *et al*., 2008)**. This can also reduce the risk of cardiovascular disease and atherosclerosis since it reduces the percentage of cholesterol in the blood. **(Kimassoum *et al*., 2016)**. Generally, vitamin A plays many critical functions, both preventive and therapeutic. The vitamin B complex is essential for the healthy functioning of the nervous system. Excluding camel, all red meat naturally contains more fat, saturated fat and cholesterol than any other food. A chronic access intake to these lipids in the body is directly responsible for numerous cardiovascular diseases, including coronary heart disease and high blood pressure. As camel meat contains less fat, therefore suggest that eating camel meat is a great factor helps reducing risk of developing life-threatening diseases, such as obesity, cholesterol

disease and colon cancer, **(Dejenie, 2013)**. Among many African and Asian countries, camel meat and products have traditionally been used to cure the following ailments; 1) camel meat is used to cure seasonal fever, sciatica, and shoulder pain as well as to remove freckles; 2) camel meat soup is used to cure corneal opacity and to strengthen eyesight; 3) camel fat is used to ease hemorrhoidal pains, and the hump fat is used to remove tapeworm; and 4) dried camel lungs used to be prescribed as a cure for asthma, especially if taken with honey. **(Kadim *et al*., 2013)**. Camel meat and offal such as liver are believed to have medicinal effects and are eaten raw stated Somalis and Indians particularly believe in the health benefits of consuming camel meat. indicated that camel meat has traditionally been used to cure the following ailments in some Middle Eastern countries: (i) seasonal fever, sciatica and shoulder pain, as well as for removing freckles (by placing hot camel meat slices on the freckled area); (ii) camel meat soup was used to cure corneal opacity and to strengthen eyesight; (iii) camel fat was used to ease haemorrhoidal pains and the hump fat was used to remove tapeworm; and (iv) dried camel lungs used to be prescribed as a cure for asthma, especially if taken with honey. (**Bekhit and Farouk, 2013**). Moreover, camel meat is believed by Somali and Indian people to have remedial effects for as many as 13 different diseases, including hyperacidity, hypertension, pneumonia and respiratory diseases and also to be an aphrodisiac. **(AbdelKareem, 2010)**. Camel meat is an excellent source of protein with many medicinal benefits for human health. Camel meat can also be used as a cure for exhaustion and fatigue because it contains energy (glycogen) needed by body cells. Camel meat has been used since the late sixteenth century in traditional Chinese medicine. It has been used to improve resistance to disease, to strengthen the muscles and bones, to moisten the skin and to relieve internal pain. **(Kadim and Sahi, 2018)**.

2.5. Chemical composition of camel meat

Camel meat varies in composition according to breed type, age, sex, condition and site on the carcass. Water content differs only slightly between species, while differences in fat content are more marked. **(Kadim, *et al*., 2008; AbdelKareem, 2010)**. Camel meat contains 70-77% moisture; these levels are higher than those in meat of other farm animal species. It is also a good source of protein containing about 20-23%. This level is similar to those in other farm animals. This level of protein in camel meat makes it a good source of high quality protein in arid and semi-arid regions. Camel meat protein may increase with age. Ash content in camel meat ranges between 1.1% and 1.5%. **(AbdelKareem, 2010)**. Chemical composition of camel meat varied between the shoulder, topside and loin. The humps, together with the fat of the prenephric areas are an important supplement to the human diet. As the animals get older, the moisture and ash content of hump fat and around the kidneys increases, try while the crude fat content decreases. It was found that there was more crude fat in the fat tissues around the kidneys than the hump. The brisket, ribs and lion are other preferred parts of the carcass. There is difference percentages protein, water, fat and ash of meat from various parts of the body. The age of animal also affects the component of the meat. Camels younger than 5 year have less protein, fat and ash than older camels. The meat is easy cured, and the high protein content provides good caloric value. They are also cheaper than sausage made from other meat. **(AbdelKareem, 2010)**. The mineral and proximate composition of camel meat from young male camels (1-3 years) was generally similar to the amounts reported for these constituents in the corresponding tissues of beef. Camel meat presents high protein content. It is rich in vitamins and low levels of fat, globally comparable and similar to bovine meat. **(Kimassoum *et al*., 2016)**. The

most highly considerable characters of the camel meats are its low fat matter and high moisture content and also considered as rich in protein content and a multi vitamin commodity. As camel meat contains less fat, therefore suggest that eating camel meat is a great factor helps reducing risk of developing life-threatening diseases, such as obesity, cholesterol disease and colon cancer. **(Dejenie, 2013)**.

2.6. Physical properties of camel meat

Camel meat is the least studied type of meat and is wrongly believed to be of lower nutritive value and quality than other types of red meat, in spite of their ability to produce good quality meat at comparatively low cost under extremely harsh environments. In addition, there is lack of research in the improvement of camel meat characteristics. Camel has unique physiological characteristics, including a great tolerance to high and low temperatures, solar radiation, water scarcity and poor vegetation. The morphological features of camels make them well adapted to the harsh environment. The camels can with stand long periods of time without any external source of water through a series of physiological adaptations that reduce feed. **(Kimassoum *et al*., 2016)**.

2.6.1. pH

The abattoir is an important step in the production of meat as it presents some of the preferable opportunities for contamination. Biological, physical and chemical hazards may be encountered at an abattoir. The most important microbial contamination sources arise from endogenous sources as the microbial load of meat mainly due to its high water activity, high protein content and approximately neutral pH [9-11]. Exogenous sources of meat occurred during or after slaughtering, processing, abuse storage conditions including; and/or during the meat transportation. **(Elsharawy *et al*., 2018).**

2.6.2. Cooking loss

Cooking loss depends also on water-holding capacity. It 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. Cooking loss was highest in leg cuts, intermediate in shoulder/arm cuts, and lowest in loin/rib cuts. Also it was lower in camel meat compared to beef. These differences are due to molecular differences or to variation in the architectural distribution of the connective tissue in different meats. Such differences in cooking loss due to several factors including the rate of thawing and cooking temperature. **(Alamin, 2015)**.

2.7. Sensory properities of camel meat

Camel meat is similar in taste and texture with beef and it is sold in those countries in fresh or in processed form. **(Kimassoum *et al*., 2016)**. Meat from young camels has been reported to be comparable in taste and texture to beef. **(Faye *et al*., 2011)**. Camel meat is described as tough, coarse, watery and sweetish in taste which may be attributed to the fact that camel meat is mainly obtained from old camels. Processing of camel meat increases the tenderness, taste and palatability of the products. **(Nour and Elsharif, 2015)**.

2.8. Definition of sausages

Sausage is derived in the Latin word '*Salsus*' meaning salted or preserved by salting or '*Salsicia*' meaning something salted. The term was probably originally applied to cured or salted meat generally. In the olden days, there were no refrigerators for meat preservation and sausage making was a way to solve this problem. Sausage has been an age long method of preservation as recorded by the primitive man, the ancient Egyptians and American Indians. The first recognizable mention of this meat food is found in a greek play called 'The Orya' or 'The Sausage' written about 500 B.C. Thereafter, the word Sausage occurs with

frequency in Greek writings such as in the *'Odyssey'* written by Homer in 830 B.C. **(Akpan, 2017)**. It is difficult to fit sausages into one single definition since they are many and varied. Attempts, however, have been made to define sausages either by shape, type or meat content. Characteristically, sausages are comminuted processed meat products made from red meat, poultry or a combination of these with water, binders and seasoning. They are usually stuffed into a casing and may be cured, smoked or cooked. **(Essien, 2003)**. Sausages are manufactured from lower-value meat to produce a higher-value product. **(Nour and Elsharif, 2015)**.

2.9. Sausage industry

Sausage production in the olden days was a way of preserving meat but in modern days, it has gradually reshaped into meat product with addition of ingredients other than salt. There has been tremendous improvement in almost all aspects of Sausage production such as Shape of the product, species of animals used, casings, ingredients, equipment and machines etc. further advances will still be made in sausage production due to revolution of technology even in areas that have been addressed and the ones that are yet to be researched. **(Akpan, 2017)**. Generally; consumers are prejudiced against fresh camel meat. If camel meat could be converted into processed products such as burger and sausage, it might be more acceptable to domestic's consumers. However, the important technological problem in manufacturing of camel meat products is the poor emulsifiability of camel fat. The high amount of connective tissue also makes camel meat a challenging raw material for producing a stable emulsion. (**Zaki, 2017**). Camel meat can be used in many food industries such as sausage, corned meat and shawarma. **(Kadim and Sahi, 2018)**.

2.10. Non-meat ingredients

Non-meat ingredients are used to impart flavor, slow bacterial growth and increase the yield of the sausage. These include water, salt, sugar, nonfat dry milk, extenders and binders, and spices. **(Tronsky *et al*., 2011)**.

2.10.1. Spices

Spices and seasonings are added for flavor. They may be added as whole seeds, coarsely ground, powdered, or in the form of oleoresin. Oleoresins are derived by solvent extraction of spices. They contain volatile and nonvolatile fractions of the spices and therefore are considered more complete than essential oils. Several companies produce spice blends that can be added to a batch of meat for the production of specific sausages. **(Tronsky *et al*., 2011)**.

2.10.2. Casing

Casing is a complementary part of sausage, separating it from the surrounding environment and making it an independent unit. It provides shape, size and integrity of sausages. The function of sausage casing begins by stuffing and ends at the consumer table. Natural or artificial casings can be used for fermented sausages. Artificial sausage casings are a better choice for production of large diameter sausages, while the natural casings used for production of small diameter sausages. **(Ibrahim, 2019)**.

2.11. Types of sausages

There are many types of sausages available for consumers, each with its special appeal to some part of the population, to classify sausages using one or multiple criteria. Sausages can be cured/uncured (fresh), cooked/uncooked, smoked/ unsmoked or a combination of any of these operations. **(Bakhit and Farouk, 2013)**.

2.11.1. Fresh sausages

Fresh Sausages are made from selected cuts of fresh and sometimes frozen meats. Fresh sausages are not allowed to contain curing agents [i.e., sodium or potassium nitrites, nitrates, or salt in sufficient quantities to preserve the product] and are not cooked. Fresh sausages are usually seasoned, and have limited water content. These types of sausages require refrigerated storage, and must be thoroughly cooked before serving. Fresh sausages are not as widely produced as cooked sausages, and are typically consumed as breakfast meals. Typical fresh sausages include products such as pork sausages, beef sausage, breakfast sausage, Italian sausage, and fresh chorizo sausages. **(United States. Department of Agriculture USDA, 2014)**.

2.11.2. Cooked sausages

Some manufacturers have gone further to cook, slice or dice primarily to add safety and convenience for the fast food and ready meal sectors. This requires cooking using the oven, grill, fat or oil to deep fry the sausages after filling. Many cooking programmer require the monitoring of time and temperature to achieve a consistent quality. In this situation probes may be used to monitor the product core temperature for good results. Further extension of the process may lead some producers to slice or dice cooked sausages for different size and shape using sharp blades. The resultant products find significance as a component in sandwich and meal sectors. **(Essien, 2003)**.

2.11.3. Cooked, smoked sausages

Cooked and smoked sausages account for approximately 85% of all sausages produced today. Typical cooked sausages, like frankfurters or bologna, are made from fresh or frozen meat that is cured during processing, fully cooked, and smoked. These types of sausages are perishable and must be refrigerated until time of consumption, or they expire. These sausages have additional flavors that are imparted through

the addition of nitrites and nitrates, and via various cooking and smoking processes. **(USDA, 2014)**.

2.11.4. Uncooked, unsmoked sausages

It is made from meat, which is ground, seasoned, stuffed into casings, and smoked. These must be completely cooked before eating such as some kielbasas, mettwurst, Teawurst, smoked country-style pork sausage. **(Tronsky *et al*., 2011; Ibrahim, 2019)**.

2.11.5. Specialty sausages

This type is varied it may contain cured, uncured, smoked, and non smoked meats that do not readily "fit" into the other categories. They are seasoned and often formed into loaves, ex: olive loaf; head cheese; jellied corned beef; scrapple; souse **(Tronsky *et al*., 2011; Akpan**, **2017**; **Ibrahim, 2019)** and sausage rolls. (**Akpan**, **2017**).

2.11.6. Fermented sausages

Fermentation, which is one of the oldest methods of meat preservation, is used in making fermented sausages. Fermented sausages are characterized by their relatively longer shelf life, which is brought about by production of lactic acid in the fermentation process. Fermented sausages are classified into dry and semi-dry. The production utilizes curing ingredients, spices and relatively large numbers of cultured micro-organisms (starter culture) in a fermentation process. Products come out at the end of the process as cured dried product. Traditionally, fermented sausages are made using acid bacteria naturally present in the meat or with the inoculation of the new batch with an old batch. The introduction of micro flora occurs at the chopping point; the mix is filled in casings and left to ferment and then dried. Some processes allow drying before cooking. The development of the pathogenic bacteria is inhibited by the acid produced by the fermentation. The low pH and the dry nature of the product are primarily responsible for the long keeping quality. Fermented

sausages have relatively higher meat content and take a longer time to prepare owing to the series of required drying processes, which may take up to seven weeks. Semi-dry sausages are smoked, cooked and finished off as dried. **(Essien, 2003)**.

2.12. Gum Arabic in Sudan

The republic of Sudan is one of the most important countries producing gum. Most of the gum produced in the Sudan comes from *Acacia senegal* which grow to about 15- 20 ft. tall and has a life of about 25-30 years. It grows in poor, sandy, reddish soil. It is found particularly in the district of Kordofan. The best quality of gum comes from *Acacia senegal* and is known as (Hashab) in the Sudan and also known as Kordofan gum hashab, 90% of the gum produced in the Sudan is from these kinds of trees and about 10% of the gum comes from the *Seyal* variety of *Acacia* which is known in the Sudan western part of the country and in the Nile region. The gum from *Seyal* trees is exuded naturally without tapping. During the rainy season, no gum is formed by the trees. So, the gum is collected during the dry season between October and May or June. A suitable age for trees which can be tapped is 6-7 years. Attempts to extract gum from trees younger than this causes death of the trees. After a few weeks, the gum form in the cuts which are depending on the weather conditions and collected every 10 days during the season). Sudan gum sets the international standards on quality and all gum exporting countries must conform well to the standards in all aspects. *A. senegal* varieties grow abundantly in areas with annual rainfall of 200 to 800 mm and high temperatures in the arid and semi-arid lands of Sudan. **(Mohammed, 2015)**.

2.12.1. Chemical composition of gum Arabic

The chemical composition of GA can vary with its source, the age of the trees from which it was obtained, climatic conditions and soil

environment. Gum Arabic is a branched-chain, complex polysaccharide, either neutral or slightly acidic, found as mixed calcium, magnesium and potassium salt of a polysaccharidic acid (Arabic acid). **(Dauqan and Abdullah, 2013; Masuelli, 2013; Musa *et al*., 2018).** The major amino acids present in the protein of an ArabinoGalactan (AG) and an Arabinogalactan-Protein Complex (AGP) were hydroxyproline, serine and proline, whereas in Glycoprotein (GP), aspartic acid was the most abundant. (**Dauqan and Abdullah, 2013)**. Its backbone consists of 1, 3-linked β-D-galactopyranosyl units. The side chains are composed of two to five 1, 3-linked β-D-galactopyranosyl units, joined to the main chain by 1, 6-linkages. Both the main and the side chains contain units of β-L-arabinofuranosyl, β-L-rhamnopyranosyl, β-D-glucuronopyranosyl, and 4-O-methyl-β-D-glucuronopyranosyl, the latter two mostly as end units. **(Masuelli, 2013)**.

2.12.2. Uses of gum Arabic

Gum Arabic, exudates from *Acacia Senegal* is an approved food additive that is acceptable as a stabilizer and emulsifier in the food industry. **(Mwove *et al*., 2017)**. Exudates gums are used in an overwhelming number of applications, mainly situated in the food area. However, there are also considerable non-food applications. Gum Arabic is being widely used for industrial purposes such as a stabilizer, a thickener, an emulsifier and an encapsulating in the food industry and to a lesser extent in textiles, ceramics, cosmetic, pharmaceutical industry and lithography. In the food industry, GA is primarily used in confectionery, bakery, dairy, as a microencapsulating agent and beverage. Gum Arabic readily dissolves in cold and hot water in concentrations up to 50%. Because of the compact, branched structure and therefore small hydrodynamic volume, gum Arabic solutions are characterized by a low viscosity, allowing the use of high gum concentrations in various

applications. Solutions exhibit Newtonian behavior at concentrations up to 40% and become pseudo plastic at higher concentrations. The pH of the solutions is normally around 4.5-5.5, but maximal viscosity is found at pH 6.0. Gum Arabic has excellent emulsifying properties. The hydrophobic polypeptide backbone strongly adsorbs at the oil-water interface, while the attached carbohydrate units stabilize the emulsion by satiric and electrostatic repulsion. Fractionation studies show that, although emulsifying properties generally improve with increasing molecular weight and protein content, the best results are obtained with mixtures of different fractions. Seemingly, the heterogeneous nature of the gum makes it an excellent emulsifier. **(Dauqan and Abdullah, 2013)**. Gum Arabic has several domestic uses namely in manufacturing ink, making adhesives, crafts making, in cosmetic products, in confectionary and in foodstuff. It is also utilized locally in special meals and as chewing gum. Focusing specifically on human consumption, gum Arabic is an excellent dietary product because it contains less than 1cal for every gram. Ever since the pharaonicera, gum has been utilized in traditional medicine as a calming and softening agent. It is equally included in (traditional) medicine concoctions to address internal ailments such as cough, diarrhea, dysentery and hemorrhage and applied externally. It is also used in veterinary medicine, to treat skin diseases and inflammations for example. **(Dauqan and Abdullah, 2013)**.

2.12.3. Food applications of gum Arabic

Gum Arabic is mainly used in the confectionery industry, where it is incorporated in a wide range of products. It has a long tradition of use in wine gums, where it produces a clarity that is higher than can be obtained with other hydrocolloids. Furthermore, it prevents sucrose crystallization, provides a controlled flavor release and slows down melting in the mouth, making the wine gum long lasting. In lower-calorie candy, gum Arabic is

used to compensate for the loss of texture, mouth feel and body, resulting from the replacement of sugars by artificial sweeteners. It is also used in chewing gum as a coating agent and as a pigment stabilizer. In aerated confectionery products, such as marshmallows, nougats and meringues, gum Arabic acts as a whipping and stabilizing agent. It is also used in toffees and caramels as an emulsifier, to maintain a uniform distribution of the fat across the product. In jelly products, it is used to provide a fibrous, fruit-like texture. Gum Arabic is widely used as an emulsifier in the manufacture of soft drinks. Due to its stability in acid conditions and its high solubility, gum Arabic is well suited for use in citrus and cola flavor oil emulsions. High levels of gum are used to ensure a complete coverage of the interface and to prevent flocculation and coalescence of oil droplets. Normally, a weighting agent is added to increase the oil-phase density, inhibiting destabilization due to creaming. Gum Arabic can also form a stable cloud in the drink, imitating the effect of added fruit pulps and juices. Gum Arabic is used increasingly as a source of soluble fiber in low-calorie and dietetic beverages. In powdered beverage mixes, gum Arabic is added to produce the same opacity, appearance, mouth feel and palatability as natural fruit juices. In microencapsulation, liquid, solid or gaseous substances are coated with a protective layer to prevent chemical deterioration and the loss of volatile compounds. It is a useful technique to convert liquid food flavors to flow able powders that can be used in dry food products. Gum Arabic is an effective encapsulation agent because of its high water solubility, low viscosity and emulsification properties and is used in soups and dessert mixes. Gum Arabic is also used to prevent gelatin in canned gravy based pet foods, as it inhibits the extraction of proteins from the meat into the gravy. Shows applications food of gum Arabic, such as: meat products, dairy products, bakery products, beverage, confectionery and flavors. Gum Arabic was

once extensively used in the pharmaceutical industry, but is now replaced by celluloses and modified starches in many applications. It is still used as a suspending agent, emulsifier, adhesive and binder in tablet ting and in demulcent syrups in cosmetics, gum Arabic functions as a stabilizer in lotions and protective creams, where it increases viscosity, imparts spreading properties and provides a protective coating and a smooth feel. It is used as an adhesive agent in blusher and as a foam stabilizer in liquid soaps. Gum Arabic is also used in the preparation of etching and plating solutions in the lithography industry. It is used as a dispersant in paints and insecticidal/a caricidal emulsions, respectively keeping the pigments and active components uniformly distributed throughout the product. In the textile industry, it is used as a thickening agent in printing pastes for the coloration of knitted cellulose fabrics. Other applications are ink and pigment manufacture, ceramics and polishes. Non-applications food of gum Arabic, such as: Ink, glue, paint, cosmetics, pharmaceutical and Textile. **(Dauqan and Abdullah, 2013)**.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. Study Area

The study was conducted at the laboratory of Meat Science and Technology, College of Animal Production Science and Technology, Sudan University of Science and Technology (SUST), and National Food Research Center (NFRC) laboratory, Shambat, Khartoum North. In September, 2020.

3.2. Equipments

The equipments for preparation include knives, cutting boards, trash bags, gloves, bowel, plate, grinder, piston stuffer, electric oven, water bath, freezer, trays, dishes, cubs, digital scale capacity 40 kg and sensitive scale. (Appendices1-8).

3.3. Meat and non meat ingredients

One kg of fresh deboned camel meat and two kg beef meat were obtained and purchased from Hillat Kuku local market. meat were used after being ground through plate of 30 mm diameter meat grinder, spices and sheep casings were purchased from Khartoum north market.

3.4. Sausages preparation

Three treatments of sausages (camel and beef sausage at 3% of gum Arabic (GA) powder of each and the third was the control with 0% of GA powder) were manufactured after mincing meat through 30 mm mincing machine. The ingredients were added to the meat and formulate the final mixture of the three treatments of sausages as shown in table (1). The mixture was stuffed in sheep casings using piston stuffer and then twisted (10 cm length), placed in polythene bags covered with plastic sacks then labeled and cooled in refrigerator $\pm 4^{\circ}C$ until sent to the laboratory for analysis.

Table 1. Ingredients of the sausages recipe

Ingredients (g)	Control sausage	Beef sausage	Camel sausage
Camel meat	-	-	670
Beef	670	670	-
Bread	100	100	100
Bake	100	70	70
Gum Arabic	-	30	30
Ice water (ml)	100	100	100
Onion	10	10	10
Coriander	5	5	5
Cinnamon	2	2	2
Nutmegs	3	3	3
Black pepper	2	2	2
Garlic	2	2	2
Salt	6	6	6
Total	1000	1000	1000

3.5. Proximate analysis of sausages

Chemical composition including moisture, crude protein (CP), fat and ash content was determined as percentage using method of **AOAC (2005)**.

3.6. Physiochemical properties of sausages

3.6.1. pH measurement

Ten grams of the samples were placed in blender gar and 90 ml of distilled water was added the mixture was blended at high speed for 1 min. The pH of the mixture was measured using a recalibrated pH meter model (HI 8521 microprocessor bench pH / MV/˚C meter). This has been calibrated using two standard buffers (6.8 and 4.0).

3.6.2. Cooking loss %

Sausage samples were cooked in water bath at 80^{o}c for 90 minutes and the cooking loss percentage was calculated using the following formulas:

$$\text{Cooking loss } \% = \frac{weight\ of\ samle\ before\ cooking - weight\ of\ sample\ after\ cooking}{weight\ of\ samle\ before\ cooking} \times 100$$

3.7. Sensory evaluations of sausages

Ten semi-trained panelists were asked to evaluate the color, texture, flavor, juiciness and overall acceptability of the three studied sausage treatments. The samples used for sensory evaluation were cooked for 6-10 minutes in cooking pan using little amount of vegetable oil, sausages were turned every three minutes to prevent excessive browning. Panelists used 8-point hedonic scale where 8 are extremely desirable and 1 extremely undesirable as method described by **Cross *et al*., (1978)**. (Appendix 9)

3.8. Statistical analysis

Statistical analysis were performed using the analysis of variance one way (ANOVA) and Duncan's multiple range test to determine differences between means at significance rate of ($P<0.05$). All statistics were expressed as mean± standard deviation was carried out using SPSS v. 16 programs.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1. Proximate analysis of sausages

Effect of added gum Arabic powder on proximate analysis of beef and camel meat sausages (table 2) shows significant differences in all studied parameters. Camel sausage of 3% GA powder was the highest in moisture content (69.15%) followed by 3% GA powder beef sausage (68.91%). While control beef sausage (0% GA powder) showed the highest percentage of protein, fat and ash as 22.68, 6.20 and 2.35 % respectively followed by beef sausage with 3% GA powder in protein and fat (22.66 and 6.17%) whereas it was the lowest ash content (2.27%). These findings were differed from those of **Soltanizadeh *et al*., (2010)** and **Alamin, (2015)** who found higher records than these in the study with exception of moisture content. This might be due to differences in the used ingredients.

Table 2. Effect of added gum Arabic powder on proximate analysis of beef and camel meat sausages

	Gum Arabic supplementation (%)			
	0	3	3	
Parameters	Control	Beef sausage	Camel sausage	Significant
Moisture	68.77±0.03^{c}	68.91±0.01^{b}	69.15±0.01^{a}	**
Protein	22.68±0.02^{a}	22.66±0.03^{a}	22.40±0.02^{b}	**
Fat	6.20±0.01^{a}	6.17±0.03^{ab}	6.13±0.01^{b}	*
Ash	2.35±0.01^{a}	2.27±0.02^{c}	2.32±0.02^{b}	**

N=3/sausage type, **=significant at p<0.01, *=significant at p<0.05
Different superscript letters within the same column means significant difference at p<0.05

4.2. Physiochemical properties of sausages

Table (3) shows the effect of added gum Arabic powder on physiochemical properties of beef and camel meat sausages, the results revealed significant differences in the pH and cooking loss %. pH was the

highest in 3% GA powder beef sausage 5.97 and lowest in control sausage 5.76 agreed results were reported by **Soltanizadeh *et al*., (2010)**. 3% of GA powder camel and control beef sausage showed the highest values of cooking loss with in significant differences. It seems to be that GA powder minimizes the cooking loss in camel meat sausage. **Soltanizadeh *et al*., (2010)** found higher cooking loss values in both camel and beef sausage as 24.2 and 30.2% respectively. However **Nour and Elsharif, (2015)** found lower cooking loss % values in camel meat sausage (18.04%).

Table 3. Effect of added gum Arabic powder on physiochemical properties of beef and camel meat sausages

	Gum Arabic supplementation (%)			
	0	3	3	
Physiochemical properties	Control	Beef sausage	Camel sausage	Significant
pH	5.76±0.01^{c}	5.97±0.01^{a}	5.81±0.02^{b}	**
Cooking loss %	20.26±0.16^{a}	12.75±1.19^{b}	21.34±5.97^{a}	*

N=3/sausage type, **=significant at p<0.01, *=significant at p<0.05

Different superscript letters within the same column means significant difference at p<0.05

4.3. Sensory evaluation of sausages

The sensory traits of different manufactured sausage types we showed in table (4). It shows significant differences (p<0.05) in texture and overall acceptability. It could be attributed to the nature of gum Arabic as flexible agent. Nearby sensory evaluation scores of beef and camel sausage were found by **Soltanizadeh *et al*., (2010)**. But lower ones were found by **Alamin *et al*., (2015)** and **Nour and Elsharif, (2015)**.

Table 4. Effect of added gum Arabic powder on sensory evaluation of beef and camel meat sausages

	Gum Arabic supplementation (%)			
	0	3	3	
Sensory traits	Control	Beef sausage	Camel sausage	Significant
Color	7.50±0.71	7.10±0.99	7.30±1.06	NS
Texture	7.00±0.94[a]	6.90±0.74[a]	6.00±1.05[b]	*
Flavor	7.20±1.14	7.10±1.10	6.40±0.84	NS
Juiciness	7.30±0.82	6.70±1.06	6.30±1.16	NS
Overall acceptability	7.25±0.62[a]	6.95±0.48[a]	6.50±0.68[b]	*

N=3/sausage type, *=significant at $p<0.05$, NS=no significant differences
Different superscript letters within the same column means significant difference at $p<0.05$

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1. CONCLUSION

- Added gum Arabic powder to beef and camel meat sausage could enhance some physiochemical properties.
- Sensory traits of sausages were less affected by adding gum Arabic powder.
- Camel meat sausage is accepted by consumers.
- Gum Arabic can be used to improve quality of beef sausage.

5.2. RECOMMENDATIONS

- Further studies are needed to assess the effects of adding Gum Arabic to camel sausage and other types of meat products.
- A camel meat product is suitable for patients of cardiac and athletes.

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APPENDICES

Appendices (1-8). Some equipments of preparation of sausages

Appendix (1). Grinder.

Appendix (2). Piston stuffer.

Appendix (3). Sensitive scale.

Appendix (4). Scale (40 kg).

Appendix (5). Water bath.

Appendix (6). Electric oven.

Appendix (7). Electric stapler.

Appendix (8). Sheep casing.

Appendix (9). Grading chart for three types of sausages

Evaluate these samples for color, texture, flavor and juiciness – for each sample, use appropriate scale to show your attitude by checking at the point that best describe the feeling about the sample. If you have any question please ask, thanks for your cooperation.

Number of sample	Color	Texture	Flavor	Juiciness	Acceptability
1					
2					
3					

Color		Texture		Flavor		Juiciness		Acceptability	
8	Excellent desirable	8	Excellent desirable	8	Excellent desirable	8	Excellent desirable	8	Excellent desirable
7	Good desirable	7	Good desirable	7	Good desirable	7	Good desirable	7	Good desirable
6	Extremely desirable	6	Extremely desirable	6	Extremely desirable	6	Extremely desirable	6	Extremely desirable
5	Very desirable	5	Very desirable	5	Very desirable	5	Very desirable	5	Very desirable
4	Moderately desirable	4	Moderately desirable	4	Moderately desirable	4	Moderately desirable	4	Moderately desirable
3	Moderately undesirable	3	Moderately un- intense	3	Moderately undesirable	3	Moderately undesirable	3	Moderately undesirable
2	Very undesirable	2	Very undesirable	2	Very undesirable	2	Very undesirable	2	Very undesirable
1	Extremely undesirable	1	Extremely undesirable	1	Extremely undesirable	1	Extremely undesirable	1	Extremely undesirable