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Effect of Partial Replacement of Meat by Pigeon pea (*Cajanus cajan* L.) on the Nutritional and Sensory Characteristics of Burger

أثر الإحلال الجزئي للحم باللوبيا العدسي على الخواص التغذوية والحسية للبيرقر

A dissertation submitted to Sudan University of Science and Technology in fulfillment of the requirement of the degree of B. Sc (Honors) in Food Science and Technology

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Dedication

To my Family

To my Teachers

To my Friends

Acknowledgment

I would like to express my appreciation with deep sense of gratitude to my supervisor **Dr. Ebrahim Alfaig Alnoor**, for his guidance and kind supervision during the period of study.

Thanks to Randa Abd Almoneim Ebramim and Eman for helping me to complete this study.

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ABSTRACT

This study was conducted to investigate the effect of partial replacement of meat by pigeon pea on the chemical and sensory characteristics of burger. Burger was produced from beef meat with the other additives (seasonings, soy bean, fat and ice) and in the experimental treatments the beef meat was partially replaced by cooked pigeon pea as follows:

Treatment 1: 100% beef meat (control), treatment 2: 75% beef meat with 25% cooked pigeon pea and treatment 3: 50% beef meat with 50% cooked pigeon pea. For all treatments chemical analysis and sensory evaluation for the cooked products were conduct. The parameters include moisture, protein, fat, ash, fiber, pH, color, flavor, taste, texture, juiciness and overall acceptability. All the measurement in three replicates were performed in the first day of production and after 3 weeks of deep freezer storage (-18±o.1). Results of chemical analysis of the burger showed that partial replacement of meat by cooked pigeon pea by 50% resulted in increasing the protein content (32.64), crude fiber (3.21), fat (8.19) and total ash content (2.84) of burger it has caused an increase in acidity (0.41) and decrease in moisture (55.79) content and pH (5.43) of burger. It can be concluded that addition of cooked pigeon pea in burger production can increase protein and fiber content and decrease the cost.

ملخص الدراسة

أجريت هذه الدراسة لإختبار أثر الإحلال الجزئي للحم باللوبيا العدسي على الخواص الكيميائية والحسية للبيرقر. تم تصنيع بيرقر من اللحم والإضافات الأخرى (البهارات، فول الصويا، الدهن والثلج) وفيالتجربة تم إحلال اللوبيا العدسي المطبوخ بدلاً عن جزء من اللحم على النحو التالي: المعاملة الأولى أو المعاملة الضابطة (100% لحم بقري)، المعاملة الثانية (75% لحم بقري، 25% لوبيا عدسي مطبوخ) والمعاملة الثالثة (50% لحم بقري، 50% لوبيا عدسي مطبوخ) وتم حفظه في المجمد.

أجري تحليل الخصائص الكيميائية والحسية للمنتج في ثلاثة مكررات للعينة الطازجة وبعد فترة تخزينه لثلاثة أسابيع.

أظهرت نتائج التحليل الكيميائي للبيرقر المصنع من اللحم واللوبيا العدسي بنسبة (50%) زيادة في نسبة البروتين إلى (32.64)، الألياف (3.21)، الدهن (8.19)، الرماد الكلي (2.84)والحمضية (0.41) وإنخفاض في نسبة الرطوبة (55.79) والرقم الهيدروجيني (5.43) للبيرقر.

يمكن أن نستنتج أن إدخال اللوبيا العدسي المطبوخ في تصنيع البيرقر سيعمل على زيادة نسبة البروتين والألياف وخفض التكلفة الإقتصادية.

CHAPTER ONE

INTRODUCTION

Meat is defined as those animal tissues which are suitable for use as food. All processed or manufactured products which might be prepared from these tissues are included in this definition. The processed meat products are define 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 (widaa, 2008).

Protein availability in developing countries at present is about one-third of its normal requirements and with ever growing human population; various nutritional development programs are facing a tough challenge to meet the targeted protein demand. Legumes in the developing world are known to offer food proteins that are generally grown under risk-prone marginal lands with low inputs (URL1).

Research problems

The direct consumption of legumes has been increased in processed products instead of meat because of:

- Global shortage of animal protein.
- Strong demand for "healthy" (cholesterol free and low in saturated fat) and religious (halal) food.
- For economic reasons.
- There is a pressure for the direct consumption of plant proteins in food products.

Objectives

- To increase the economic value of the pigeon pea by utilization in a processed meat products.
- To determine the effect of partial replacement of the meat by pigeon pea on the nutritional value and the sensory characteristics of burger.

CHAPTER TWO

LITERATURE REVIEW

2.1 Legumes

Plant proteins play a significant role in human nutrition; they are specially needed in developing countries (Hassan, 1994). Kakade and Lay (1974) reported that the protein nutritive value may be defined as the ability of a protein to provide a pattern of amino acids in proper concentrations similar to body proteins depending upon factors such as protein concentration, protein quality and protein digestibility.

Grain legumes provide food of high nutritive value to both humans and their domestic animals. Quantitatively grain legumes are second to cereals as a source of calories and protein El-Haradallou (1979).

Ahmed and Nour (1990) stated that leguminous seeds play small role in the Sudanese diet until people recently started to consider them as part of their diet due to the escalating prices of animal products. The protein content of essential selected Sudanese leguminous seeds is high: faba bean (29%), cow pea Spp. (24-26%), pigeon pea (22%) and soy bean (38%).

2.2 Pigeon pea

The presence of high genetic diversity made to believe that India is the primary center of origin of cultivated pigeon pea from where it spread to Africa about 4000 years ago (De, 1974).

2.2.1 Classification

Scientific name: *Cajanus cajan* (L.)

Family: *Fabaceae* (alt. *Leguminosae*)

subfamily: *Faboideae*

tribe: *Phaseoleae*

subtribe: *Cajaninae*.

Common names: Congo pea, pigeon pea, red gram, yellow dahl (English); ambrévade, pois d'Angole (French); straucherbse (German); arhar, tuver (India); feijoaguandu, guandú, guisante-de-Angola (Portuguese); cachito, gandul (Spanish); kachang (Asia) (URL2).

2.1.2 Morphological description

An erect woody, annual or short-lived perennial shrub or small tree, 1–4 m tall with a deep taproot (to 2 m). Young stems are angled and pubescent. Leaves trifoliate, alternate, set in a spiral around the stem; leaflets oblong, lanceolate, 2–10 cm long and 2–4 cm wide, pubescent; discolorous - green above, grayish-green below. Lateral petioles 2–3 mm long, terminal one 10–20 mm; stipules linear, 2–3 mm long. Flowers usually yellow, sometimes with purple or red streaks or plain red; calyx 10–12 mm long with 5 linear teeth. Pods flat, acuminate, pubescent, 5–9 cm long, 12–13 mm wide, containing 2–9 oval to round seeds varying in color from light beige to dark brown. 16,000–18,000 seeds/kg (URL1).

2.1.3 Distribution

Native to:

Asia: Afghanistan, Bangladesh, Bhutan, India, Sri Lanka.

Africa: Ethiopia, Kenya, Malawi, Tanzania, Uganda (URL1).

Globally, it is cultivated on 4.79 M ha in 22 countries but with only a few major producers. In Asia, India (3.58 M ha), Myanmar (560,000 ha), and Nepal (20,703 ha) are important pigeon pea producing countries. In African continent, Kenya (196,261 ha), Malawi (123,000 ha), Uganda (86,000 ha), Mozambique (85,000 ha), and Tanzania (68,000 ha) produce considerable amounts of pigeon pea. The Caribbean islands and some South American countries also have reasonable areas under pigeon pea cultivation (URL2).

2.2.4 The nutritional value of seeds

It is recognized that food grain legumes, such common bean, lentils and kidney beans, represent the main supplementary protein source in cereal and starchy food-based consumed by large sectors of the population living in developing countries. Although, the nutritional value of these legumes is of great importance, their intake is unfortunately lower than that what is desirable. Furthermore, food grain legumes should be frees of anti-physiological substances, have high nutrient bioavailability and be easily processed into edible, acceptable products (Bressani, 1989; Bressani, 1993). The nutritional value of grain legumes, not always fully understood and accepted by consumers, is divided here into two large groups: positive and negative factors. The positive factors include high protein and lysine content, which allows legumes to serve as excellent protein supplements to cereal grains (Bressani, 1989; Bressani, 1993).

The negative factors fall into two groups. Anti-nutritional factors such as enzyme inhibitors, flatulence factors, poly-phenols, tannin and phytic acid. The negative nutritional factors include protein and carbohydrate digestibility, sulfur amino acid deficiency (Bressani, 1989; Bressani, 1993).

2.2.5 Anti-Nutritional Factors

Like other legumes, pigeon pea seeds also contain some anti-nutritional factors. These include oligo-saccharides (raffinose and verbascose), polyphenols (phenols and tannins), phytolectins, and enzyme inhibitors (trypsin, chymotrypsin, and amylase). According to Kamath and Belavady (1980), pigeon pea seeds also have some amounts of unavailable carbohydrates which adversely affect the bioavailability of certain vital nutrients. Some of the anti-nutritional factors such as phytolectins are heat sensitive and are destroyed during cooking.

2.2.6 Chemical composition of pigeon pea

2.2.6.1 Moisture content

Sanjeev *et al.,* (1991) obtained a variation between 10.00 and 11.00% moisture for six varieties of pigeon pea. Papiti (1970) reported about 5.0% moisture content of grain legumes grown in Sudan.

2.2.6.2 Crude protein content

Singh and Eggum (1984) obtained a variation between 17.9 and 24.3% crude protein of 43 commonly cultivated varieties of pigeon pea. ICRISAT (1987) found a range in protein content from 18.2 to 19.80% for six varieties of pigeon pea crude protein of 43 commonly cultivated varieties of pigeon pea.

2.2.6.3 Fat content

Sanjeev *et al*., (1991) obtained a variation between 1.19 and 1.37% fat for six varieties of pigeon pea. While El-Hardallou *et al*., (1980) found 2.0% fat content of legumes grown in Sudan.

2.2.6.4 Crude fiber content

El-Hardallou *et al*., (1980) found about 6.4% fiber content of legumes grown in Sudan. About the same value 6.10% was observed by (Aletor and Aladetimi, 1989).

2.2.6.5 Ash content

El-Hardallou *et al*., (1980) obtained 3.6% ash content of legumes grown in Sudan. About the same value obtained by (Aletor and Aladetimi, 1989).

2.2.7 Effect of heat processing on nutrients

The heating process has four desirable effects ,first, it partially sterilizes the food by killing microorganisms; second, it increases the availability of nutrients by breaking down the plant cellulose cell walls that cannot be broken down by the enzymes in the human intestinal tract (Bradbury *et al*., 1984); third, it solubilises starch and makes it more digestible; fourth, it denatures proteins, converting insoluble collagen in meat into soluble gelatin and inactivating protolytic enzyme inhibitors that are potential anti-nutritional factors present in many plant food (Bradbury and Holloway, 1988).

2.3 Meat

2.3.1 Definition of meat

Meat is defined as those animal tissues which are suitable for use as food (Judge *et al*, 1990). There is very large number of animals can use as human food, such as; cow, sheep, deer and buffalo.

2.2.2 Meat and Human Nutrition

Meat in fact a desired food which is the central item of most meals in many countries. Ultimately, meat value is based on its degree of acceptability by consumers. Satisfaction derived from meat consumption depends on psychological and sensory responses unique among individuals such factor as appearance, purchase price aroma during cooking, cooking losses ease of preparation and serving, edible portion, tenderness, juiciness, and flavors among individuals. There are wide variations in importance attributed to such factors (Widaa, 2008).

2.2.3 Meat composition

The chemical and biochemical constitution of muscle is affected by intrinsic and extrinsic factors. The most important intrinsic factors are species, breed, sex, age and anatomical location of muscle. The extrinsic factors are nutrition, fatigue, fear, pre-slaughter manipulation and environmental conditions before, during and after slaughter. Generally, the composition of meat is 75% water, 18% protein, 3.5% soluble non protein substances and 3% fat (Lawrie, 1979).

Meat consist primarily of muscular tissue with amounts of fatty tissue varying only with breed, age sex and diet of the animal but also with anatomical location (Lawrie, 1979).

2.2.3.1 Water

For a given muscle from mature animals there is little difference in water content between rabbit, sheep, pig and whale. In general, breed, sex and plane of nutrition affect the water content only in so far as the latter bears a reciprocal relation with the percentage intramuscular fat (Cole and Lawrie, 1975).

2.2.3.2 Protein

The protein of typical mammalian muscles after rigor mortis but before post-mortem degradative changes contains about 19% protein: 11.5% is structural protein-actin and myosin (myofibrillar), 5.5% soluble sarcoplasmic protein in the muscle juice, 2% connective tissue (collagen and elastic) encasing the structural protein and about 2.5% fat dispersed fibers (Bender, 1992).

William and peter (2007) reported that raw red muscle meat contains protein around 20-25g/100g. Cooked red meat contains 28-36g/100g, because the water content decreases and nutrients become more concentrated during cooking. The red meat protein is highly digestible 94%, compared with the digestibility of 78% in beans and 86% in whole wheat. Protein from meat provides all essential amino acid (lysine, threonine, methionine, phenylalanine, tryptophan, leucine, isolucine and valine) and has no limiting amino acids. The amino acid glutamic acid/glutamine is presenting in the highest amount (16.5%) followed by arginine, alanine and aspartic acid.

2.2.3.3 Carbohydrates

Carbohydrates constitute less than one percent of the weight of meat. Most of which is present as glycogen and lactic acid. Since the liver is the principle storage site for glycogen most carbohydrate in the animal body is in the liver thus, most, meats are poor source of carbohydrates, except those processed to which sugars or other carbohydrates have been added (Judge *et al*, 1990).

2.2.3.4 Fat

Structural fats are largely phospholipids and include long chain fatty acids. Fatty acids are of three types (1) saturated fatty acids in which all the carbon atoms in the chain carry their full quota of hydrogen atoms and the carbons linked by single bond (2) mono-unsaturated fatty acids (MUFA) in which one hydrogen is missing from each of two adjacent carbon atoms which are therefore linked by double bond and (3) poly unsaturated fatty acid (PUFA) in which two or more pairs hydrogen atoms are missing and there are several double bounds in the carbon chain (Bender, 1992).

William and peter (2007) added that saturated fatty acid on average 4% of total fatty acids in the lean component and 48% in the fat component of red meat poly unsaturated fatty acids range from 11% to 29% of total fatty acids, pasture fed beef is a better source of omega-3 fats than grain feed beef.

2.2.3.5 Minerals

Studies of mineral content of meat have been largely confined to calcium, phosphorus, sodium, potassium and iron in addition to these five minerals recent studies have reported on the content of magnesium, copper and zinc. Meat is a good source of dietary phosphorus and iron but is low in cesium (peal *et al*, 1966).

Williams and Peter (2007) added that red meats are also good sources of selenium, providing over 20% RDI/100g serve; lean meat is low in sodium, with a potassium- sodium ratio of > 5. The copper content in raw lean cuts range from 0.055 to 0.190 mg in beef and real.

2.2.3.6 Vitamins

As with other animal food red meat is an excellent source of bio available vitamin in B_{12}, up to 25% of riboflavin, niacin, vitamin B_6 and antithetic acid also be provided by 100g of red meat. Levels of vitamin D in meat are low and difficult to measure and have often not been included in food composition data previously (Williams and Peter, 2007).

Peal et al 1966 reported that the meat is an excellent source of the B-complex and is poor in the fat soluble group and vitamin C (ascorbic acid).

2.2.4 Quality attributes of meat

The quality attributes like color, water holding capacity and some of the odor of the meat detected both before and after cooking and provide the consumer with a more prolonged sensation than do attributes like juiciness, texture, taste and most of the odor which detected on mastication (Lawrie, 1979).

2.2.4.1 Color

The color of the meat is an important quality attributes which affects meat consumer. The appearance of fresh meat depend on color which is defined as the concentration of the pigment myoglobin and by the relative proportions of it is common forms, oxymyglobin(bright red), myoglobin (purplish red) and metmyoglobin (brown). The concentration of myoglobin affects the color of muscle (Oard and Wes drop, 1971).

Myoglobin quantity varies with species, sex, muscle and physical activity (Judge *et al*, 1990). The appearance of the meat surface to the consumer depends on the quantity of myoglobin present also on the type of myoglobin molecule, on it is chemical state and on the chemical and physical conditions of other components in the meat. In fresh meat, before cooking, the most important chemical form of myoglobin is oxymyoglobin which is known as bloom and it represents the bright red color desired by purchasers. The principle pigment of cooked meat is known as globin haemichromogen (lawrie, 1991).

The gradual change in surface color from red to brown, often encountered during storage and display of fresh and frozen meat, is largely a result of thermal and photochemical autoxidation of the red oxymyoglobin to brown metmyoglobin (Anderson *et al*, 1989).

2.2.4.2 Water holding capacity

Water holding capacity (WHC) is the ability of meat to retain its water or added water during application of external forces such as cutting, heating, grinding, or pressing. Many of the physical properties of meat (include color, texture, and firmness of raw meat, and juiciness and tenderness of cooked meat) are partially dependent on WHC (Judge *et al*, 1990).

Water exists in the form of bound, immobilized and free. Water molecules are not electrically neutral, but have positively and negatively charged ends, i.e. they are polar. Thus they are associated with electrically charged reactive groups of muscle protein. Of the total water in muscle 4-5 percent is bound water. Other water molecules are termed immobilized water which is weaker as the distance from the reactive groups on protein becomes greater. Water held only by weak surface forces is known as free water. The number of reactive groups on the protein and their availability for binding water are dependent on the production of lactic acid, loss of ATP, onset of rigor mortise and changes of cell structure associated proteolytic enzyme activity (Judge *et al*, 1990).

The water holding capacity of meat is affected by several factors such as species, age and muscular function; muscles having high content of intramuscular fat tend to have a high WHC (Saffel and Brazler, 1959).

The water holding capacity is strongly dependent on the pH of the meat. At pH 5, corresponding to the isoelectric point of actomyocin WHC of meat is at its minimum (Thomsen and Zeuther, 1988).

2.2.4.3 Juiciness

Juiciness of cooked meat has two organoleptic components. The first as the impression of wetness during the first few chews and is produced by the rapid release of meat fluid, the second is one of the sustained juiciness, largely due to the stimulatory effect of the fat on salivation (Weir, 1960).

The principal sources of juiciness in meat, as detected by the consumer, are the intramuscular lipids and the water content. The marbling that is present also serves to enhance juiciness during the cooking process when the melted fat apparently becomes translocated along the bands of perimysial connective tissue. This uniform distribution of lipids throughout the muscle may act as a barrier to moisture lost during cooking (Judge *et al*, 1990).

Good quality meat is juicier than that of the poor quality, the difference being at least partly attributable to the higher content of intramuscular fat in the former. There are some suggestions, that juiciness reaches a minimum when the pH level of the meat is about 6. This possibly reflects the greater ability of the muscles protein to bind water in this pH region.

2.2.4.4 Flavor

Flavor is a complex it involves odor, taste, texture, temperature and pH. Of these odor is the most important (Lawrie, 1991).

Lawrie (1979) reported that the evaluation of odor and taste still depends mainly on the taste panel. It's true that, in recent years, gas chromatography has permitted precise measurement of the volatiles from food stuffs, but this has not infrequently confused the tissue.

Judge *et. al.* (1990) reported that many constituents of the meat tissue become flavor compounds upon being heated. Some evidence shows that insomniac IMP and hypoxanthine are breakdown products of ATP; it's obvious that muscles with large energy stores would have a more pronounced flavor. Most of the constituents of meat responsible for the meaty flavor are water soluble component of muscle tissue. They also reported that some undesirable flavor changes that occur during storage could be due to metabolic end products.

Pokorny (1970) studied the aromatic substances which were extracted from boiled beef in deep vacuum distillation. About 56 components were separated from the extraction by gas chromatography and were identified it was found that aldehydes, ketones, alcohols, thiols, cyclic derivatives of benzene furan and particularly 2, 4, 5- trimethy-3 oxazoline and 3.5 dimethy 1, 2, 4 trithiolone are primarily responsible for the characteristic meat aroma.

The study also showed the vacuum during and along cold storage reduces their concentrations.

2.2.4.5 Tenderness and Texture

The overall impression of tenderness to the palate includes texture and involves three aspects, firstly, the initial ease of penetration of the meat by the teeth, secondly, the ease with which the meat breaks into fragments, and thirdly, the amount of residue remaining after chewing (Weir, 1960). Tenderness is probably the most important factor considered by the consumer in assessing the eating quality of meat. Tow structural components have been shown to determine the tenderness of meat, namely the collagen of connective tissue and the contractile apparatus of myfibriliar protein (Ali, 2003).Lawrie (1991) reported that the rate of post mortem glycolysis is one of the most important factors effecting tenderness. With the progress of post mortem glycolysis tenderness decreases due to formation of permanent bonds between actin and myocin resulting in actomyocin formation.

Kumar *et al*. (1974) showed that the pre-slaughter and post-slaughter factors effecting meat texture include species, bread, sex, age, feed, pre-rigor factors and processing.

Ihekoronye and ngoddy (1992) reported that the lesser the amount of connective tissue in meat the more tender is the meat. They also reported that when meat is heated in water, the connective tissue is changed to a sort of tender gelatin and it becomes more palatable. Earlier work has indicated a relationship among chilling temperature, muscle shortening and tenderness (Koh *et al,* 1987).

There have been many attempts to device objective physical and chemical methods of assessing tenderness which would compare with subjective assessment by taste panels. Thus physical methods have included the basis for measuring the force in shearing, penetrating, compressing and stretching the meat. Chemical methods have involved determination of connective tissue and enzymic digestion amongest other criteria (lawrie, 1991).

2.3 Processed meat products

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. Salting and smoking of meat was an ancient practice even in the time of Homer, 850 B.C. These early processed meat products were prepared for one purpose, their preservation for use at some future time (Judge *et al*, 1990).

2.3.1 History of burger

The origin of hamburger is a bit hazy and unclear. This is because there is no proper documentation to give us an idea about how the fast food came into being. Still, many people have claimed that hamburger "patty" was first noticed in the medieval times. Tartars (a band of Mongolian and Turkish warriors) used to place pieces of beef under their saddles. Under the weight of the rider and the saddle, the pieces used to turn tender enough to be eaten raw. Thus was born the initial beef "patty". A food item resembling the present-day burger, to some extent, reached America around the 19th century. The dish, called hamburger style beef, was brought to Hamburg (Germany) from Russia in the 14th century and when the German immigrants arrived in America, they brought it along with them. With time, the raw, chopped piece of beef evolved into the "patty sandwiched in a bun". Thus, it can be said that America had a major role in giving the world the hamburger as we know. Beef burger consists of more finely minced beef (70-80%), spices, seasoning, sodium chloride and fat (20%). Thoroughly mixed to form dough texture and pressed in small rounded metal objects to form ring like structure of about (10 cm in diameter and 1 cm thick) (URL3).

2.3.2 Burger processing

A transit document is checked when fresh or frozen beef is delivered. Each delivery is inspected to ensure it complies with certain specifications.

Checks, including temperature checks, are carried out before the goods are accepted. These checks are recorded and maintained to ensure quality and traceability of the products. A database is used to record details of each delivery. At the beginning of the burger making process, the chilled and frozen meat are transferred from the stores to the manufacture floor and placed into large hoppers. The process of batch formulation is computer controlled to ensure a consistent amount of meat is added.

A combination of 70% chilled and 30% frozen meat is used. The meat will increase in temperature due to the mechanical action of the grinder.

The addition of frozen meat helps to maintain a low temperature. The frozen meat also helps to ensure the mixture is stiff enough to form burgers in the forming machine without sticking to the machinery and causing problems and delays (URL4).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

3.1.1 Meat

Fresh beef meat was used in the manufacturing as it has been obtained from Alwagba factory. Then, the meat was sliced into smaller pieces for a better grinding process, then the desired weight of meat were put in polyethylene bags and wrapped up tightly and stored at a temperature of (- 18 ± 2^{o}C) until the meat is used again.

3.1.2 Pigeon pea

Pigeon pea was obtained from Omdurman market, cleaned thoroughly; 1.8 liter was added to the pigeon pea (0.5 kg) in cooking pot and boiled for 2 hours under pressure. Then, the cooked pigeon pea were filtered from the remain water and stored in refrigerator.

3.1.3 Spices

A variety of (black pepper, coriander and cinnamon) spices were obtain from Omdurman market and ground separately and put in glass jars until use. Percentage of the spices was 0.2% of each (black pepper, coriander and cinnamon).

3.1.4 Salt

A purified and free of impurities table salt (NaCl) was add to the mixture. The percentage was 1.5% of the weight of the manufactured product for each treatment.

The experiment included three treatments, as follows:-

The first treatment: (100% beef meat) (T1).

The second treatment: (75% beef meat + 25% boiled pigeon pea) (T2).

The third treatment: (50% beef meat + 50% boiled pigeon pea) (T3).

3.2 Methods

3.2.1 Meat preparation

Stored beef meat were frozen at (- 18 ± 2) over night, sliced and ground using an electric grinder.

3.2.2 Pigeon pea preparation

Stored pigeon pea was preserved at refrigerator temperature ($4^{o}C$), ground using electric grinder.

3.2.3 Spices preparation

Spices where cleaned and ground.

3.2.4 Soy bean preparation

The weights of soy bean (21g) for each treatment (700g) soaked in water equal their weight two times (42 ml) and leaved until absorbed all the added water.

3.2.5 Experiment design

Table 1. Products formula for production of (700g) burger.

Ingredients	**T1**	**T2**	**T3**
	Weight in grams	Weight in grams	Weight in grams
Meat	490	367.5	245
Pigeon pea	-	122.5	245
Added ice	70	70	70
Added fat	70	70	70
Soy bean	21	21	21
Skimmed milk	21	21	21
Salt	10.5	10.5	10.5
Spices	4.5	4.5	4.5

Treatment 1: 100% beef meat.

Treatment 2: 75% beef meat and 25% cooked pigeon pea.

Treatment 3: 50% beef meat and 50% cooked pigeon pea.

3.2.6 Process of burger production:

The deboned beef meat was chopped coarsely, and then the desired weight for each treatment was weighed separately.

↓

Cooked pigeon pea was chopped coarsely chop and the desired weight for each treatment was weighed separately.

↓

Fat, soaked soy bean and ice were added to the chopped meat and pigeon pea then the mixture was chopped to get fine chop.

↓

After that, spices, salt and skimmed milk powder were added and mixed well.

↓

The mixture of each treatment was divided and formed into small ball (50g)

↓

Using the piston, the divided weights were pressed and placed in market dished.

↓

The products were stored at (-18±.1) until it was analyzed.

3.3 Chemical analysis

3.3.1 Moisture content

The moisture content was determined according to standard methods of association if official analytical chemists (AOAC, 2003).

Principle

The moisture content is a weighed sample removed by heating the sample in an oven under atmospheric pressure at 105 ±1^{o}C. then the difference in weight before and after drying is calculated as percentage from the initial weight.

Procedure

A sample of 5g ±1mg was weighed into a pre-dried and tarred dish. Then the sample was placed into an oven at 105 ±1^{o}C until a constant weight was obtained. After that the covered sample was transferred to desiccators and cooled to room temperature before reweighting. Triplicate results were obtained for each sample and the mean value was reported.

Calculation

$$\textbf{Moisture content\%} = \frac{M2-M3}{M2-M1} \times 100$$

Where:

M1= weight of dish + cover.

M2 = weight of dish + cover + sample before drying.

M3 = weight of dish + cover + sample after drying.

Percentage of moisture from 100%.

3.3.2 Crude protein

The crude protein was determined in all samples by micro-Kjeldahl method using a copper sulphate and sodium sulphate catalyst according to the official methods of **AOAC (2003).**

Principle

The method consists of sample oxidation and conversion of Nitrogen to ammonia, which react with excess amount of sulphuric acid forming ammonia sulphate. The solution is made alkaline and the ammonia is distilled into a standard solution of boric acid (2%) to form the ammonia-boric acid complex, which is titrated against standard solution of HCL (0.1). Accordingly, the crude protein content is calculated by multiplying the total N% by 6.25 as a conversion factor for protein.

Procedure

2g ± 1mg of sample was accurately weighed and transferred together with 2-3 glass pellets, kjeldahl catalysit (No 33064, BDH, Germany) and 30 ml of concentrated sulphuric acid into kjeldahl digestion flask. After that, the flask was placed into a kjeldahl unit (Tecator, Sweden) for about 3 hours, until a colorless digest was obtained. Following, the flask was left to cool to room temperature. The distillation of ammonia was carried out in 30 ml of boric acid (2%) by using 40 ml distilled water and 60 ml sodium hydroxide solution (33%). Finally, the distillate was titrated with standard solution of HCL (0.1) in the presence of 2-3 drops of indicator (Bromocreasol green and methyl red) until a brown reddish color was observed.

Calculation

$$\textbf{Crude protein\%} = \frac{TV \times N \times 14 \times F}{1000 \times Sample\ weight\ (g)} \times 100$$

Where:

TV = actual volume of HCL used for sample.

N = normality of HCL.

F = protein conversion factor = 6.25.

14: Each ml HCl is equivalent to 14 mg nitrogen.

3.3.3 Fat content

The crude fat in the sample was determined according to the standard methods of **AOAC (2003).**

Principle

The method determines the substances which are soluble in hexane (B.P, 40-60^{o}C) and extractable under the specific conditions of Sox let extraction method. The dried hexane extract is weighed and reported as percentage of the matter as crude fat.

Procedure

A sample of 5g ±1mg was weighed into an extraction thimbles (30-100mm) and covered with cotton that previously extracted with hexane. Then, the sample and a pre-dried and weighed Erlenmeyer flask containing about 150 ml hexane (No 1622, BDH, England) were attached to the extraction unit (Electro thermal, England) and the temperature was adjusted to produce about 150 to 200 drops of the condensed solvent per minute for 16 hours. At the end of the distillation period, the flask with was disconnected from the unit and the solvent was redistilled. Later the flask with the remaining crude hexane was put in an oven at 105°C for 3 hours, cooled to room temperature in desiccators, reweighed and the dried extract was registered as crude fat % DM according to the following **formula**

$$\textbf{Fat content\%} = \frac{W1-W2}{W3} \times 100$$

Where:

W1 = weight of flask and ether extract.

W2 = weight of empty flask.

W3 = initial weight of sample.

3.3.4 Ash content

The standard analytical methods of AOAC (2003) were used for determined of ash content in the samples.

Principle

The inorganic materials which are vary in concentrations and compositions are customary determined as a residue after being ignited at a specified degree.

Procedure

A sample of 2g ± 1mg was weighed into a pre-heated, cooled weighed and tarred porcelain crucible and placed into a muffle furnace (Carbolite, Sheffield, England) at 550 to 600°C until a constant weight and a white gray ash was obtained. The crucible was transferred to a descanter then allowed to cool to room temperature and weighed. The ash content was calculated as a percentage based on the initial weight of sample.

Calculation

$$\textbf{Ash content\%} = \frac{(wt\ of\ crucible + ash) - wt\ of\ empty\ crucible}{initial\ weight\ of\ sample} \times \mathbf{100}$$

3.3.5 Crude fiber content

The crude fiber was determined according to the official methods of the AOAC (2003).

Principle

The crude fiber is determined gravimetrically after the sample is being chemically digested in chemical solution. The weight of the residue after ignition is then corrected for ash content and is considered as a crude fiber.

Procedure

About 2g ± 1mg of a defatted sample was placed into a conical flask containing 200 ml of H_2SO_4 (0.26 N). The flask was then, fitted to a condenser and allowed to boil for 30 minutes. At the end of the digestion period, the flask was removed and the digest was filtered (under vacuum) through a porcelain filter crucible (No. 3). After that, the precipitated was repeatedly rinsed with distilled boiled water followed by boiling in 200 ml NaOH (0.23 N) solution for 30 minutes under reflux condenser and the precipitate was filtered, rinsed with hot distilled water, 20 ml ethyl alcohol (96%) and 20 ml diethyl ether.

Finally, the crucible was dried at 105^{o}C (overnight) to a constant weight, cool, weighed, ashes in a Muffle furnace (No.20. 301870, Carbolite, England) at 550 to 600^{o}C until a constant weight was obtained and the difference in weight was considered as crude fiber.

Calculation

$$\textbf{Crud Fiber\%} = \frac{W1 - W2}{Sample\ weight\ (g)} \times 100$$

Where:

W1 = weight of sample before ignition (g).

W2 = weight of sample after ignition (g).

3.4 Statistical analysis

Data obtained from chemical analysis was subjected to Analysis Of Variance (ANOVA) minitab17. The mean values also were subjected to Tukey comparison test. Sensory evaluation data subject to excel Microsoft analysis.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Chemical analyses of burger

4.1.1 Analysis before storage (0 day)

4.1.1.1 Moisture content

Results in table (2) have shown the percentages of moisture content in treated burger before storage according to the treatment were (60.62%, 56.20% and 53.32%) for treatments T1, T2 and T3, respectively. Result of moisture content of treatment T2 was close to the results obtained by Horna *et al* (2002) who studied the incorporated legumes as non-meat protein in fresh beef sausages, as the moisture content who studied the in treatment (75% lean meat, 25% soy bean) was (60.82%) and (75% lean meat, 25% chick peas) was (60.88%). Result of moisture content of treatment T3 was close to that found by Abdullah and Abass (2016) who studied the effect of partial replacement of meat with some legumes such as (Chickpea) on some of the chemical and sensory characteristics of the manufactured burger, as the moisture content who studied the in the treatment (50% veal meat, 50% boiled chickpeas) was (60.9%).

Table 2. Effect of treatments on chemical characteristics before storage (0day)

Factors	Treatment1	Treatment2	Treatment3
Moisture	60.62 ± 0.1^{a}	56.20 ± 0.1^{b}	53.32 ± 0.1^{c}
Protein	19.48 ± 0.1^{c}	32.28 ± 0.5^{b}	33.74 ± 0.1^{a}
Fat	7.77 ± 0.2^{b}	8.08 ± 0.2^{b}	8.66 ± 0.2^{a}
Ash	2.06 ± 0.1^{c}	2.99 ± 0.1^{b}	3.20 ± 0.1^{a}
Fiber	1.14 ± 0.03^{c}	2.46 ± 0.1^{b}	3.13 ± 0.1^{a}
pH	5.96 ± 0.03^{a}	5.63 ± 0.3^{a}	5.46 ± 0.01^{a}
Acidity	0.35 ± 0.01^{c}	0.38 ± 0.01^{b}	0.45 ± 0.01^{a}

*Means values having different superscript (s) litters in a row are significantly different ($p \leq 0.05$).

Treatment 1: 100% beef meat.

Treatment 2: 75% beef meat and 25% cooked pigeon pea.

Treatment 3: 50% beef meat and 50% cooked pigeon pea.

4.1.1.2 Protein

Results in Table (2) indicated that the protein ratios were (19.48%, 32.28%, and 33.74%) for treatment T1, T2 and T3, respectively. Result of protein content of treatment T2 was close to that found by Horna *et al* (2002) who incorporated legumes as non-meat protein in fresh beef sausages, as the protein content who studied the in the treatment (75% lean meat, 25% soy bean) (17.65%) and (75% lean meat, 25% chick peas) (13.90%). Result of protein in the treatment T3 was confirming more than the finding of Abdullah and Abass (2016) they studied the effect of partial replacement of meat with some legumes such as (Chickpea) on some of the chemical and sensory characteristics of the manufactured burger, as the protein content who studied the in the treatment (50% veal meat, 50% boiled chickpeas) was (14.25%).

4.1.1.3 Fat

Results in Table (2) have shown that the percentages of fat were (7.77%, 8.08% and 8.66%) for the treatments T1, T2 and T3, respectively. Result of fat content of treatment T2 was (8.08%) less than that found by Horna et al (2002) who studied the incorporated legumes as non-meat protein in fresh beef sausages, as the fats content who studied the in the treatment (75% lean meat, 25% soy bean) was (17.5%) and in the treatment (75% lean meat, 25% chickpeas) was (12.28%). Result of fat content in the treatment T3 was less than that found by Abdullah and Abass (2016) who studied the effect of partial replacement of meat with some legumes such as (Chickpea) on some of the chemical and sensory characteristics of the manufactured burger, as the protein content who studied the in the treatment (50% veal meat, 50% boiled chickpeas) was (10.75%).

4.1.1.4 Ash

Results shown in Table (2) that the percentages of ash were (2.06%, 2.99% and 3.20%) for the treatments T1, T2 and T3, respectively. Result of treatment T3 (50% veal meat, 50% boiled chickpeas) was more than the finding of Abdullah and Abass (2016) who studied the effect of partial replacement of meat with some legumes such as (Chickpea) on some of the chemical and sensory characteristics of the manufactured burger, as the ash content who studied the in the treatment (50% veal meat, 50% boiled chickpeas) was (1.45%).

4.1.1.5 Fiber

It also noted from Table (2) that the percentages of total fiber were (1.14%, 2.46% and 3.13%) for treatments T1, T2 and T3, respectively. Result of fiber in the treatment T3 was far less than that finding of Abdullah and Abass (2016) who studied the effect of partial replacement of meat with some legumes such as (Chickpea) on some of the chemical and sensory characteristics of the manufactured burger, as the fiber content who studied the in the treatment (50% veal meat, 50% boiled chickpeas) was (10.75%).

4.1.1.6 pH

Results in Table (2) have shown that the pH values were (5.96, 5.63 and 5.46) for treatments T1, T2 and T3, respectively. Result of pH in the treatment T2 close to what has been found by Horna et al (2002) who studied the incorporated legumes as non-meat protein in fresh beef sausages, as the pH who studied the in the treatment (75% lean meat, 25% soy bean) was (6.10) and (75% lean meat, 25% chick peas) was (6.05). Result of pH in the treatment T3 was less than the finding of Abdullah and Abass (2016) who studied the effect of partial replacement of meat with some legumes such as (Chickpea) on some of the chemical and sensory characteristics of the manufactured burger, as the pH content who studied the in the treatment (50% veal meat, 50% boiled chickpeas) was (7.7).

4.1.1.7 Acidity

Results in Table (2) shown that the acidity values were (0.35%, 0.38% and 0.45%) for treatments T1, T2 and T3, respectively.

4.1.2 Analysis after storage (3weeks)

4.1.2.1 Moisture content

Results in Table (3) have shown that the percentages of moisture content

were (57.00%, 58.63% and 55.79%) for treatments T1, T2 and T3, respectively. These results were comparable to the results of the fresh samples shown in Table (2) which were (60.62%, 56.20% and 53.32%) for treatments T1, T2 and T3, respectively.

4.1.2.2 Protein

Results in Table (3) have shown that the protein ratios were decreased to (19.25%, 30.06% and 32.64%) for treatments T1, T2 and T3, respectively. The protein contents were slightly decreased if compared with the results of protein content in Table (2) which were (19.48%, 32.28%, and 33.74%) for treatment T1, T2 and T3, respectively.

4.1.2.3 Fat

Results in Table (3) have shown that percentages of fat content were decreased also to (7.36%, 7.71% and 8.19%) for treatments T1, T2 and T3, respectively. The fat contents were slightly decreased if compared with the results of fat content in Table (2) which were (7.77%, 8.08% and 8.66%) for treatments T1, T2 and T3, respectively.

4.1.2.4 Ash

It noted that result in Table (3) have shown that the ash content (1.90%, 2.81% and 2.84%) for treatments T1, T2 and T3, respectively. The ash contents were also slightly decreased if compared with the results of ash content in Table (2) which were (2.06%, 2.99% and 3.20%) for treatments T1, T2 and T3, respectively.

Table 3. Effect of treatments on chemical characteristics after storage (3weeks)

Factor	Treatment 1	Treatment 2	Treatment 3
Moisture	57.00 ± 0.02[c]	58.63 ± 0.1[b]	55.79 ± 0.1[a]
Protein	19.25 ± 0.03[c]	30.06 ± 0.3[b]	32.64 ± 0.3[a]
Fat	7.36 ± 0.20[c]	7.71 ± 0.10[b]	8.19 ± 0.10 [a]
Ash	1.90 ± 0.10[b]	2.81 ± 0.03[a]	2.84 ± 0.02[a]
Fiber	1.10 ± 0.00[c]	2.41 ± 0.04[b]	3.21 ± 0.30[a]
pH	5.74 ± 0.03[a]	5.49 ± 0.02[b]	5.43 ± 0.03[b]
Acidity	0.30 ± 0.01[c]	0.34 ± 0.02[b]	0.41 ± 0.01[a]

*Means values having different superscript (s) litters in a row are significantly different ($p \leq 0.05$)

Treatment 1: 100% beef meat.

Treatment 2: 75% beef meat and 25% cooked pigeon pea.

Treatment 3: 50% beef meat and 50% cooked pigeon pea.

4.1.2.5 Fiber

Results in Table (3) have shown that the fiber content were (1.10%, 2.41% and 3.21%) for treatment T1, T2 and T3, respectively. These results were almost the same if compared with the results of fiber content before storage in Table (2) which were (1.14%, 2.46% and 3.13%) for treatments T1, T2 and T3, respectively.

4.1.2.6 pH

Results in Table (3) have shown that the pH values were (5.74pH, 5.49pH and 5.43pH) for treatment T1, T2 and T3, respectively. These results were almost the same if compared with the results of pH before storage in Table (2) which were (5.96pH, 5.63pH and 5.46pH) for treatments T1, T2 and T3, respectively.

4.1.2.7 Acidity

Result in Table (3) have shown that the acidity percentage to (0.30%, 0.34% and 0.41%) for treatment T1, T2 and T3, respectively. These results were almost the same if compared with the results of acidity in Table (2) which were (0.35%, 0.38% and 0.45%) for treatments T1, T2 and T3, respectively.

4.2 Sensory evaluation of burger

4.2.1 Evaluation before storage (0 day)

Figure (1) showed the results of sensory assessment of the cooked burger samples before storage, as color rates were (5.96, 4.36 and 2.12) for treatments T1, T2 and T3, respectively out of (7). Taste rates were (6.15, 4.15 and 3.18) for treatments T1, T2 and T3, respectively out of (7). Flavor rates were (6.11, 4.71 and 3.27) for treatments T1, T2 and T3, respectively out of (7). Texture rates were (4.01, 5.04 and 6.11) for treatments T1, T2 and T3, respectively out of (7). Juiciness rates were (4.19, 5.28 and 6.39) for treatments T1, T2 and T3, respectively out of (7). Overall acceptability rates were (6.25, 4.39 and 3.68) for treatments T1, T2 and T3, respectively out of (7).

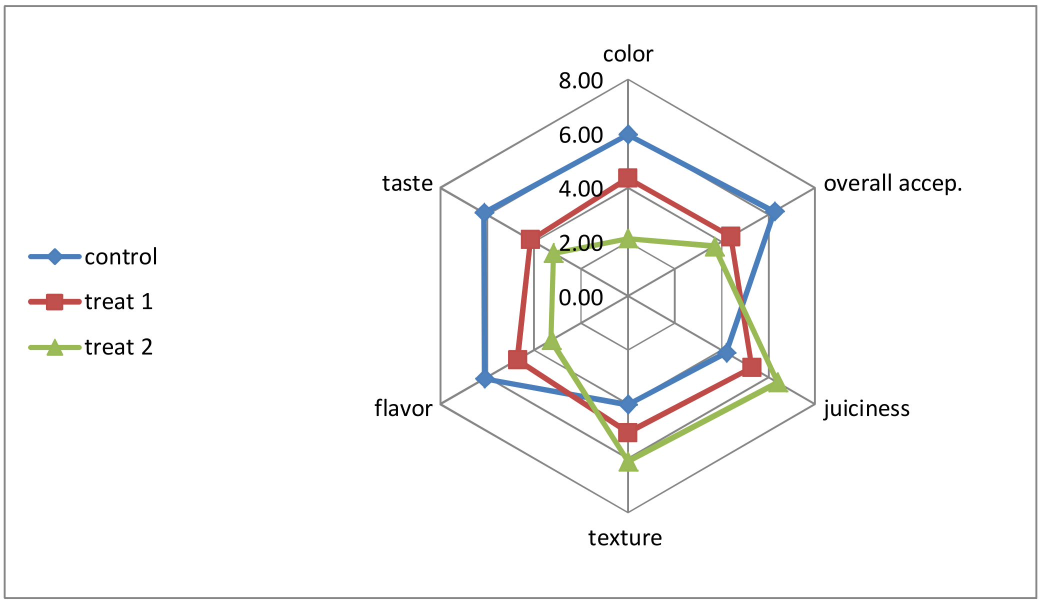

Figure 1: Effect of treatments on sensory characteristics of cooked burger (0 day)

4.2.2 Evaluation after storage (3 weeks)

Figure (2) showed the results of sensory assessment of the cooked burger after storage, as color rates were (5.89, 4.22 and 2.08) for treatments T1, T2 and T3, respectively out of (7). Taste rates were (6.04, 4.05 and 3.07) for treatments T1, T2 and T3, respectively out of (7). Flavor rates were (5.72, 4.61 and 3.13) for treatments T1, T2 and T3, respectively out of (7). Texture rates were (3.73, 4.72 and 6.13) for treatments T1, T2 and T3, respectively out of (7). Juiciness rates were (4.04, 5.21 and 6.13) for treatments T1, T2 and T3, respectively out of (7). Overall acceptability rates were (6.08, 4.23 and 3.22) for treatments T1, T2 and T3, respectively out of (7).

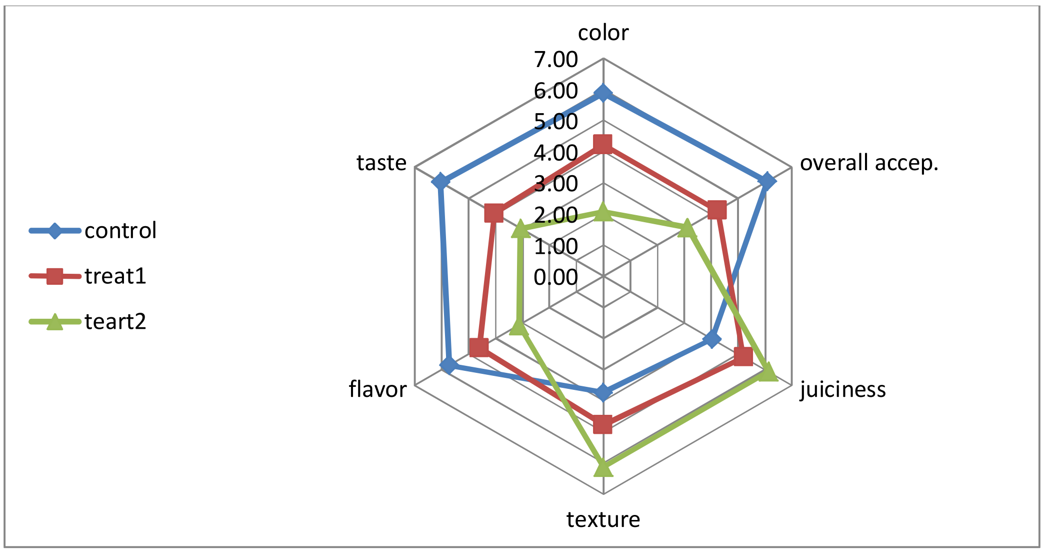

Figure 2: Effect of treatments on sensory characteristics of cooked burger (3weeks)

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions:

- Based on the results obtained in this study it can be concluded that using of cooked pigeon pea increased the protein and fiber content of the burger.
- Replacement of 50% of the meat by cooked pigeon pea improved texture and juiciness of the burger.
- Compared the replacement of meat by 25% and 50% cooked pigeon pea it can be concluded that the treatment of 25% cooked pigeon pea is better than 50% regarding the flavor, taste, color and overall acceptance.

5.2 Recommendations:

- The pigeon pea incorporation in processed meat products is recommended to increase the protein and fiber content and to decrease the cost.
- Further studies are needed to adopt the percent of pigeon pea in processed meat products.

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APPENDICES

Appendix 1: Effect of treatments on sensory characteristics of burger before storage (0day)

Parameters	Treatment 1	Treatment 2	Treatment3
Color	5.96	4.36	2.12
Taste	6.15	4.15	3.18
Flavor	6.11	4.71	3.27
Texture	4.01	5.04	6.11
Juiciness	4.19	5.28	6.39
Overall acceptance	6.25	4.39	3.68

Treatment 1: 100% beef meat.

Treatment 2: 75% beef meat, 25% cooked pigeon pea.

Treatment 3: 50% beef meat, 50% cooked pigeon pea.

Appendix 2: Effect of treatment on sensory characteristics of burger after storage (3weeks)

Parameters	Treatment 1	Treatment 2	Treatment3
Color	5.89	4.22	2.08
Taste	6.04	4.05	3.07
Flavor	5.72	4.61	3.13
Texture	3.73	4.77	6.13
Juiciness	4.04	5.21	6.12
Overall acceptance	6.08	4.23	3.12

Treatment 1: 100% beef meat.

Treatment 2: 75% beef meat, 25% cooked pigeon pea.

Treatment 3: 50% beef meat, 50% cooked pigeon pea.