Evaluation of Unripe Papaya (*Carica papaya* L.) Fruits as Beef Tenderizer

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October, 2015
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**Date of Examination:** 30/10/2015
DEDICATION

To My Lovely Country, Sudan.

My Teachers,

To the Soul of my late Mother

To My Father

To My Brothers and Sisters

To My Friends

I dedicate this piece of work

Husna
ACKNOWLEDGMENT

Above all, I render my thanks to the merciful "Allah" who offered me health and patience to accomplish this study.

I would like to express my grate appreciation to my main supervisor Prof. Hyder Osman Abdalla for this valuable and constructive suggestions during the planning and development of this research. I am also grateful to my Co. supervisor Dr. Fawgia Sir Elkhatim Siddig for giving me her time. I am grateful to Dr. Siddig Eisa Idris for helping in the statistical analysis of the results. I would like to thanks the staff of meat laboratory. I am grateful to the administration of prisons and rehabilitation of Gezira state for giving me this opportunity. I would like to extend my thanks to my family and my friends.

Last but not least, my thanks go to every one, who contributed to this work.
Evaluation of Unripe Papaya (*Carica papaya* L.) Fruits as Beef Tenderizer

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**Abstract**

Meat tenderness is a highly desired quality trait in meat, that affect both acceptability and palatability. The objective of this study was to test the effectiveness of unripe papaya fruits as meat marinade. Two muscles (costa oculus and semitendinosus) of three beef carcasses were used. Nine unripe papaya fruits were collected and prepared in three forms (powder, extract and slices). One kg of each muscle from each carcass was used. Four slices were cut from each muscle (each weigh 200 g and 2.5cm thick). Three incisions were made on the surfaces of the slices. Each slice was assigned for each treatment (four treatments). Two g of the powder form were scattered on the surface of each slices assigned for powder treatment. Two ml of the fruit extract were sprayed on the surface of the slice assigned for extract treatment. Nine thin fruit slices were stuffed in the incisions of the slices assigned for slices treatment and removed before cooking. The treated slices were wrapped in aluminum foil and left for one hour before cooking. Little salt was added to each slice and the cooking trays were rubbed with thin layer of vegetable oil. The cooking was done in an electric kitchen oven at 200˚C for one hour. The cooked slices were cut into small pieces of 10 g. Six trained panelists evaluated the sensory traits (tenderness, taste and flavor) plus the number of chewings in each day (three days). The results showed a positive effect of the different forms of papaya fruits on the different traits compared with the control. There was a significant difference (P ≤ 0.05) in tenderness among the different treatments, with powder form had the highest effect followed by the slices and extract forms. Although there was no significant difference in the number of chewings due to different treatments, but still, there was a negative effect of the different forms of papaya fruits on the number of chewings compared with the control. There was no significant difference in other sensory traits among the different treatments. For high tenderness in tough meat cuts, it is recommended to use unripe papaya fruit powder.
تقييم ثمار الباباي غير الناضجة كمطري لللحوم الأبقار

(Carica Papaya L.)

حسين جمعه محمد حسب الله

ملخص الدراسة

تعتبر الطراوة من الصفات المرغوبة جداً في اللحوم والتي لها تأثير كبير على درجة قبول واستساغة اللحوم. الهدف من هذه الدراسة هو اختبار كفاءة ثمار الباباي غير الناضجة كمطري للحوم الأبقار. تم اختيار عضلاتين (عضلة البانكو والعضلة العينية) من ثلاث ذبائح من الأبقار (نسبة يوميا). تم جمع تسعة من ثمار الباباي غير الناضجة حيث تم تجيهزها في ثلاثة أشكال (مسحوق جاف، عصير وشرائح). تم شراء واحد كيلوجرام من كل عضلة من كل ذبحة. تم قطع إلى أربعة شرائح من كل عضلة (وزن 200 جم ومسك 2.5 سم) وتم تخصيص شريحة لكل معاملة (اربعة معاملات). تم قطع ثلاثة فتحات على سطح كل شريحة. تم نثر 2 جرام من مسحوق ثمرة الباباي على شريحة كل شريحة معدة لمعاملة المسحوق كما تم إضافة 2 مل من العصير على شريحة كل شريحة معدة لمعاملة العصير. بينما تم حشو تسعة من رقائق ثمرة الباباي في الفتحات على سطح كل شريحة لحم معدة لمعاملة الرقائق. بعد ذلك تم لف الشرائح المعاملة برقائق الألمنيوم وترك لمدة ساعة قبل أن تطبخ. قبل الطبخ تم إضافة القليل من الملح. كما تم مسح صواني الفرن بطبقة رقيقة من زيت الطعام. استمر الطبخ لمدة ساعة في درجة حرارة 200م. تم تقطيع الشرائح المطبوخة إلى قطع صغيرة وزنة 10 جرام. شارك في تقييم الصفات الحسية والذي شملت الطراء، المذاق والنكهة بالإضافة إلى عدد الضغط عدد ستة من المتلقيين في كل يوم (مدة ثلاثة أيام). أظهرت النتائج أن هناك تأثير إيجابي لاستعمال الأشكال المختلفة من ثمرة الباباي على كل الصفات الحسية وأيضاً على عدد الضغطات مقارنة بالشاهد. أظهرت النتائج وجود اختلافات معنوية إيجابية (P<0.05) في الطراء وسط المعاملات المختلفة حيث كان التأثير الأعلى لمسحوق ثمرة الباباي ثم الشرائح ثم العصير. للحصول على طراوة عالية في اللحوم غير طرية، يصبح استعمال مسحوق ثمرة الباباي غير الناضجة واحداً من الخيارات المتاحة التي يوصي بها.
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CHAPTER ONE
INTRODUCTION

Meat is the flesh of animals that can be used as food and it is essential for human growth and development, as it provides proteins, energy, vitamins, and some minerals, specially iron (Lawrie, 1991). The demand for meat is increasing with rapid growth of the world population and this is also applied to Sudan, which is mainly an agricultural country with large livestock population. The most important problem related to meat consumption is the lack of tenderness, especially in old animals meat.

Tenderness is one of the important quality attributes of meat (Pike et al., 1973). The toughness of the meat is resulted from the development of connective tissues especially collagen fibers in the meat. The collagen content in muscles is affected by several factors that include species, breed, sex of the animal, age, physical movement, handling and treatment of the meat after the slaughtering. The collagen rich animal muscles are generally tough, even under the most favorable ageing conditions (Bouton et al., 1977). Of all the attributes of eating quality of meat, tenderness is rated as the most important trait by consumers. There are several means of tenderizing meat either chemically or physically.

Treatment by proteolytic enzymes is one of the popular methods for meat tenderization (Koohmaraie et al., 1991). There are several enzymes of plant origin among which is papain enzyme from papaya trees.

Objective of the study:

The general objective is to evaluate the papaya fruit as meat tenderizer.

The specific objectives:

1. To evaluate the use of different forms of unripe papaya fruit as meat tenderizer.
CHAPTER TWO
LITERATURE REVIEW

2.1. Meat:

Meat is defined as the flesh of animal used as food (Lawrie, 1991). Meat and meat products are concentrated sources of high quality proteins, and their essential amino acids content usually compensate for deficiencies in diets made mainly of cereal and other vegetable proteins.

Meat is the food essential for human growth and development, as it provides proteins, energy, vitamins and some minerals, and this contributes to health and vigor (Lawrie, 1991).

2.1.1. Meat quality attributes:

Meat quality is described as combination of physical, structural and chemical characteristics, which result in maximum desirability from the stand point of appearance and eatability.

Meat acceptability and palatability is determined by the interplay of such factors as appearance, color, aroma and flavor, juiciness, and tenderness. These factors are affected by animal species, sex, age, various aspects of animal production, pre-slaughter and methods of cooking. Consumers equate an attractive bright red color with long shelf-life and good quality. Various approaches have been used to meet this expectation, (Hood and Mead, 1993).

2.1.1.1. Meat color:

The color of meat is a result of muscles myoglobin content and its chemical state as well as to hemoglobin content. Muscle pH affects meat color which becomes bright at pH 5.6 and dark above 6.5 (Lawrie, 1991).

Meat color is affected markedly by stress, age, sex, breed and nutrition, (Preston and Willis, 1974). Meat which is in the process of losing its freshness, no longer shows a bright red color, even when intensively exposed to the air, because of the partial destruction of the red meat pigments which result in a grey, brown or greenish color. Once these conditions occur the consumer has to decide, after carefully checking the appearance, together with testing smell and taste, whether the meat has to be discarded as a whole or whether use can be made of some parts which so far have not been altered (http://fao.org/docrep, 2000).
2.1.1.2. Meat tenderness:

Tenderness is the most important single characteristic influencing the acceptability of meat, mainly affected by age. Many workers reported that meat becomes less tender as animal age increase (Bailey et al., 1974). Tenderness is the most important palatability attribute. Sensory perception of texture depends on the deformation resulting from the application of pressure and to surface properties such as toughness, smoothness or stickiness estimated by the sense of touch (Yatman, 1972).

2.1.1.2.1. Factors affecting texture and tenderness of meat:

Factors associated with meat texture have been classified according to time sequence which starts in the muscle of intact animal and continues through slaughter, rigor mortis, and aging, to cooking (Lawrie, 1991).

A. Pre-slaughter factors:

1. Connective tissue content:

   Tenderness of meat significantly related to the connective tissue component of the muscle (Jeremaih, 1981). The connective tissue that affect meat tenderness are those fibers composed the connective tissue proper, mainly the collagen, elastin and reticular, and since the muscle contains more collagen than elastin, and since muscle collagen is converted to gelatin on cooking, the amount of residual collagen rather than total connective tissue may be important.

2. Fat deposition:

   Fat occurs in meat as adipose tissue, (marbling and separable fat). Marbling is generally considered to be a desirable quality and is used as one of the criteria in grading of meat. There is a correlation between marbling and tenderness however, some researchers have detected no correlation (Dolezal et al., 1982).

B. Animal factors affecting tenderness:

1. Muscle size and location:

   Within any species, there is a considerable variation in tenderness among muscles. For example, tenderloin is much more tender than the fore-shank or heel of the round in beef. This difference is due in part to the amount of connective tissue in the various cuts. The tender loin usually has small amount of connective tissue compared with fore-shank or heel of the round. The amount of connective tissue
present is due to the function of the muscle in the live animal. The fore-shank and heel of the round are used quite heavily in locomotion (movement) and therefore have relatively large amount of connective tissue. Conversely, the tender-loin provides no support function in the animal and therefore has less connective tissue (Lawrie, 1991).

Another source of muscle-to-muscle variation in tenderness is in the amount of stretch or tension applied to each muscle while the carcass is being chilled. This stretching is due to the weight of the carcass and prevents shortening (contraction) of the muscle, which in turn results in more tender meat. The major muscles in the rib and the loin are stretched more during the chilling process than the major muscles in the round; therefore, cuts from the rib and loin are more tender than cuts from the round. This is the major reason that the tender loin is the most tender muscle in the carcass (internet: Rich and J. Epley, 1992).

2. Effect of breed on tenderness:

The mature size of the breed has a lot to do with tenderness. The large mature size breeds reach the desired level of fatness and hence the desired degree of marbling at older age compared with the small mature size breeds. The old age of large mature size breeds at slaughter affect adversely the tenderness of the meat beside the adverse effect of the muscle bundles and muscle fibers sizes. On the other hand the small mature size breeds are slaughtered at younger age which means tender meat (Lawrie, 1991).

3. Age of the animal:

The meat of young animals is tenderer than the meat of old animals because the protein breaking down enzyme system decrease as the animal gets older. Animal age affects both, the amount and the strength of the collagen fibers. The collagen fibers being few and easy to break in the young animal, and as the animal gets older, the number of the collagen fibers increase and become difficult to break due to the formation of too many strong bridges and bonds between the collagen fibers. Hence, the decrease in tenderness with increasing age may be attributed to the changing meat collagen, which is the main connective tissue protein found in the meat (Judge, et al., 1990).
4. Sex:

In general, male have less marbling fat than female, whereas, the castrated males have more marbling fat than corresponding sexually entire animal. Numerous studies had attempted to link bull meat toughness to high amount of connective tissue than that of steers. However, a strong relationship between myofibrillar proteolysis and meat tenderization has been reported in steer and heifers (Whipple et al., 1990).

5. Plane of nutrition:

It is obvious that a high plane of nutrition increase the percentage of intramuscular fat. Marbling fat tends to dilute the connective tissue an element of muscle in which it is deposited, and this may explain the greater tenderness of beef from well-fed animals with good quality feed (Kemp and Powel, 1971). They also reported that meat tenderness could be improved by feeding aged cows concentrates before slaughter. French et al., (1999) reported that inclusion of vit- D3 in the pre-slaughter diet of cattle increased tenderness by acceleration of postmortem tenderization.

C. Post-slaughter factors affecting tenderness:

1. Post-mortem glycolysis:

Rigor mortis, which usually takes place 24hours after slaughter, is characterized by a contraction of muscle fibers with an increasetoughening of meat. Other changes characteristics of rigor mortis are drop in pH, a conversion of glycogen to lactic acid, a loss of protein buffering capacity, a decrease in creatine phosphate, and breakdown of adenosine triphosphate (Lawrie, 1991).

The degree of myofibrillar contraction in muscle of normal ultimate pH is high , also the adhesion value was significantly increased in contracted fibers. The rate of post-mortem glycolysis has another effect on tenderness, where the sarcoplastic proteins are denatured and precipitated onto those of myofibrillar, the latter may also be denatured to some extent since they become less soluble in these circumstances. A more rapid decrease in pH at high temperature may rupture the lysosomal membrane, in which some cathepsins could hydrolyze specific myofibrillar proteins, also the combination of low pH and high temperature could promote an earlier release of Ca++ from the sarcoplasmic reticulum, thus activating calcium-dependent protease-1 which retains only 24 to 28% at 15°C. This enzyme hydrolyses those myofibrillar proteins that change with post-mortem storage. Rapid decline of pH
of early post-mortem has been suggested to be desirable because the combination of low pH and high temperature, is conducive to proteolytic activity and increased myofibrillar proteins solubility (Koohmaraie et al., 1991).

2. Conditioning:

Due to conditioning, the principle proteins of the myofibrillar, actin and myosin, are dissociated and myosin is extracted at high ionic strength. During post-mortem, conditioning, the proteins of myofibrillar and sarcoplasmic denature at varying degree (Judge et al., 1990).

3. Chilling:

More rapid chilling of carcasses may reduce shrinkage and chilling time. Use of more rapid chilling techniques however, may have an adverse effect on meat tenderness. Immediately after slaughter, many changes take place in muscle that result in contraction and stiffening of muscle known as rigor mortis (Judge et al., 1990).

4. Freezing:

Freezing rate plays small role in tenderness. This freezing increases the loss of juices which results in meat that is less juicy upon cooking, and therefore is usually perceived as being less tender. Miller et al., (1980) reported that lengthening of the period in frozen storage resulted in greater amount of thaw exudates and greater losses of extractable proteins.

5. Cooking:

As cooking progresses, the contractile proteins in meat become less tender, and the major connective tissue protein (collagen) becomes more tender, thus, for cuts that are low in connective tissue such as steaks and chops from the rib, cooking methods including frying, broiling, roasting are suitable.

Dry heat raises the temperature very quickly and the flavor of meat will develop before the contractile proteins have the opportunity to become significantly less tender. There is an increase in tenderness with increased solubilization of collagen in braising, but relative little softening despite increased collagen solubility on roasting (Pool, 1975).
D. Artificial tenderization:

1. Enzyme activity:

   As an alternative to the addition of proteolytic enzymes, meat can be artificially tenderized by stimulation of the muscles own proteolytic activity. Induced vitamin E deficiency would enhance the activity of the lysosomal enzyme (Taylor, 1974).

2. Blade tenderization:

   Blade tenderized meat has higher sensory panel score for overall tenderness and significantly reduced Warner-Bratzler value in cooked meat (Miller, 1975).

3. Carcass suspension:

   When beef carcasses were suspended horizontally during postmortem glycolysis, the sarcomere length in such muscle as psoas major and rectus femora's were greater, and toughness was less than when carcasses were suspended in a vertical position (Miller, 1975).

4. Application of sodium chloride:

   Tenderness of meat generally improved by the application of sodium chloride prior to cooking (Neer and Mandigo, 1980). They also reported that the addition of NaCl to either hot or cold deboned rolls significantly reduced the shear force values. The most tender treatment combination was cold de-boned meat with 15% NaCl.

5. Using of calcium chloride:

   It has been demonstrated that meat tenderness can be improved dramatically at day one postmortem by infusing the whole carcass or by injecting the carcass with CaCl$_2$ solution (Shackelford, 1991).

6. Pressure-heat treatment:

   Tenderization of meat by high pressure heat treatment has been reported by Macfarlane (1973) who found that brief exposure of pre-rigored meat to high pressure for few minutes at ambient temperature, produced marked drop in final shear force values.

7. Electrical stimulation:

   Low voltage electrical stimulation may increase meat tenderness by inflicting structural damage to muscle through induction of atitancic contractions (Takahashi et al., 1990). Also low voltage reduced sarcomere shortening in aged muscle, and this
may increase filament surface area and the accessibility of filament surface area to the proteolytic enzymes to muscle proteins and thereby increase tenderness (Eikelenboom and Nanni Costa, 1990).

The tenderizing effect of electrical stimulation had been attributed to variety of causes including the reduction or avoidance of effect of cold shortening (Chrystal and Hagyard, 1979), an acceleration of the ageing process (Elgasim and Alkanhal, 1992), increase activity of acid protease (Dutson et al., 1980), physical disruption of the myofibrillar structure (Savell et al., 1978), and alteration in the thermal stability of collagen (Judge et al., 1990).

2.1.1.3. Juiciness:

It ranks second to tenderness as a contributory factor of eatability. It is defined as the initial impression of wetness due to rapid release of meat fluid and the longer lasting effect brought about by the stimulating action of fat on the salivary gland (Lawrie, 1991).

2.1.1.3.1. Factors affecting Juiciness: (Lawrie, 1991)

1. Age:

Young animals have good quality meat which is juicier than the old animals which have poor quality meat.

2. Nutrition:

High plan nutrition results in more fat deposition and hence more juiciness.


The males will grow faster than the other two sexes, and at the same weight the females will contain more fat than the other sexes as the results of their hormonal type (Estrogen Vs Androgen). Androgen usually increases the synthesis of protein and decrease the deposition of fat. Estrogens on the other hands decrease the synthesis of protein and increase the rate of fat synthesis and deposition.

4. Species:

Species which have a relative higher content of fat tend to have higher level of juiciness (sheep Vs cattle).
2.1.1.4. Flavor and Aroma:

They are defined as the intrinsic quality of meat odors and taste, and can not easily be separated from each other. They are affected by cooking much more than any other component of eatability (Lawrie, 1991).

2.1.1.4.1. Factors affecting flavor and aroma:

All the factors affecting the juiciness will affect the aroma and the flavor of the meat. These factors include:

1. Age.
2. Sex.
3. Species.
4. Fat.

2.1.2. Nutritive value:

Nutritionally regarded, meat is a very good source of essential amino acids, and to a lesser extent of certain minerals. Although vitamins and essential fatty acids are also present, meat is not usually relied upon for these components in a well balanced diet (Lawrie, 1991).

Meat provides calories from fat, proteins and limited quantities of carbohydrates present (Judge et al., 1990). The lysine and sulfur amino acids contents of variety of meats are found to be as follows: lysine is constant between 0.51 and 0.57% and methionine plus cysteine between 0.21 and 0.26% (Bender, 1975). On nutritional bases alone, meat is vital to the diet.

Meat is one of the few foods which provide complete protein, as well as being rich source of such essential nutrients as iron, niacin and vitamin B₁₂ (Lawrie, 1991).

2.1.2.1. Protein:

Meat protein contains all the essential amino acids in the correct proportions required by the body. The quality of the protein in meat basically means that most of its amino acids can be used for protein synthesis and limits the amount burned as fuel. Meat proteins are largely those of the muscle and connective tissues. Although raw muscle contains 18-22% proteins, this content is quite variable in many meat products and varies inversely with the amount of fat. Amino acids are the basic building blocks of which all proteins are composed (Forrest, 1975). Further, there is evidence that the content of certain essential amino acids may differ at different parts of the carcass.
The amino acids content may be affected by processing (e.g. heat ionizing, and radiation) (Lawrie, 1991).

2.1.2.2. Lipids:

The lipids content of meat is generally the most variable component. The amount of lipids depends upon the cut of the meat. The lipids component that are of major concern, from a nutritional stand point, are the triglycerides, phospholipids, cholesterol and the limited quantities of the fat soluble vitamins (Forrest, 1975).

2.1.2.3. Vitamins:

Meat is generally an excellent source of the water insoluble B-complex group, and of the fat soluble vitamins A, D, E, and K but it is a poor source of the water soluble vitamin C (Forrest, 1975).

2.1.2.4. Minerals:

Lean meat is generally a good source of all minerals except for calcium, it is an especially good source of iron, nutrient that is essential for maintaining good health [hemoglobin and myoglobin] (Forrest, 1975).

2.1.2.5. Carbohydrate:

The main fuel used by the body during exercise is carbohydrates, which is stored in muscle as glycogen (form of sugar) (http://www.en.wikipedia, 2007). Glycogen is a multibranched polysaccharide of glucose that serves as a form of energy storage in animals. The polysaccharide structure represents the main storage form of glucose in the body. In human, glycogen is made and stored primarily in the cells of the liver and the muscles, and functions as the secondary long-term energy storage. Muscle glycogen is converted into glucose-6-phosphate by muscle cells, and liver glycogen can be metabolites to glucose for use throughout the body including the central nervous system. Carbohydrates constitute less than 1% of the weight of meat, most of which is present in the form of glycogen and lactic acid. Most meat is poor sources of carbohydrates (Forrest, 1975).

2.1.3. Chemical composition:

Meat is the post-mortem aspect of complicated biological tissue, the muscle. The chemical and biochemical composition of the muscle are affected by a large number of factors related to function. The most important of these are species, breed, sex, age, anatomic location of muscle, training or exercise and plane of nutrition. In
addition to these factors, pre-slaughter manipulation and environmental conditions before, during and after slaughtering are involved. In broad sense, the chemical composition of lean meat can be approximate to 75% water, 20% protein, 4% soluble non-protein substances and 3% fat (Lawrie, 1991).

2.1.4. Structure and Function of muscle as related to meat quality:

Surrounding the muscle as a whole is a sheath of connective tissue known as the epimysium. The inner surfaces of the later forms septa of connective tissue, which penetrate into the muscle and separate the muscle bundles, these separating septa constitute the perimysium.

The connective tissue around each fiber is called endomysium. The connective tissue proper consists of collagenous, elastic and reticular protein fibers embedded in an amorphous ground substance.

The adipose tissue generally consists of true fat to an extent of more than 90%. The fat of muscle, marbling, has a considerable content of phospholipids and unsaponifiable constituents, such as cholesterol.

The proteins in the muscle can be broadly divided into sarcoplasmic proteins, myofibrillar proteins and the structural or stromal proteins of connective tissue. The sarcoplasmic proteins differ in various parameters, including their relative susceptibility to denaturation (Bate-Smith, 1973). Myosin is the most abundant myofibrillar protein, which is built from two types of subunits, light (L) and heavy (H) meromyosine.

Since tenderness is determined by a set of morphological traits, it can be only point out the possible nature of the relationship between the structure and tenderness.

2.1.4.1. The thickness of muscle sheath: (connective tissues):

2.1.4.1.1. Endomysium:

Endomysium, means within the muscle, is a layer of alveolar connective tissue that ensheaths each individual muscle fiber, it also contains capillaries and nerves. It ensheaths the muscle fiber sheath call sarcolemma (Internet. Thomas, 1999).
2.1.4.1.2. Perimysium:

Perimysium is a sheath of connective tissue which groups muscle fibers into primary muscle bundles and the primary muscle bundles into secondary muscle bundles.

2.1.4.1.3. Epimysium:

Epimysium is a layer of connective tissue, which ensheaths the entire muscle (Internet. Thomas, 1999). It is composed of dense irregular connective tissues; it is continuous with fascula and other connective tissue wrapping the muscle, including the endomysium and perimysium. It is also continuous with tendons where it becomes thicker and collagenous. The epimysium also protects muscle from friction against other muscles and bones, (Internet. search, 2008).

2.1.4.2. Connective tissue proper:

The connective tissue proper consists of structure-less mass called the ground substance, in which the cells and extra cellular fibers include those of reticulin, collagen and elastin are embedded (Judge et al., 1990).

2.1.4.2.1. Collagen:

Collagen is the most abundant protein in the animal body and significantly influences meat tenderness. In most mammalian species collagen constitutes 20-25% of the total protein in the body. Collagen is the principal structural protein of connective tissue. Networks of collagen fibers are present essentially in all tissues and organs, including muscle. The distribution of collagen is not uniform among skeletal muscles, but the amount present generally parallels their physical activity. Muscles of the limbs contain more collagen than those of the back and consequently the former are less tender than the later (Judge et al., 1990).

2.1.4.2.2. Elastin:

Elastin is a much less abundant connective tissue protein than collagen. Elastin is rather a rubbery protein that is present through out the body in ligaments and in the walls of the arteries, as well as in the framework of number of organs including muscle. Elastin fibers are easily stretched and when tension is released, they return to their original length. The extreme insolubility of elastin is largely attributed to the high content of non-polar amino acids and to its desmosin cross links (Lawrie, 1991).
2.1.4.2.3. Reticulin:

Reticulin is composed of small fibers that form delicate networks around cells, blood vessels, neural structures and epithelium which hold them in place. During embryonic development, reticular fibers are the first to appear in the differentiation of loose connective tissue (Judge et al., 1990).

2.1.5. Types of meat:

Meat can be grouped into two large categories, red meats and white meats (Judge et al., 1990).

2.1.5.1. Red meat:

Red meat is a traditional terminology refers to meat which is red in color, while when cooked. Red meat includes the meat of many mammals and some fowls. Gastronomically red meat is dark-colored as contrasted with white meat. The exact definition varies by time, place and culture, but the meat of adult mammals such as cattle, sheep, goats, camels and game animals invariably considered red (Judge et al., 1990).

2.1.5.2. White meat:

White meat includes those of chicken, sea food and rabbit. The main determinant of the definition of the color of meat is the concentration of myoglobin in the muscle fibers, which is usually affected by age and physical activity. The white meat of chicken has under 0.05%; chicken thigh has 0.18 – 0.20%, pork and veal have 0.1 – 0.3%, young beef has 0.4 – 1.0% and old beef has 1.5 – 2.0% (Iowa, 2009).

2.2. The Papaya tree:

Papaya is dicotyledonous rapid growing tree. Its fruits are melon-like oval to nearly round, 15-50 cm long. Unripe fruits and the milky sap contain a papayaproteolytic enzyme known as papain which is similar to pepsin. Papain break down proteins by hydrolysis. It has been utilized for thousand of years in its native South America and in Southern Sudan. It is sold as a component in powdered meat tenderizers. This enzyme has ability to breakdown tough meat fibers and to hydrolyze the connective tissues (Villegas the world, 1997).

2.2.1. Origin and distribution:

Although opinions differ on the origin of papaya in Tropical America, it's likely that *carica papaya* originated in the low lands of Central America, from Mexico to Panama (Nakasone and Paull, 1998).
Papaya is widely distributed throughout the tropical and sub tropical areas of the world (Villegas et al., 1997). Classification of papaya has been changed over the years. The genus carica is a classified plant family.

**Scientific classification of papaya:**

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unranked</td>
<td>Angiosperms</td>
</tr>
<tr>
<td>Unranked</td>
<td>Eudicots</td>
</tr>
<tr>
<td>Unranked</td>
<td>Rosids</td>
</tr>
<tr>
<td>Order</td>
<td>Brassicales</td>
</tr>
<tr>
<td>Family</td>
<td>Caricaceae</td>
</tr>
<tr>
<td>Genus</td>
<td>Carica</td>
</tr>
<tr>
<td>Species</td>
<td><em>Carica. Papaya</em></td>
</tr>
</tbody>
</table>

Binomial name

*Carica papaya*

From encyclopedia (2009).

**2.2.2. Botanical description:**

Papaya is a dicotyledonous, rapid growing tree like herbaceous plants, with short life span (Cano et al., 1998). The papaya has a single or a branched stem which can attain a height up to nine meters, terminating with a crown of large leaves (Nakason and Paull, 1998). The main stem exhibit prominent leaf scars and it is 30-40cm in diameter (Purseglove, 1974). The leaves emerge directly from the upper part of the stem on nearly horizontal petioles, which is 30 to 105 cm long, hollow, succulent, green or more or less dark purple in color.

The life span of the leaf is four – six months. Both the stem and the leaves contain copious white milky latex (Morton, 1987). The papaya flowers occur in one of three sexual forms, male, female, or hermaphrodite. These forms are expressed in the plant flower (Chia and Richard, 2001). The papaya plant started to flower in July and the second flowering appeared in November. The number of days ranged from 238 to 248 to the first flowering and from 345 to 357 to the second flowering.

The fruit is melon like, oval to nearly round, some whatpyre form, or elongated club-shaped, 15-50 cm long, 10-20 cm in diameter and weighing up to 9 kg (Morton, 1987). According to Paull et al., (1997), fruit size ranges from 200 g to 10 kg, with flesh thickness ranging from 1.5 - 4 cm. Flesh color is greenish-white in
immature fruit, to pale- orange -yellow, salmon pink, or red, depending on cultivars, when ripe.

2.2.3. Enzymes of papaya tree:

There are two main enzymes that can be produced from papaya tree. These are papain and pectin (Paull et al., 1997).

2.2.3.1. Papain enzyme:

Papain is the main enzyme present in milky juice of the papaya tree, it is similar to pepsin and hence it catalyzed the breakdown of protein by hydrolysis. Papain is used in biochemical research involving the analysis of protein, in preparations of various remedies for indigestion, in tenderizing meat, and in enzyme action cleaning for soft contact lenses. It is used to shrink dissolve ruptured disks in certain kind of lumbar spine injures, and other wise as a digesting of protein (Encyclopedia Britannica, 2009).

2.2.3.2. Uses of papain:

Papain is used to dissociate cells in the first step of cell culture preparations. It is also used as an ingredient in various enzymatic debriding preparations, notably accuzyme. These are used in the care of some chronic wounds to clean up dead tissue. Papaya are also used to make salads, preserves, jellies, pies, sherbet, and juices. The seeds have a peppery taste and are sometimes used to make salads dressing. Unripe papaya are normally cooked and eaten as vegetable, like squash.

Papain can induce asthma and rhinitis and the related enzyme calpain can cause paralysis, numbing of the nerve centers and cardiac depression.

2.2.3.3. Pectin enzyme:

Pectin is used in jam and jelly making, papaya contains up to 2% of pectin, which may be extracted from the by-products of papaya canning (Williams et al.1980).

2.2.4. Location of papaya trees in Sudan:

The main locations of papaya tree in Sudan is in Blue Nile, Sennar, Ramash, Abassia and Senga (Elawad 1980).
2.2.5. Chemical composition of papaya:

The chemical composition of whole ripe papaya fruit, expressed on fresh weight basis is shown in table (2.1) the table indicates that the moisture content is 89.4%.

Table: (2.1): Chemical composition of papaya ripe fruit on (fresh weight basis).

<table>
<thead>
<tr>
<th>Common botanical name</th>
<th>Paw-paw, <em>carica papaya</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Arabic name</td>
<td>Papaya</td>
</tr>
<tr>
<td>Metabolizable energy (K,cal/100g)</td>
<td>37</td>
</tr>
<tr>
<td>Total carbohydrate%</td>
<td>7.9</td>
</tr>
<tr>
<td>Protein %</td>
<td>1.3</td>
</tr>
<tr>
<td>Fat %</td>
<td>0.0</td>
</tr>
<tr>
<td>Crude ash %</td>
<td>0.7</td>
</tr>
<tr>
<td>Crude fiber %</td>
<td>0.7</td>
</tr>
<tr>
<td>Calcium( mg/100g)</td>
<td>149</td>
</tr>
<tr>
<td>Iron (mg/100g)</td>
<td>3.6</td>
</tr>
<tr>
<td>Phosphorus (mg/100g)</td>
<td>6.0</td>
</tr>
</tbody>
</table>

Source: Elawad (1980).
CHAPTER THREE
MATERIALS and METHODS

The experiment was carried in the laboratory of milk and meat, Department of food science, Faculty of science technology, to test the effectiveness of different forms of unripe papaya fruits as beef tenderizers.

Two muscles, Semitendinosus (the Bianco) and Costa Oculus (the Rip-eye) of three different beef carcasses were chosen to test the effectiveness of the different treatments which include, three forms of unripe papaya fruits (slices, powder and extract) plus the control, in a complete randomized design.

3.1. Sources of papaya fruits:

The papaya fruits used in the experiment were collected from papaya trees found in Wad Madani city and Kosti city and some were bought from the vegetables and fruits market in Wad Madani city.

3.2. Collection of meat samples:

One kg of each of the two muscles, Bianco muscle (Semitendinosus) and Rip-eye muscle (Costa Oculus) of three beef carcasses were purchased from a meat shop in the local meat market in Wad Madani city. The meat samples collection was carried through three days. The two muscles samples of each carcass were collected in each day. The collected meat samples in each day were left in a deep freezer for overnight. Four similar slices (200g weight and one inch thick) were obtained from each muscle sample using a graded electrical saw on the next morning.

3.3. Collection and preparation of papaya unripe fruits forms:

Nine medium size fresh unripe papaya fruits were collected to be used in the experiment.

Three fruits were cut into thin slices and dried under the sun for three days and then minced into powder using a mincing machine and kept in a glass bottle till it was used. Three other fruits were cut into small pieces and blended with water in a ratio of 1:1. The mixture was left to set, the suspend was removed and the left over was sieved to separate the rest of the solids, transferred into a plastic jar and kept in a refrigerator till it was used latter. The last three fruits were cut into thin slices to be used as slices.
3.4. Preparation of meat samples and application of treatments:

Four incisions were made on the surface of each muscle slice. Papaya fruits slices were stuffed into the incisions on the surface of the meat slices assigned for fresh papaya fruit slices treatment. Two grams of dried unripe papaya fruits were spreaded on the surface of the meat slices assigned for the powder treatment. Meat slices assigned for papaya fruit extract received two mls of the prepared unripe papaya fruit extract. All treated meat slices of the two muscles were wrapped with aluminum foil and left for one hour before cooking. Just before cooking a little amount of table salt was added to all treated and untreated slices. The cooking trays were covered with thin layer of vegetable cooking oil.

3.5. Cooking of the experimental meat slices:

All the meat slices assigned for the different treatments were arranged on the cooking trays and covered with aluminum foil. The cooking of the meat slices was performed in a kitchen oven (mix grill apparatus, made in Turkey) at 200c for one hour. The meat slices were then removed from the oven. The cooked slices were then cut into small similar size pieces, of 10 gms each, to be used by the panelists for the evaluation of the treatments.

3.6. Questionnaire evaluation sheet:

A questionnaire evaluation sheet was designed to involve three sensory traits (tenderness, taste and flavor) plus the number of chewings. The evaluation scale of the sensory traits involved three grades; excellent, good, and acceptable which received sex, four and two points respectively. The points received by each sensory trait was calculated by multiplying the grade points by the number of the panelists who gave the grade.

The overall assessment for each treatment was calculated by adding the total points given for the all three traits. The number of chewings needed before the meat piece can be swallowed was recorded for each meat sample.

3.7. Evaluation procedure:

The small pieces of the two muscles slices of the four treatments were displayed on show trays. The two muscles were coded with A and B for Bianco and Rip-eye respectively, and the different treatments with different numbers (one through fore) (control treatment) A1,B1, (extract treatment) A2,B2, (powder treatment) A3,B3 and (slices treatment) A4,B4 respectively. Six trained panelists were involved in the
evaluation of the effect of the different treatments on the different sensory traits in each day.

3.8. The statistical analysis:

A Completely Randomized design (CRD) was used for the analysis of the data.

Differences among treatment means were compared using Duncan’s (1955) multiple range tests designed by Steel and Torrie (1980).

All statistical analysis was done using M STAT-C for perfect results probability 0.05.
CHAPTER FOUR

RESULTS and DISCUSSION

As seen in table (4.1) effect of different forms of unripe papaya fruits (powder, extract and slices) on the tenderness of two muscles (Bianco and Rip-eye) of three beef carcasses. The data showed that there was no significant difference in tenderness between the two muscles, but the Rip-eye muscle is a little bit more tender than the Bianco. The Rip-eye muscle tended to be more tender than the Bianco muscle and this may be attributed to their location, the Rip-eye is located on the back with less movement, while the Bianco is located on the upper part of the hind with more movement and hence more collagen fibers. Nevertheless, there was a very high significant difference (P<0.05) in tenderness between the different forms of unripe papaya fruits and the control. In general, there was a clear positive effect of unripe papaya fruits forms on tenderness. The powder form had the highest effect on tenderness (27.67), followed by the extract form (26.33) and slices form (26.00). These results may be due to the fact that the powder form contained the highest amount of the proteolytic enzyme of the papaya (Papain enzyme) compared with the extract form which subjected to dilution, or with slices. The slices had the lowest effect because they were removed before cooking while the other two forms were left on the meat samples during the cooking.

The data showed a significant difference (P<0.05) in tenderness due to the interaction between muscle types and the different forms of the unripe papaya fruits. The interaction between the BiancoX Powder form and the Rip-eye X extract had the highest effect on tenderness (30.67 and 29.33) respectively. The interaction of the muscle type and the different forms of papaya fruits had the same trend of the different forms alone. The results of the present study agreed with those reported by Nour Aldaim (poultry 2010) and Altigani (meat 2013).
Table(4.1): Effect of different treatments on tenderness of different muscles of beef carcass.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>F.value</th>
<th>Prob</th>
<th>Sig</th>
<th>LSD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Muscle type</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bianco</td>
<td>24.00</td>
<td>1.207</td>
<td>0.288</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Rip-eye</td>
<td>25.33</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Treatment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>18.67c</td>
<td>11.22</td>
<td>0.0003</td>
<td>***</td>
<td>1.348</td>
</tr>
<tr>
<td>Extract</td>
<td>26.33ab</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Powder</td>
<td>27.67a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slices</td>
<td>26.00b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Interaction between muscle type and treatment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bianco X Control</td>
<td>16.67e</td>
<td>4.68</td>
<td>0.0157</td>
<td>*</td>
<td>2.267</td>
</tr>
<tr>
<td>Bianco X Extract</td>
<td>23.33c</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bianco X powder</td>
<td>30.67a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bianco X Slices</td>
<td>25.33bc</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rip-eye X Control</td>
<td>20.67a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rip-eye X Extract</td>
<td>29.33a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rip-eye X powder</td>
<td>24.67bc</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rip-eye X Slices</td>
<td>26.67b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Prob: (Probability).
Sig: (Significance).
LSD: (Least Significant Difference).
Table (4.2) described the effect of different treatments on the taste of two muscles on three beef carcasses. The results showed that there was no significant difference in taste due to muscle type, however, Rib-eye muscle had relatively more taste, and this may be attributed to the presence of some marbling fat in the Rib-eye muscle compared to Bianco muscles which lack the presence of any fat.

Although there was no significant difference in taste among the different treatments, however, the powder form had the best taste among the different treatments. It is well documented that there is a high positive correlation between tenderness and taste, hence, as the powder form had a relatively positive effect on tenderness, it is also had a relatively positive effect on taste. The interaction between muscle types and treatments showed no significant difference nevertheless, the interaction between the Bianco X Powder and the Rip-eye X control had the highest level of taste followed by the interaction between the Rip-eye X Powder.

The interaction between muscle types and different treatments had the same trend of muscle types on taste and that of the different treatments on taste.
Table (4.2): Effect of different treatments on taste of different muscles of beef carcass:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>F.value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Muscle type</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bianco</td>
<td>24.67</td>
<td>0.0460</td>
</tr>
<tr>
<td>Rip-eye</td>
<td>25.00</td>
<td></td>
</tr>
<tr>
<td><strong>Treatment</strong></td>
<td></td>
<td>0.077</td>
</tr>
<tr>
<td>Control</td>
<td>25.00</td>
<td></td>
</tr>
<tr>
<td>Extract</td>
<td>24.33</td>
<td></td>
</tr>
<tr>
<td>Powder</td>
<td>25.33</td>
<td></td>
</tr>
<tr>
<td>Slices</td>
<td>24.67</td>
<td></td>
</tr>
<tr>
<td><strong>Interaction between muscle type and treatment</strong></td>
<td></td>
<td>1.364</td>
</tr>
<tr>
<td>Bianco X Control</td>
<td>22.67</td>
<td></td>
</tr>
<tr>
<td>Bianco X Extract</td>
<td>24.67</td>
<td></td>
</tr>
<tr>
<td>Bianco X powder</td>
<td>27.33</td>
<td></td>
</tr>
<tr>
<td>Bianco X Slices</td>
<td>24.00</td>
<td></td>
</tr>
<tr>
<td>Rip-eye X Control</td>
<td>27.33</td>
<td></td>
</tr>
<tr>
<td>Rip-eye X Extract</td>
<td>24.00</td>
<td></td>
</tr>
<tr>
<td>Rip-eye X powder</td>
<td>23.33</td>
<td></td>
</tr>
<tr>
<td>Rip-eye X Slices</td>
<td>25.33</td>
<td></td>
</tr>
</tbody>
</table>
Table (4.3) shows the effect of the different treatments on the flavor of two muscles of three beef carcasses. The results showed that there was no significant difference in flavor between the two muscle types, however, the Bianco muscle seems to have more flavor than the Rib-eye muscle. This result was unexpected because the flavor of the meat is related to the taste and both of them are affected by the same factors (fats, proteins and minerals). The data showed no significant differences in flavor among the different treatments, however, the papaya powder form showed the highest flavor. This result go along with the previous result on taste. The effect of interaction between muscle types and treatments on flavor followed the same trend of the effect of muscle types and that of the treatments. Although there was no significant difference in flavor among the different interactions, nevertheless, the Bianco \( \times \) powder interaction had the highest level of flavor, followed by the Rib-eye \( \times \) powder interaction.
Table (4.3): Effect of different treatments on flavor of different muscles of beef carcass:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>F.value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscle type</td>
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<td></td>
</tr>
<tr>
<td>Bianco</td>
<td>24.50</td>
<td>1.725</td>
</tr>
<tr>
<td>Rip-eye</td>
<td>22.33</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>23.00</td>
<td>0.418</td>
</tr>
<tr>
<td>Extract</td>
<td>22.67</td>
<td></td>
</tr>
<tr>
<td>Powder</td>
<td>25.00</td>
<td></td>
</tr>
<tr>
<td>Slices</td>
<td>23.00</td>
<td></td>
</tr>
<tr>
<td>Interaction between muscle type and treatment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bianco X Control</td>
<td>25.33</td>
<td></td>
</tr>
<tr>
<td>Bianco X Extract</td>
<td>22.67</td>
<td></td>
</tr>
<tr>
<td>Bianco X powder</td>
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</tr>
<tr>
<td>Bianco X Slices</td>
<td>23.33</td>
<td></td>
</tr>
<tr>
<td>Rip-eye X Control</td>
<td>20.67</td>
<td></td>
</tr>
<tr>
<td>Rip-eye X Extract</td>
<td>22.67</td>
<td></td>
</tr>
<tr>
<td>Rip-eye X powder</td>
<td>23.33</td>
<td></td>
</tr>
<tr>
<td>Rip-eye X Slices</td>
<td>22.67</td>
<td></td>
</tr>
</tbody>
</table>
As seen in table (4.4) effect of the different treatments on the number of chewings needed for the different muscle types of beef carcass. The results showed that there was no significant difference in the number of chewings according to the type of muscle, however, the average number of chewings needed by the Bianco muscle was more than that needed by the Rip-eye muscle, this may be attributed to the level of tenderness of the two muscles, the Rip-eye muscle is more tender and hence needed less chewings before being swallowed.

The results also showed that there were no significant differences in the number of chewings due to the different treatments, nevertheless, the powder form had the lowest number of chewings, while the control had the highest number of chewings. All the different muscles treated with papaya fruits had less number of chewings compared with the control. The results reflected the influence of the different forms of unripe papaya fruits on the level of tenderness of the different muscles. Although there was no significant differences in the number of chewing’s among the different interactions between the type of muscles and the different treatments. The results showed that the general trend of the muscles and treatments in the number of chewings was recognized in the interactions and hence the interaction between the Rip-eye muscles X powder form had the lowest number of chewings. While the highest number of chewings was observed in the Bianco muscle X control interaction, followed by the Rip-eye muscle X control interaction.
Table (4.4): Effect of different treatments on number of chewings of different muscles of beef carcasses:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>F.value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Muscle type</strong></td>
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</tr>
<tr>
<td>Bianco</td>
<td>40.67</td>
<td></td>
</tr>
<tr>
<td>Rip-eye</td>
<td>38.25</td>
<td>0.213</td>
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<tr>
<td><strong>Treatment</strong></td>
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</tr>
<tr>
<td>Control</td>
<td>52.17</td>
<td></td>
</tr>
<tr>
<td>Extract</td>
<td>37.50</td>
<td>2.757</td>
</tr>
<tr>
<td>Powder</td>
<td>32.67</td>
<td></td>
</tr>
<tr>
<td>Slices</td>
<td>36.50</td>
<td></td>
</tr>
<tr>
<td><strong>Interaction between muscle type and treatment</strong></td>
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</tr>
<tr>
<td>Bianco X Control</td>
<td>53.33</td>
<td></td>
</tr>
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<td>Bianco X Extract</td>
<td>39.33</td>
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</tr>
<tr>
<td>Bianco X powder</td>
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<td>Bianco X Slices</td>
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<tr>
<td>Rip-eye X Control</td>
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<td>Rip-eye X Extract</td>
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</tr>
<tr>
<td>Rip-eye X powder</td>
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<tr>
<td>Rip-eye X Slices</td>
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</table>
CHAPTER FIVE
CONCLUSIONS and RECOMMENDATIONS

5.1. Conclusions:

1. The different forms of unripe papaya fruits had a positive effect on the different sensory traits under study except the taste of rip-eye.
2. Among the different forms of unripe papaya fruits, the powder form had the highest effect on the tenderness and other sensory traits.
3. Different forms of unripe papaya fruits had a negative effect on the number of chewings which can be taken as an indication of positive effect of tenderness.

5.2. Recommendation:

Powder form of unripe papaya fruits can be used effectively to increase the level of tenderness of tough meats and to improve the sensory traits of the meat.
REFERENCES


Internet Definition "Epimysia" from the freedictionary.com "reviewed 2008-05-29.


Appendices

Appendix (1):

A questionnaire about the factors affecting the tenderness of meat

1. Age: < 20 years ( ) 20-30 years ( ) 30-40 years ( ) > 40 years ( )

2. Gender: Male ( ) Female ( )

3. Occupation: Student ( ) Personal ( ) Labor ( ) House wife ( )

4. What is the most tender ruminant animal?
   
   Camel ( ) Cattle ( ) Sheep ( ) Goats ( )

5. Which is the most tender type of meat?

   Red meat ( ) White meat ( )

6. Which is more tender?

   Old animal meat ( ) Young animal meat ( )

7. Which carcass cuts are more tender?

   Back muscles ( ) Leg muscles ( )

8. How could we improve tenderness of tough meat?

   Cutting ( ) Cooling ( ) Addition of weak acids ( ) Addition enzymes ( )

9. What do you use for tenderizing the roasting meat?

   Lemon ( ) Vinegar ( ) Papaya ( )
10. Do you have any idea about using papaya as meat tenderizer?

Yes (  )       No (  )

11. What part of papaya tree do you use for tenderizing meat?

Ripe fruit (  )  Unripe fruit (  )  Leaves (  )  Stem (  )

12. In what form do you use the different papaya parts as meat tenderizer?

Fresh (  )  Extract (  )  Powder (  )

13. What is the nature of the active ingredient in papaya fruits?

Acid (  )  Enzyme (  )  Hormone (  )

14. What is the suitable time after treatment and before cooking?

Hours (  )  2 Hours (  )  3 Hours (  )

15. Is there any negative effects of using papaya products?

Yes (  )  No (  )
Appendix (2):

**Questionnaire about the effect of different forms of unripe papaya fruit on some quality attributes of beef.**

<table>
<thead>
<tr>
<th>Trait</th>
<th>Tenderness</th>
<th>Taste</th>
<th>Flavor</th>
<th>Number of chewing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Excellent</td>
<td>Good</td>
<td>Acceptable</td>
<td>Excellent</td>
</tr>
<tr>
<td>Evaluation Sample</td>
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<tr>
<td>Bianco X control</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Rip-eye X Slices</td>
<td></td>
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</tr>
</tbody>
</table>

Excellent:(6) points.
Good:(4) points.
Acceptable: (2) points.
Plate

Plate (1):

*Flowers of papaya*

Plate (2):

*Female flowers of papaya tree*

Plate (3):

*Male flowers of papaya tree*
Plate (4):

Tree of un Ripe papaya fruits
Plate (5):

Collection of unripe papaya fruits

Plate (6):

Preparation of unripe papaya fruits
Plate (7):

Preparation of Rip-eye lean meat

Plate (8):

Preparation of Bianco lean meat