IMPROVEMENT OF PUMPKIN (*Cucurbita pepo*) JAM BY ADDITION OF DIFFERENT PERCENTAGES OF GODEIM (*Grewia tenax*)

By

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Collage of Agricultural Studies
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1998

A Dissertation Submitted to the University of Khartoum in partial fulfillment of the Requirement for the Degree of MSc. in Food Science and Technology

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June 2007
Dedication

To the soul of my father—be it in higher paradise
To my dear mother
To my loved brothers
To my loved sisters … nieces, nephews

***************

I dedication this work with love and respect

Gada
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTENTS</td>
<td>I</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>V</td>
</tr>
<tr>
<td>LIST OF FIGUERS</td>
<td>VI</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENT</td>
<td>VII</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>VIII</td>
</tr>
<tr>
<td>ABSTRACT (Arabic)</td>
<td>X</td>
</tr>
<tr>
<td>CHAPTURE ONE: INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>CHAPTURE TWO: LITERATURE REVIEW</td>
<td>4</td>
</tr>
<tr>
<td>2.1 Godeim</td>
<td>4</td>
</tr>
<tr>
<td>2.1.1 Scientific and common names of Godeim</td>
<td>4</td>
</tr>
<tr>
<td>2.1.2 Botanical description</td>
<td>5</td>
</tr>
<tr>
<td>2.1.3 Distribution</td>
<td>6</td>
</tr>
<tr>
<td>2.1.4 Benefits and uses of Godeim in Sudan</td>
<td>7</td>
</tr>
<tr>
<td>2.1.5 Chemical composition of Grewia tenax fruit (Sudan sample)</td>
<td>8</td>
</tr>
<tr>
<td>2.2 Pumpkin</td>
<td>9</td>
</tr>
<tr>
<td>2.2.1 Scientific names of Cucurbita species</td>
<td>9</td>
</tr>
<tr>
<td>2.2.2 Agro ecology</td>
<td>9</td>
</tr>
<tr>
<td>2.2.3 Botanical description</td>
<td>9</td>
</tr>
<tr>
<td>2.2.4 Chemical composition of pumpkin</td>
<td>10</td>
</tr>
<tr>
<td>2.2.4.1 Carbohydrates</td>
<td>11</td>
</tr>
<tr>
<td>2.2.4.2 Fats</td>
<td>12</td>
</tr>
<tr>
<td>2.2.4.3 Ash</td>
<td>12</td>
</tr>
<tr>
<td>2.2.4.4 Crude fiber</td>
<td>13</td>
</tr>
</tbody>
</table>
3.2 Methods ........................................................................................................... 29
3.2.1 Procedure of jam making ................................................................. 29
3.2.1.1 Preliminary treatment ................................................................. 29
3.2.1.2 Jam processing ............................................................................ 31
3.2.2 Physiochemical and proximate assessment ........................................ 31
3.2.2.1 Total soluble solids ................................................................. 31
3.2.2.2 pH measurement ........................................................................ 31
3.2.2.3 Total acidity ............................................................................. 32
3.2.2.4 Total sugars and reducing sugars ............................................... 32
3.2.2.5 Moisture content ................................................................. 34
3.2.2.6 Crude protein content ............................................................... 34
3.2.2.7 Crude fiber content ................................................................. 35
3.2.2.8 Fat content ............................................................................. 36
3.2.2.9 Ash ......................................................................................... 36
3.2.2.10 Determination of iron content ................................................... 37
3.2.2.11 Food energy determination ....................................................... 37
3.2.2.12 Sensory evaluation ................................................................. 38
3.2.2.13 Statistical analysis ................................................................. 38
CHAPTER FOUR: RESULTS AND DISCUSSION ........................................... 39
Part one ........................................................................................................... 39
4.1.1 Analytical specification ..................................................................... 39
4.1.2 Effect of different formulae in acidity contents ................................. 40
Part two .......................................................................................................... 42
4.2 Nutritional evaluation ........................................................................... 42
Part three ....................................................................................................... 49
4.3 Sensory evaluation .............................................................................. 49
CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATION .............. 51
5.1 Conclusions ........................................................................ 51
5.2 Recommendation .................................................................. 52
Appendix ....................................................................................... 53
1 Food Energy .............................................................................. 54
2 Panel Test Table ....................................................................... 54
REFERENCES ............................................................................... 55
<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Detection of total soluble solids by Refractometer or thermal way ..........</td>
<td>24</td>
</tr>
<tr>
<td>2</td>
<td>The formulae of Pumpkin, Pumpkin mixed with Godeim and Godeim jams ..........</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>Physiochemical analysis of Pumpkin, Pumpkin mixed with Godeim and Godeim jams</td>
<td>41</td>
</tr>
<tr>
<td>4</td>
<td>Chemical composition of Pumpkin, Pumpkin mixed with Godeim and Godeim jams</td>
<td>45</td>
</tr>
<tr>
<td>5</td>
<td>Iron content of Pumpkin, Pumpkin mixed with Godeim and Godeim jams ..........</td>
<td>46</td>
</tr>
<tr>
<td>6</td>
<td>Nutritional components in Pumpkin, Pumpkin mixed with Godeim and Godeim jams and market Pumpkin jams samples</td>
<td>47</td>
</tr>
<tr>
<td>7</td>
<td>Organoleptic scores of Pumpkin, Pumpkin mixed with Godeim and Godeim jams</td>
<td>50</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Energy values of Pumpkin, Pumpkin mixed with Godeim and Godeim jams</td>
<td>48</td>
</tr>
</tbody>
</table>


ACKNOWLEDGEMENT

All thanks are due to my God Allah, who provides me with health and strength and help me throughout this study.

My deepest sincere thanks and gratitude gave to my supervisor Dr. Hassan Ali Mudawi, for his continuous keen and guidance throughout the term of study.

I would like to express my great thanks to all staff of the Department of Food Science and Technology, Faculty of Agriculture, University of Khartoum for support and assistance.

My deeply thanks gave to Prof. Abdel Halim Rahama (FRC), for advice, keen and helpful with Knowledge.

My deeply indebted gave to Mr. Mohammd Abd Elaziz and Mr. Alamin Abd Almajeed from (Saeed factory for food manufacture), for their helpful and support with knowledge and skills.

All my thanks gave to mother and all members of family, especially Salah and Mohammed for their encouragement that led to obtain this degree and financial support.

Words can not express the deep thank and appreciation to my friends and all those loved me, especially Salwa and Frdoos for help and encouragement.
ABSTRACT

One of the most important aims of this research work is to study the possibility of the production of natural jam from pumpkin pulp, Godeim juice, sugar, pectin and acid, without addition of any other artificial color or flavor. Also an attempt for fortification of pumpkin jams by nutritive components from Godeim. The analytical study was carried out for four mixtures samples in percentages: 80: 20, 60: 40, 40: 60, 20: 80 (Godeim: pumpkin), beside Pumpkin jam and Godeim jam as control.

First, the physiochemical analysis was carried out to determine pH, total soluble solid, and invert sugar, to assess the quality according to Sudanese specification of jam (SSMO, 1989). The obtained results can be summarized as follows pH 3.1- 3.3, total soluble solids 67- 69°Brix, invert sugar 26.40-27.30%. Chemical analysis of samples was carried out to determine the nutritive value of jams and the results showed a gradual, significant (p ≤ 0.05) increase in the following parameters: ash in range of 0.64 to 4.32%, fat in range of 0.07 to 0.28%, fiber in range of 0.36 to 0.46%, carbohydrate in range of 23.06 to 28.93%, protein was found in highly significant (p ≤0.01) increase in range of 0.9 to 5.98%, also iron content was found in highly significant
(p ≤0.01) increase in range of 0.97 to 6.80 mg/kg. These results confirmed that jam can be source of nutritive components. Sensory evaluation results showed that panelists confirm at that samples of jams having higher amount of Godeim was best in the parameters color, flavor, taste (sweetness), consistency and overall acceptability.
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١. أداة الرجولة السماوية

٢. أدمج تدفق ضياء

٣. أداة الرجولة الصغرية

٤. أدمج تدفق ضياء

٥. أداة الرجولة الصغرية

٦. أدمج تدفق ضياء

٢:١

٨. أداة الرجولة الصغرية

١٠. أدمج تدفق ضياء

٨١. أداة الرجولة الصغرية

٩. أدمج تدفق ضياء

٢٥. أداة الرجولة الصغرية

٣٠. أدمج تدفق ضياء

٥٠. أداة الرجولة الصغرية

٨٠. أدمج تدفق ضياء

١٠٠. أداة الرجولة الصغرية

٢٠٠. أدمج تدفق ضياء

٣٠٠. أداة الرجولة الصغرية

٤٠٠. أدمج تدفق ضياء

٥٠٠. أداة الرجولة الصغرية

٦٠٠. أدمج تدفق ضياء

٧٠٠. أداة الرجولة الصغرية

٨٠٠. أدمج تدفق ضياء

٩٠٠. أداة الرجولة الصغرية

١٠٠٠. أدمج تدفق ضياء

١٠٠٠٠. أداة الرجولة الصغرية

٢٠٠٠٠. أدمج تدفق ضياء

٣٠٠٠٠. أداة الرجولة الصغرية

٤٠٠٠٠. أدمج تدفق ضياء

٥٠٠٠٠. أداة الرجولة الصغرية

٦٠٠٠٠. أدمج تدفق ضياء

٧٠٠٠٠. أداة الرجولة الصغرية

٨٠٠٠٠. أدمج تدفق ضياء

٩٠٠٠٠. أداة الرجولة الصغرية

١٠٠٠٠٠. أدمج تدفق ضياء
CHAPTER ONE

INTRODUCTION

The jam is very important commodity in the trade of most countries and is<br>widely consumed in ever-increasing quantities especially by children.<br>Jam making is still one of the most important methods for preserving fruits and<br>some vegetables. These are made by boiling fruit or fruit pulp with sugar and<br>water until the mixture sets to a jelly on cooling.<br>Jams comprising jams, marmalades, jelly jams, and jelly marmalades which are<br>basically, sugar-pectin gels containing either fruit or fruit juice, without<br>retaining the shape of the fruit (Herschoerdor, 1972). This is made from<br>practically all varieties of fruits. Which may be prepared from a single fruit or<br>combination of two or more fruits, dried, canned fruits or preserved pulps may<br>also be used.<br>Most of important jams are manufactured from stone fruits such as apples and<br>apricots or soft fruits for example strawberries fruits which may not be grown<br>commercially under Sudan conditions. Therefore increase the need of utilization<br>of locally available agriculture and forest fruits into jam. In Sudan several<br>savanna trees yield edible fruits i.e. Aradib (Tamarindus indica), Dom<br>(Hyphaene thebaica), Gunguleis (Adansonia digitate), Nabag (Ziziphus
spinachrisiti), Gudeim (Grewia tenax) these fruits are extensively used as a diet for rural people, these fruits have an exceedingly wide range of uses i.e. food source, beverages and medicinal uses. They are rich of proteins; vitamins and minerals so they ensure food and nutritional security (Mohamed, 2004). Gudeim have been traditionally applied as chilled unpasteurized fruits juice, prepared by cleaning the fruit, soaking overnight pressing or blending, sieving and sweeting, other application of Gudeim is the manufacture of porridge called Nesha, this is prepared from the juice by addition of custard and flour (Mohamed, 2004).

Pumpkin is cheap vegetable grown in many parts of Sudan especially during the rainy season. Most of pumpkin pulps are consumed locally when cooked with meat and tomato (Mulah), but recently pumpkin pulp have various applications i.e. pie filling, nectar and jam making, because it has good properties, bright color, sweet taste and needs less amounts of pectin when used for jam making .(El -Shafie, 1981).

Excellent jam could be manufacture from pumpkin which is produced and developed by Food Research Centre (FRC) scientists.

Gudeim can be mixed with pumpkin to make jam with high nutritive value and good chemical and physical characteristics.
Objectives of the research:


2. Variation extending the scope of possible local ingredients which can be utilized in jam – making.
CHAPTER TWO
LITERATURE REVIEW

2.1 Godeim

2.1.1 Scientific and common names of Godeim plant

According to Westermier and Kraus (1999), the scientific name of Godeim is *Grewia tenax* (Forssk.) Fiori under the family Tiliaceae.

Sudanese investigators (Eltohami 1998, Abdelmuti 1991, Elsiddig 2002) agreed on the scientific name *Grewia tenax* (forssk.) Fiori, those investigators reported slightly different local names i.e. Godeim (Abdelmuti 1991), Gaddeim (Eltohami 1998), and (Elsiddig 2002) reported the local name is Gudeim, and other Arabic names Godem, Gaddein, Gaddeim and ummageda however common name in Africa are Damak, Defarur, Dekah and Duferu in Somali.

Since Godeim is the most commonly used name in Sudan we will use it throughout this text.

Westermier and Kraus (1999) reported the following species of the genus *Grewia* among the famine foods of the family Tiliaceae:

*Grewia asiatic, Grewia microcos, Grewia oppositifoli, Grewia pilosa,
Grewia villosa, Grewia tiliaefolia, Grewia tenax.*
2.1.2 Botanical description

VonMally, (1986) and El-Amin, (1990), reported that members of the genus *Grewia* are shrubs of mean height between 2-3 m bark is dark – brown to grey with smooth, and the branches are brown with white lenticels.

El -Amin, (1990) reported that *Grewia tenax* shrubs, sometime scrambling, up to 3m high, bark is dark or brown to grey, smooth. Branches are dark brown with white lenticels. Leaves broadly ovate or cordate or bicular, 2- 5 ×3.5cm, sparingly stellate – pubescent beneath; petioles slender, up to 1.25cm long. Inflorescence solitary, axillary, or a pair; flowers white or yellow, scented; sepals 5; base nectaris 1.2 – 1.8cm long enlarged above to a board hair scale exceeding the width of the petal claw. Fruit is fleshy, sweet scented, orange red color, about 1.25cm across, 1 to 4 lobed, shiny, and glabrous. Flowers Nov. to July; fruits Dec. to July. Leaves are alternate, sample, stipules present or absent (Andrews, 1956). Elsiddig (2002) reported that Godeim tree is a tropical bush tree, up to 2m high, with rounded pendulous fruit 5 to 10 mm across. The wood is hard and durable, Vogt Kess (1995) reported that *Grewia* plant propagation by seeding. Tree fruits are grouped into deciduous and ever green (Desroseir, 1977).

The fruit defined as ripened ovaries of a flower; the edible portion is usually the fleshy covering over the seeds, pendulous fruit, and 5 to 10 mm across. Fruit
change gradually from green to red when quite ripe. The fruit is shiny, fleshy, sweet- scented, orange and red color when ripened, in the size of maize kernel, glabrous edible (VonMaydell, 1990)

2.1.3 Distribution

Grewia tenax is highly drought resistant and occurs in the driest savannas at desert margins and regions of higher rainfall, where it grow in thick on termite mounds, otherwise in seasonally flooded country, in the sahel it grows in rocky places on hill sand slopes (Elsiddig, 2002).

In Sudan Grewia tenax distribution on sandy soil and on rocky ground in the dry grass savanna, in Red sea hills, North and central Sudan (Bule Nile, White Nile, Kassala, Khartoum), Kordofan, upper Nile, Bahar Elgazal and Equatorial states (El-Almin, 1990). Abdelmuti, (1991) is found in rocky, sandy depressions, dunes, and clay and temporary pools.

The genus Grewia comprises about 150 species growing in Africa (Willis, 1973). Grewia species widely distributed in the tropical and subtropical areas of Africa, Asia and Australia they are rarely found in the temperate regions. They are of discontinuous distribution, being found in the arid zone of Morocco, Mauritania, Senegal to India, Sudan, Chad, Botswana, Ethiopia, Mali, Tanzania, Namibia, Niger, Nigeria, Algeria, Saudi Arabia (FAO, 1988).
VoyMaydell, (1990) also are founded in Kenya, Somali and grow exotically in Pakistan and India.

2.1.4 Benefits and Uses of Godeim in Sudan

Elsiddig (2002) reported that Godeim fruit is eaten fresh or dried for later consumption. The firm, fleshy layer surrounding the stone is edible and is relished out- of- hand by children and adults.

*Grewia tenax* trees are considered as one of several savanna trees that yield edible fruits. These fruits are widely used in rural people diet; they provide their consumers with useful nutrients (Gebauer *et.al*. 2002).

Abdelmuti, (1991) reported that godeim fruits are eaten fresh or used in juice-making. Prepare juice by soaking the fruits overnight then pressing, sieving and sweetening (Mohamed, 2004).

Native people use godeim to improve hemoglobin level, to cure malaria and anemia, and a light boridge called ‘Nesha’ is used for feeding lactating mothers to improve their health and breast feeding abilities, and also used as a famine and snack food (Abdelmuti, 1991; Khurdiya and Waskar, 1993).

Eltohami (1998) includes the Godeim in the list of the medicinal and aromatic plants of Sudan.

*Grewia tenax* is regarded as one of India famine foods and that it has an acrid taste as orange fruit usually eaten raw (Elsiddig, 2002).
2.1.5 Chemical composition of *Grewia tenax* fruit (Sudan sample)

Chemical composition of *Grewia tenax* fruit (Sudan sample) on dry base was reported by Abdelmuti, (1991) who found that protein, Fat, Fiber, Ash, Carbohydrate, Sucrose, D- Glucose and D- Fructose are 6.3%, 0.4%, 8.1%, 4.5%, 15.1%, 1.6%, 21.0%, and 24.3% respectively, also the following amino acids: aspartic acid 8.1g, serine 2.1g, threonine 2.4g, lysine 2.0g, alanine 2.4g, histidine 1.1g, cysteine 1.0g.

Minerals contents in an inorganic matter of analyzed Godeim fruit in mg/100g were include sulfur 0.1%, potassium 0.8%, magnesium 0.7%, calcium 0.61%, sodium 0.01%, potassium 1.45%, zinc 2.1%, iron 7.4%, copper 0.7% and manganese 1.0%.

Westermeier and Kraus (1999) reported that *Grewia tenax* juice contain different minerals, soluble solids, vitamin C, in different proportions. The juice contained phosphors, iron, manganese, magnesium, calcium, sodium, potassium, ascorbic acid, total soluble solids and total dry solids in the amount of 81.5 mg/kg, 7.02 mg/kg, 0.66 mg/kg, 108 mg/kg, 73.7 mg/kg, 61.6 mg/kg, 1610 mg/kg, 25 mg/kg, 8.42° Brix/20 °C and 8.43% respectively. This juice had a pH of 4.50, a Titratable acidity of 2.60 mg/kg, and a Relative Density 20/20 of 1.03375.
2.2 Pumpkin

2.2.1 Scientific Names of *Cucurbita* species

Pumpkin belongs to the family *Cucurbitaceae*. Most of which are tendril climbing herbaceous annuals containing some extremely well known edible fruits such as pumpkin, squash, cucumber, musk melon and water melon (Vaughan, 1970). There is some confusion in literature regarding the terms pumpkin and squash (Thompson and Kelly, 1957), because the cultivation of these plants over a long period of time has resulted in the development of a great number of varieties and forms (Eckey, 1954). The genus *Cucurbita* includes *Cucurbita pepo*, *Cucurbita moschata*, *Cucurbita maxima*, *Cucurbita mixta*, and *Cucurbita taxana*.

2.2.2 Agro Ecology

Pumpkin plant grows in warm humid and sometimes humid regions, and cannot withstand frost. It was grown better on fertile, warm, well-drained lighter soil (Thompson and Kelly, 1957; Whitaker and Davis, 1962).

2.2.3 Botanical description

Many authors (Winton and Winton, 1935; Whitaker & Davis, 1962; Cobley, 1963) described pumpkin plant as training, vine-link, with rough angle stem which show tendency to root at the nodes. The unisexual flowers are single in the same plant. Fruits are variable in size, shape, and color which are usually flatten globes with longitudinal graves and hard yellow-brown to greenish rind
enclosing a thick layer of orange-colored flesh with numerous seeds in the central placetae. Seeds are white or brown in color, flatten and with marginal region (Winton and Winton, 1935).

In Sudan *Cucurbita* spp. (pumpkins) are planted in February-March and August-October, (with 1-2 kg/ fed., seed rate). On one side of mustaba 2-3 meters wide and one meter between plants. After 12-15 weeks fruits are ready to harvest with average yield of 150-200 kg/fed., Most of pumpkin consumed in Sudan is grown in Kordfan in Western Sudan and Kassla in Eastern Sudan (El-Awad, 1980) Little information is available concerning pumpkin grown in the Sudan and little research has been carried out. As far as we know, there are no district varieties or known species.

### 2.2.4 Chemical composition of pumpkin

Gangadharam and Sirsi (1955) reported that the dry fruit of *Cucurbita pepo* contained 17.69% protein, 2.63% fat, 8.3% ash, 71.38% carbohydrate, 0.501gm/100 kg calcium determined as CaO, 23.03mg/100g phosphorous P2O5, and 0.11mg/100g iron as Fe2O3 on dry basis. Howard *et al* (1962) found that *Cucurbita moschata* contain 85% moisture, 1.0% protein, 0.1% fat and 5.0% total sugars, while he found that *Cucurbita mixima* contains 88.97% moisture, 2.0% protein, 0.2% fat, and 3.5% total sugars on fresh weight basis.
Oke (1969) reported that *Cucurbita pepo* fruit contains 3.5% crude fat, 20.2% crude fiber and 10.2% ash, on dry weight basis.

Sudanese pumpkin fruits evaluated by El-Awad (1980) were found to contain 89.5% moisture, 1.3% protein, 0.1% fat, 0.5% ash, 8.6% carbohydrate, 22.00mg/100g calcium, 0.5mg/100g iron, 37mg/100g phosphorus, with food energy of 41(Kcal).

Muthukrishnan and Sandararajan (1976) studied small- size pumpkin fruit and found them to contain 16.8% total soluble solid, 3.4% total sugar, 1.9% reducing sugars and 100mg /100g as ascorbic acid used with pectin in food industry.

**2.2.4.1 Carbohydrates**

Arasimovich (1940) reported that the greatest part of the carbohydrate of pumpkin was represented by starch. He detected glucose, fructose and sucrose. He also reported that the sugar content was not very high 3 to 7.5 %. Sayre (1931) reported a starch content of 1.25 to 3.38%. Damodaran and Rangachari (1945) reported pectin content for pumpkin (*Cucurbita pepo*) of 11.38 % expressed as calcium pectate on dry weight basis. They also reported that the isolated pectin has satisfactory jellying characteristics.
2.2.4.2 Fats

Belyaev (1929) reported that pumpkin seed oil resembles sunflower seed oil in its physical and chemical properties. The seed freed from the seed coat contained 50% oil, Riebsomer and Nesty (1934) found that pumpkin seed oil contains 6.5% palmitic acid, 5.4% stearic acid, 37.5% oleic acid and 42.2% linoleic acid.

Hidaka (1966) reported that fresh pumpkin pulp gave 0.5-1.1% crude fats. The major fatty acid components were found to be palmitic, oleic and linoleic, while lauric, myristic and stearic were present as minor components. He also reported that approximately 70% of the total fatty acids were unsaturated.

2.2.4.3 Ash

Watt and Marril,(1963) reported that the inorganic residue left after combustion of (Cucurbita pepo) contains was 8.4% on dry weight basis and 0.8% on fresh weight basis. In this ash, the presence of potassium, sodium, calcium, magnesium, iron, phosphorous and sulphur was detected. Pecknik and Luiz (1965) found that (Cucurbita pepo) contains 0.1225 mg/100g zinc. Howard et al. (1962) gave a value of 14-33mg/100g calcium for (Cucurbita pepo) cultivars, a value of 48mg/100g calcium for (Cucurbita moschata) and a value of 14-27mg/100g for (Cucurbita maxima) cultivars on fresh weight basis.
2.2.4.4 Crude fiber

The fiber content reported by Atwater and Bryant (1934) are 1.1% for the pulp of medium size pumpkin fruit and 1.2% for the large size.

2.2.4.5 Acidity

Like all members of the family Cucurbitaceae, the total acidity of pumpkin fruit is very low. It seldom exceeds 0.15% calculated as citric acid (Winton and Winton, 1935). Hartmann and Hilling (1934) gave a value of 0.03% titrable acidity calculated as tartaric acid.

2.2.4.6 Vitamins

Pumpkin contains appreciable quantities of vitamins A and B. Dehydrated pumpkin contains about 0.2-0.35 times as much vitamin B as dried brewers yeast and about 0.1 times as much vitamin A as cod liver oil (Morgan and Lillian, 1924).

Howard et al. (1962) reported a value of 55-450 mg/100g vitamin A for Cucurbita maxima. They also reported a value of 5-24 mg/100g for Cucurbita pepo, 21mg/100g for Cucurbita moschata cultivars and 6-11 mg/100 g for Cucurbita maxima cultivars as vitamin C on fresh weight basis.
2.2.4.7 Amino acids

According to work of Kamath and Kanala (1955), the protein content of the dry fruit of pumpkin (Cucurbita maxima) ranges between 22-23%. They identified twelve amino acids in pumpkin protein showing a similar pattern as casein. However, pumpkin has 3.5 times as much arginine and 5.0 times as much cysteine as casein. Lysine was found to be the limiting amino acid.

2.2.5 Uses of pumpkin fruits

Pumpkin fruits are used boiled or baked. Arved (1919) stated that pumpkin can serve not only as a palatable food, but can be used as a substitute for potatoes in bread. In America, it is also used as stock feed (Culpepper and Moon, 1945). In Sudan, most of pumpkin fruits are consumed locally when cooked with meat and tomato. Recently in Sudan, pulp from pumpkin fruit is used in the production of jam.

El-Shafie (1981) carried out a research on the pectic substances from the pumpkin fruit pulp; he found that it is a good source of pectin for jam making industries. However, similar mention was made by Gangadharam and Sirsi (1955) also they are regarding the medicinal properties of pumpkin fruit with particular reference to its antitubercular activity.
2.3 Jam

2.3.1 Definition of jam

The preservation of fruit by jam making is a familiar process carried out on a small scale by housewife in many parts of the world. Factory jam making has become a highly complex operation, where strict quality control procedures are employed to ensure a uniform product.

Jam is prepared by boiling the whole fruit pulp with sugar (sucrose) to a moderately thick consistency without retaining the shape of the fruit or vegetable. In England a jam is usually considered to consist of fruit pulp cooked with sugar to jelly consistency, the United States government pure regulations require the use of not less than 45lb. of fruit to each 55lb. of sugar (Cruess, 1938).

Jam may be made from practically all varieties of fruit. Various combinations of different varieties of fruit can be often be made to advantage, many kinds of fruits best for blending purposes because of it’s pronounced flavor and acidity.

2.3.2 Raw materials for Jam manufacture

When composing a formula for Jams or marmalade it must be remembered that the best result is always obtained if all the raw materials are matched in such away as to give the shortest possible cooking time. By doing so, the natural flavor and color of the fruit is retained (Saeed and Elmubark, 1974).
The following are the main raw materials used in Jam manufacture.

2.3.2.1 Fruits

Fruits selected for jam making should have reached full maturity in order to possess a rich flavor and be of the most desirable texture, and free from defects such as mould and bruises. Fruits are the major raw materials used in jam processing and include:

1. Citrus fruits (orange, grapefruit)
2. Mango.
5. Water melon.
6. Pumpkin.

2.3.2.2 Sugar

Sugar plays an important part in jam making, (Rauch, 1965). Sugar must be present in the proper proportions with pectin and acid to make a good gel, also contributes to the taste and prevents the growth of microorganisms in the product.

Artificial sweeteners cannot be substituted for sugar in regular recipes because gel formation specifically requires sugar. The amount of sugar used in jam or jelly depends on the amount and quality of the pectin used. When the sugar
content of a mixture is increased or the pectin content decreased, a weaker jelly will result. If added too little amount of sugar, the effect is the same as for an excess of pectin, and the jelly will be tough (Griswold, 1962).

2.3.2.3 Pectin

Pectic substances are complex colloidal carbohydrate derivatives that occur in or are prepared from plants and contain a large proportion of anhydrogalacturonic acid units that are thought to exist in a chain like combination. The carboxyl groups of polygalacturonic acids may be partly esterified by methyl groups and partly or completely neutralized, includes, polygalacturonic acids colloidal those are known pectinic acids, which are containing more than a negligible proportion of methyl ester groups. pectinic acids under suitable conditions, are capable of forming gels with sugar and acids or, if suitably low in methoxyl content, with certain metallic ions. The salts of pectinic acids are either normal or acid pectinates. Pectins are water-soluble pectinc acids of varying methyl ester content and degrees of neutralization that are capable of forming gels with sugar and acid under suitable conditions (Pual and Palmer, 1972)

Pectin is the natural substance found in fruit that causes the fruit juice to gel. Some kind of fruits has enough natural pectin to make a gel but other kinds of fruits will usually need to add pectin, these fruits are low in pectin.
The most sources of commercial pectin are citrus waste (lime, orange and grapefruit) and apple. Other secondary sources for pectin production (Doesburg, 1962) include sisale, flax and sunflower heads. Domadoran and Rangaschri (1945) found other sources of commercial pectin; these include guava, pumpkin, country pears and melons.

The amount of pectin required for jam making depends on:

1. The quality and quantity of the natural pectin in the fruit.
2. The contents of the soluble solids in the jam.
3. The nature of the recipe.

Rapid set pectin (apple or citrus source) is usually used for jam manufacture (Saeed and Elmubark, 1974). Commercial fruit pectin should be stored in a cool, dry place and do not hold commercial fruit pectin over from one year to the next. Grading of pectin does not refer to color or purity, but rather to the ability of the pectin to form a gel.

2.3.2.4 Acid

Tarr, (1923) recognized that the amount of acids necessary are not on total but on active acidity or pH. The success of jam manufacture depends, to a considerable degree, upon obtaining the required pH for a correct set. Jelly formation is usually possible only below pH 3.5. As the pH is decreased below 3.5 the firmness of the jelly increases until an optimum pH, usually in the range
of 2.6 to 3.4 is reached (Kertesze, 1951). At pH below the optimum syncretism or weeping occurs (Tarr, 1923). pH may be reduced by the addition of small quantities of acid.

Citric and tartaric acids are commonly being used for this purpose. Lactic and malic acids may also be used (Herschdoerfer, 1972).

Acid may be added when fruits are low in acid. The exact value of the optimum pH depends on the amounts of pectin and sugar.

The time of adding the acid is another variable. Acid that is present during boiling hydrolyzes some of the sucrose as the jelly is stored. The presence of acid in the boiling jelly mixture may have the unfortunate effect of degrading the pectin by hydrolysis of some of its methyl groups. For this reason, commercially often acid is added after the jam and jelly has cooked (Griworld, 1962).

If the pectin starts setting before the jam can be filled into the jars, as may happen below pH 3, accored jelly results. This is avoided by raising the pH of the jam by adding sodium bicarbonate or trisodium citrate but not by extra boiling or by adding more pectin, as has sometimes been attempted (Morris, 1952). Acid may have another property by preserves flavor.
2.3.2.5 The characteristics of preservation in jam

Jam is preserved by their sugar content which is enough to prevent the growth of microorganisms this owing to the high osmotic pressure of its solution in high concentration, except for mould growth on the surface. Access of moulds to home made jam is prevented by paraffin seal or canning jar lid. The commercial protected by vacuum cops and may be prevented after the containers are filled. Jam contains all or most of the insoluble solids of the fruit because whole crushed, macerated or pureed fruit is used in their manufacture. Technically jams and preserved are identical, but in continuing the whole fruit, especially if the pieces are large.

The Food and Drug Administration in (USA) requires that all jams and jellies (sold interstate commerce is made from real fruit and sugar). This has been concentrated by heat until the soluble solids of jams be not less than 65- 68 percentage depending on the type of fruit, the concentration read by a refractometer, pectin and acids may be added to compensate for any deficiency in the fruit. These provisions protected the consumer by insuring that the product is made from real fruit, which can be fresh, frozen or canned that an adequate amount of fruit is sufficiently concentrated. Combinations of fruits can be used if they corrected each other deficiency (Griswold, 1962).
2.3.3 Jam processing technique

2.3.3.1 Preparation of the fruit

Fruits for jam making must be selected fully ripped and free from defects such as mould and bruises, fruits with heavy skin must be peeled then extraction of fruit juice by pulped or chips the fruit pulp by crusher or cut into small pieces. Otherwise some fruits that will yield juice to processing were sorted manually and according to a protocol of preparing concentrations, weighed amount of fruits are soaked in demineral water in the ratio of 1:2 (fruit: water) over night at room temperature. Then extract juice from the soaked fruits mechanically by blender and then sieve to obtain a clean juice.

Blanching fruit pulp by sufficient quantity of water, this step for pasteurizes, softening tissues.

2.3.3.2 Jam boiling

The boiling kettles are charged with prepared fruits and the sugar should be stirred continuously for 3-4 minutes. Boiling is continued to near the end-point and the jam is discharged immediately (Rauch, 1965). Saeed and Elmubark, (1974) reported that the total boiling time should not exceed ten or eleven minutes.

During jam boiling all micro-organisms are destroyed within the product, and if it is filled hot into clean receptacles which are subsequently sealed and then
inverted so that the hot jam contacts the lid surface. Spoilage by micro-organisms will not take place during storage.

**2.3.3.3 Pectin used**

The combining of fruit pulp with pectin obtained products with jelly like consistency. The pectin must be completely dissolved in hot water (Saeed and Elmubark, 1974). Its use assure uniformly successful results and permits standardization of operation (Cruss, 1958).

Saeed and Elmubark, (1974) found that the pectin is mixed with a little amount of sugar in dry container, then added the hot water slowly to mixture with stirring until the pectin is completely dissolved, in the following ratio

70 parts hot water
20 parts sugar
10 parts 150 grade pectin

**2.3.3.4 Addition of Acid**

Citric acid is usually added after being dissolved in water in order to determine the acid requirement; the following procedure could be adopted: after checking the pH of the pulp, take 50g of citric acid and dissolve in water and make to 100ml mark in volumetric flask (each ml contain 0.5g citric acid) weigh 250g of the pulp in a beaker and add about 100ml water to it and titrate with the citric acid solution previously prepared until the pH drops to 3.3. Citric acid used to
drop pH is citric acid powder require for 1kg of pulp or juice. (Saeed and Elmubark, 1974)

2.3.3.5 Sugar requirement

If the jam to be manufactured contains 50% fruit, the finished jam is to be calculated as follows, using the methods adopted by Moyles et. el. (1962), if the total soluble solid of fruit is e.g.16°Birx soluble solid desired by 100 units of jam less soluble solid in 50 units of fruit in 16°Birx

<table>
<thead>
<tr>
<th>Soluble solid desired</th>
<th>68 units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soluble solid in 50 units of fruit in 16°Birx</td>
<td>8 units</td>
</tr>
<tr>
<td>Amount of sugar needed</td>
<td>60 units</td>
</tr>
</tbody>
</table>

Thus to 50 units of fruits add 60 units of sugar (Moyles, et. el. 1962).

2.3.3.6 The end point

Fresh or pre-cooked fruit is boiling with a solution of cane or beet sugar until sufficient water has been evaporated to give a mixture which will set to a gel on cooling and which contains 32- 34% water. The end point is determined by the following methods:

1. Refractometer method used to determine the end point, by means of refractometer the soluble solids in a jam can be exactly determined in a few seconds. Jam manufacture generally employ an Abbe refractometer for determining the finishing point.
A drop or two of the liquid is placed on the prism of the instrument, the prism being cooled by a water jacket. The scale of the instrument is usually graduated in Brix degrees; consequently it is a direct reading instrument. (Cruss, 1958).

2. Most jam should be concentrated to a boiling point of 219 to 221°F, the end point varying with the fruit variety, proportion of sugar and other factors. A jelly thermometer may be used with advantage to determine the end point of boiling process. (Cruss, 1958)

Jelly thermometer must be accurately calibrated and it is fast working. The following table shows the boiling points of jams at 760mm mercury pressure (Saeed and Elmubark, 1974)

Table 1: Detection of Total soluble Solids by Refractometer or thermal way

<table>
<thead>
<tr>
<th>Refractometer in %</th>
<th>Boiling point in centigrade</th>
<th>Boiling point in Fahrenheit</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>104.87</td>
<td>220.6</td>
</tr>
<tr>
<td>65</td>
<td>105.10</td>
<td>221.2</td>
</tr>
<tr>
<td>66</td>
<td>105.35</td>
<td>221.6</td>
</tr>
<tr>
<td>67</td>
<td>105.61</td>
<td>222.1</td>
</tr>
<tr>
<td>68</td>
<td>105.94</td>
<td>222.7</td>
</tr>
<tr>
<td>69</td>
<td>106.90</td>
<td>223.3</td>
</tr>
<tr>
<td>70</td>
<td>106.82</td>
<td>223.9</td>
</tr>
</tbody>
</table>
When desired concentration is reached according to the reading of the thermometer, shut off (heat resource) supply and transfer the jam to cooling.

3. Spoon test used when the jam has been boiling for some time and has become sufficiently thick in consistency, dip a spoon into it and let the product to run off the sides of spoon. If on cooling the product falls off in the form of a sheet instead of flowing readily in a single stream, it means that the end point has been reached.

3. By placing some of the jam on a sheet or surface of a cover and turning the sheet or the cover upside down after a few seconds, if it doesn’t run off, that means the end point has been reached. (Molyes et. el. 1962)

2.3.3.7 Packaging

The glass container (jar) is almost universally used for jam packing. The processes of filling and sealing are done by automatic machinery. Fill the hot jam into dry sterilized jams and fix the sterilized lid to the jar then immediately cooling under running cold water.

2.3.4 Recipes and Formulas

Preparation of a test batch: recipes were found to be satisfactory. Small test batch should be made in the factory before producing a commercial quantity.

The reason for the test batch is the variation in the chemical composition of
the fruit, pH, acidity, sugar and pectin. Content of fruit varies considerably according to the variety, maturity, cultural practices and climatic conditions. When the test batch is manufactured (take a good representative sample of the fruit). Cool the batch for 12 hours and analyze for pH, acidity, total soluble solid, reducing sugars, consistency and make an organoleptic test. If the test batch is satisfactory then the quantities should be covered to the required factory size batch. (Saeed and Elmubark, 1974).

2.3.5 Sensory evaluation

Quality of food product may be understood as measure of desirability of a product and how much it is close to consumer acceptance for jam products.

2.3.6 The troubles in making jam

The source of trouble in jam making is crystallization, which can only be prevented at a concentration of 72% solids by having invert sugar or glucose present but, as invert sugar is formed naturally during the boiling there is normally no need to add either of these ingredients. With too little invert sugar in jam, sucrose is liable to crystallize out, while when too much invert sugar is present dextrose granulation can occur. The latter is the more common trouble and arises when the jam is boiling too long, practically that occur form very acid fruits such as plum or black current. Dextrose granulation take the form of honey like crystals in the body of jam, giving it
a most unpleasing appearance, sucrose granulation is less objectionable, usually appearing as a surface crystallization which can be easily prevented by adding invert syrup to the jam during boiling. Dextrose granulation may be prevented by reducing the boiling time, or by raising the pH of jam. This, however, may produce other difficulties in connection with the setting or jellying of the jam.

A save proportion of invert or reduce sugar to attain in the finished jam is 25-40%, as inversion will continue slowly in the jam during storage, even in the sold storage (Morris, 1952)

2.3.7 Factors affecting production control of jam

Every factory own process of production and develops its own peculiar quality, yet there are certain factors applicable to all good quality jams. These factors which should be established are:-

a- Soluble solids content of jam: most of the laws of the world provide for a minimum percentage of 66% total solids and a minimum fruit content of 45%. Jams of total solids below 66% will be subject to spoilage from yeast and moulds.

b- The sucrose – invert sugar balance of the jam: the sucrose- invert sugar balance is very important in manufacture otherwise crystallization will occur during storage. Moyles, et. el. (1962) recommended that jam with
total soluble solids of 68 to 70% should contain analyze 20 to 28% reducing sugars, while Rauch (1962) preferred the figure to be kept within 28-32%. The pH of the jam, boiling temperature and boiling time are factors affecting the inversion of sugar.

c- pH of jam: this factor affects the setting of the jam. The pH of the jam should be kept in the range of 3.2 to 3.4. A pH above 3.4 may lead to failure of the jam to set while a pH value of less than 3.2 leads to bleeding of the jam. (Rauch, 1962)
3.1 Materials

Materials include

a. Ingredients: Fruits (Godeim and Pumpkin), sugar cane, commercial pectin and citric acid.


Godeim fruits were purchased from local market (Khartoum North Market) but brought from Western Sudan.

Pumpkin obtained from Saeed Factory, the origin of pumpkin Abu Gebeha in Western Sudan.

3.2 Methods

3.2.1 Procedure of jam making

3.2.1.1 Preliminary treatment

The preliminary treatment of the fruits varies according to variety:

A. Godeim juice: Fruits were sorted manually and weighed, then soaked in demineral water in the ratio of 1: 2 (fruit: water) over night, soaked fruits were blended by electric blender and sieved. godeim juice was kept at refrigerator until used.
B. Pumpkin fruits were selected sorted and washed, then peeled, and cut to small dices. The fruit pulp was chipped by crusher after blanched.

C. Blanching the fruit pulp extraction.

After preparation the godeim juice and pumpkin pulp were divided into 6 samples godeim100%, pumpkin 100% and according to percentages:
20: 80, 40: 60, 60: 40, 80: 20 (godeim: pumpkin) the weighted samples were blended to make 6 formulas.

Table 2: The formulae of Pumpkin, Pumpkin mixed with Godeim and Godeim jams

<table>
<thead>
<tr>
<th>Sample (code)</th>
<th>Percentage weight Godeim: Pumpkin</th>
<th>Name of sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20: 80</td>
<td>Mixture jam</td>
</tr>
<tr>
<td>B</td>
<td>40: 60</td>
<td>Mixture jam</td>
</tr>
<tr>
<td>C</td>
<td>60: 40</td>
<td>Mixture jam</td>
</tr>
<tr>
<td>D</td>
<td>80: 20</td>
<td>Mixture jam</td>
</tr>
<tr>
<td>G</td>
<td>100: 0</td>
<td>Godeim jam</td>
</tr>
<tr>
<td>P</td>
<td>0: 100</td>
<td>Pumpkin jam</td>
</tr>
</tbody>
</table>

The sample code will be used throughout this text.

All jam formulas are prepared from sugar, acid and pectin solution according to description of (Saeed and Elmubark, 1974).
3.2.1.2 Jam processing

Concentration of the fruit – sugar – water mixture usually carried out in aluminum pan, boiling with continued stirring until the total soluble solids reached about 61- 63°Brix, acid then pectin were added gradually while stirring. The total soluble solids were checked by hand refractometer when about 68°Brix was reached heat was turned- off. Hot jam was filled into jar immediately, tightly closed and cooled.

3.2.2 Physiochemical and proximate assessment

To evaluate jam the assessment of the following must be carried out: soluble solids, pH, total acidity, total sugars and reducing sugars, crude protein, crude fiber, crude fat, iron content and sensory evaluation.

3.2.2.1 Total soluble solids

Total soluble solids were determined using a hand refractometer, it were expressed as °Brix degree scale 50- 100.

3.2.2.2 pH measurement

The pH was determined by immersing pH electrode in solution sample, 50g sample was placed in a 150ml beaker. Sufficient solution to cover the tip of the electrodes was used. pH- meter (765- Calimatic) at 30 °C was used for the measurement.
3.2.2.3 Total acidity

According to the official Lane and Eynon titrometric method (AOAC, 1984) the total titratable acidity was determined, ten ml of sample were taken in a 50 ml beaker and phenolphthalein was added as an indicator. This was titrated carefully with 0.1N (NaOH) and titratable acidity was determined using the following formula:

\[
\text{Total acidity (as citric acid %)} = \frac{\text{Titr. value} \times 0.1 \times 64 \times \text{Dil factor} \times 100}{\text{Volume of sample} \times 1000}
\]

Dilution factor \[\text{= Total volume of sample \over \text{Sample volume used in titration}}\]

3.2.2.4 Total sugars and reducing sugars

They were determined according to the official Lane and Eynon titrometric method (AOAC, 1984).

Twenty– five grams of the pulps were filtered through a whatman filter paper (No. 4) and transferred to a 250 ml volumetric flask. 100 ml of distilled water were carefully added and then neutralized with 1.0 N NaOH. About 2 ml of lead acetate was added and the flask was then shaked, and left to stand for 10 minutes. Then 2 g of sodium oxalate was added to remove the excess lead.
Distilled water was again added to make the volume to mark (250 ml). The solution then filtered and 50 ml of the filtered were pipetted into a 250 ml volumetric flask. 50 g citric acid and 50 ml distilled water were added slowly to the new mixture. The contents of the flask were boiled gently for 10 minutes to invert the sucrose, and when cooled a few drops of phenolphthalein were added. In order to neutralize the mixture, a 20% NaOH solution was continuously added until the color of the mixture disappeared, and the volume was made to mark before titration.

Standard method of titration: 10 ml of a mixed solution of fehling A and B were pipetted into a conical flask. A burette was filled with a clarified sugar solution and the whole volume required reducing the fehlings solution was run so that 0.5-1.0 ml was still required to complete the titration performed. The contents of the flask were mixed and heated to boiling for 2 minutes. Three drops of methylene blue indicator were added. Then the titration was complete until the color has completely disappeared.

Calculation:

Total sugar mg/100ml = \( \frac{\text{factor} \times 100}{\text{Titre}} \)

(The factor is obtained from the table of invert sugar).

Total sugar % = \( \frac{mg/100g \times \text{dilution} \times 100}{1000 \times \text{wt. taken}} \)
From most jams, the reducing sugars were very low, so that filtrate can be used directly for titration according to AOAC (1984), using the following equation:

\[
\text{Reducing sugar} = \frac{\text{mg/100g} \times \text{dilution} \times 100}{1000 \times \text{wt. taken}}
\]

3.2.2.5 Moisture content

The moisture content of jams was assessed according to AOAC (1984).

Five grams of sample were spread on the bottom of dish. The dish and its contents were accurately weighted, placed in an air oven drier, at about 65°C and left to dry for 24 hrs. After drying to a constant weigh, the percentage of moisture content was calculated using the following formula for the triplicate samples.

\[
\text{Moisture content %} = \frac{W_1 - W_2 \times 100}{W}
\]

Where:

- \(W_1\) = weight of dish plus sample.
- \(W_2\) = weight of dish plus sample after drying.
- \(W\) = weight of original sample.

3.2.2.6 Crude protein content

The nitrogen was determined by applying the micro-kjeldahl technique according to the method of the (AOAC, 1984). A 0.2g of sample was weighed.
accurately into kjeldahl flask, 0.4g of catalyst mixture and 3.5ml of concentrated sulphuric acid were added, the flask was placed in the digestion equipment for 2hrs. Then the digested sample was placed in the distillation apparatus. 20ml of 40% NaOH were added and the ammonia evolved was received in 10ml of 2% boric acid solution. The trapped ammonia was titrated against 0.02N/Hcl using universal indicator methyl red and bromocresol green.

\[
\% \text{ Nitrogen} = \frac{\text{Volume of Hcl} \times 0.02\text{N/Hcl} \times 14 \times 100}{\text{Sample weight} \times 1000}
\]

Protein % = Nitrogen % × 6.25

3.2.2.7 Crude fiber content

Crude fiber content percentage was estimated for sample according to the method described by Egan, et. al. (1981), as follows: 2 g of sample were placed in 1000ml conical flask. Then 200ml sulphuric acid 0.23 N was added. The filled flask was transferred to a cold finger condenser and heated for 30 minutes. Then the flask contents were filtered using Buchner funnel while washing sample using a wash bottle filled with hot distilled water. After that, the washed sample was transferred to a conical flask filled with 200 ml sodium hydroxide 0.26 N. Then returned to the cold finger condenser and heated for thirty minutes, after that washed as mentioned previously. The sample was transferred to an air oven drier and left for 24 hrs at 65°C, cooled in a desiccator’s and then
reweighed. After that, the sample was placed in muffle furnace, for 3 hrs at 550 °C and reweighed after cooling. Crude fiber content was expressed as a percentage and calculated as follows:

\[
\% \text{ Crude fiber content} = \frac{2 - (W_1 - W_2) \times 100}{2}
\]

Where:
2 = weight of original sample.
\( W_1 \) = weight of dried sample.
\( W_2 \) = weight of ignited sample.

3.2.2.8 Fat content

Fat was determined according to the AOAC, (1984) method. A 2g of sample were extracted with hexane for 8hrs in soxhlet apparatus:

\[
\% \text{ fat content} = \frac{\text{weight of extracted fat} \times 100}{\text{weight of sample}}
\]

3.2.2.9 Ash content

Ash content was evaluated according to the AOAC, (1984) method. A 2 gm of sample was ignited at 550 °C in a muffle furnace for 3 hrs and reweighed after cooling. Ash content (%) was calculated as follows:
Ash content % = \frac{W_1 - W_2 \times 100}{W_1}

W_1 = weight of dried sample.

W_2 = weight of ignited sample.

3.2.2.10 Determination of iron content
Iron was estimated according to the analytical method for Atomic Absorption Spectrometry (Perkin Elmer, 1994), iron was determined by using an atomic absorption spectrophotometer, (Perkin Elmer company, model No. 3110) at Environmental Research Institute, Khartoum.

The ash was dissolved in a 10 ml HCl 5N. The solution was warmed to dissolve residue, filtered through an acid washed filter paper, then the volume of the solution was made up to 50 ml with distilled water, and taken for determination of iron according to equation:

Iron content % = \frac{\text{mg/L} \times \text{volume used \times 100}}{\text{Weight of sample} \times 1000}

3.2.2.11 Food Energy determination

The three energy nutrients carbohydrate and fat, with protein as a backup have as basic fuel factors. These factors reflect their relative fuel densities:
Carbohydrate gave 4 kcal /g, fat gave 9 kcal/ g and protein gave 4 kcal/ g (Williams, 1992)

3.2.2.12 Sensory evaluation

Sensory evaluation was conducted using a taste panel of 17 persons, the panelists were asked to evaluate six samples of jam for taste, color, odor, consistency and acceptability. The samples were subjected to the judgment of panelist using Ranking scale of 1-10.

3.2.2.13 Statistical analysis

Nutritive values and sensory evaluation were assessed by Analysis of Variance (ANOVA) as shown by Sendecor and Cochran, 1987 and by Dancan’s Multiple Range Test (Duncans, 1959).
CHAPTER FOUR
RESULTS AND DISCUSSION

This study was carried out in an attempt to utilize local raw materials in the manufacture of jams of good quality and high nutritional value in accordance, with specification of Sudanese standard of jams as stated by Sudanese Standard and Metrology Organization, SSMO (1989). The processing was carried out without any addition of artificial color or flavor. The discussion is divided into three parts. The analytical study was carried out for mixtures samples (A, B, C, and D), beside Pumpkin jam and Godeim jam as control, refer to table (2)

Part one

4.1 Analytical Specifications

The total soluble solids (T.S.S.), pH and invert sugars are considered as the most important indicators to define production quality, the Sudanese specification (SSMO, 1989) recommended standard parameters for jam quality pH (3.1 – 3.4), T.S.S. (65 – 70%), invert sugar (20- 28%).

Table (4) shows the T.S.S. values of samples, which read 68.0, 67.0, 67.5, 69.0, 67.0, and 68.5° Brix for Pumpkin jam, A, B, C, D, and godeim jam respectively these values fall within the Sudanese Specification. The quality of standard Pumpkin jam was in agreement with that of Saeed and Elmubark (1974), samples A, B and D have lower values than Saeed and Elmubark, (1974), but
agree with values obtained by Abdelgadir (2003). Samples C and Godeim jam have the highest value.

Table (4) shows pH values of the samples, the results of pH fall between 3.23 and 3.35 these were in agreement with Sudanese Specification (SSMO, 1989), those values were higher than values (3.12-3.15) obtained by Abdelgadir, (2003). But the values were lower than (3.4) reported by Saeed and Elmubark, (1974).

Table (4) shows the results of invert sugar contents for the six samples which were 27.2, 26.40, 25.70, 26.77, 26.80, and 27.30 for Pumpkin jam, A, B, C, D, and Godeim jam respectively these results were in agreement with the Sudanese Specification (SSMO, 1989), but these values were lower than most values recorded by Abdelgadir, (2003), but higher than values obtained by Saeed and Elmubark (1974). The pH, boiling temperature and boiling time represented factors which lead to inversion of sugar and were indicators of low cooking quality.

4.2 Effect of different formulae in Acidity contents

As shown in Table (4) the reduction of acidity content was related to the increase of pH. All values were higher than values obtained by Abdelgadir, (2003). As later can be observed by sensory evaluation in table (5) the panelist preferred a sourness taste incorporated with sweetness taste.
Table 4: Physiochemical analysis of Pumpkin, Pumpkin mixed with Godeim and Godeim jam

<table>
<thead>
<tr>
<th>Samples</th>
<th>Acidity (mg/ 100g)</th>
<th>pH</th>
<th>Total Soluble Solid (T.S.S) %</th>
<th>Invert Sugar %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumpkin jam</td>
<td>0.746</td>
<td>3.301</td>
<td>68.00</td>
<td>27.20</td>
</tr>
<tr>
<td>A</td>
<td>0.768</td>
<td>3.230</td>
<td>67.00</td>
<td>26.40</td>
</tr>
<tr>
<td>B</td>
<td>0.768</td>
<td>3.296</td>
<td>67.50</td>
<td>25.70</td>
</tr>
<tr>
<td>C</td>
<td>0.796</td>
<td>3.279</td>
<td>69.00</td>
<td>26.77</td>
</tr>
<tr>
<td>D</td>
<td>0.732</td>
<td>3.280</td>
<td>67.00</td>
<td>26.80</td>
</tr>
<tr>
<td>Godeim jam</td>
<td>0.704</td>
<td>3.350</td>
<td>68.50</td>
<td>27.30</td>
</tr>
</tbody>
</table>

A ≡ mixture jams (20% godeim and 80% pumpkin)  
B ≡ mixture jams (40% godeim and 60% pumpkin)  
C ≡ mixtures jam (60% godeim and 40% pumpkin)  
D ≡ mixtures jam (80% godeim and 20% pumpkin)
Part two

4.2 Nutritional evaluation

The incorporation of Pumpkin and Godeim in jam formulae affected positively the nutritive value of jam, whereas protein, fat, ash, fiber and carbohydrate were expressed in percentage and iron in mg/kg. The significant (p ≤ 0.05) increase in ash and fat contents in all samples was shown in Table 5. It was found that an increase in these nutrients was in close association with the increased amount of Godeim in formulae; this can be observed in the variation in the results of ash contents which ranged from 0.64% recorded by pumpkin jam to 4.32% recorded by Godeim jam. The highest value of 3.56% in mixed jam was recorded by sample D, samples A, B, and C recorded 1.52, 2.17, and 2.21 respectively. The lowest value of fat content was 0.07 recorded by pumpkin jam whereas Godeim jam has the highest value in fat content (0.28%), mixture samples A, B, C, D had recorded 0.11, 0.15, 0.19, 0.23, respectively, thereby sample D has a higher amount of fat.

Fiber contents have significant (p ≤ 0.05) different values as Pumpkin jam recorded 0.36% and Godeim jam recorded 0.35% A, B, C, D respectively recorded 0.26, 0.29, 0.33, 0.31. The different distribution in fiber contents depend on the original fiber content in pumpkin pulp and Godeim concentrated juice which were nearly the same amount according to El-Awad (1980) for pumpkin, and Elsiddig, (2002) for Godeim.
A significant ($p \leq 0.05$) reduction in carbohydrate values from 28.93% recorded by pumpkin jam to 23.06% recorded by Godeim jam can be observed and there was gradual reduction of carbohydrate in mixture jam as follows 26.04, 26.09, 25.33, 22.84 from A, B, C and D jams respectively according to the increased amount of Godeim. This can be attributed to the fact that carbohydrate calculated by difference of nutritive values from dry weight basis and Godeim have higher amount of nutrient components.

Protein contents in jams samples can be shown in Table 5 there was highly significant ($p \leq 0.01$) increase in protein contents according to the increased amount of Godeim in formulae so pumpkin jam recorded lower value 0.9%, but Godeim jam recorded 5.98% and mixtures jam recorded 2.9, 3.27, 3.94, 4.96 for A, B, C and D respectively.

From Table 6 it can be shown that a highly significant ($p \leq 0.01$) increase in iron contents indicates positive correlation between amount of Godeim and results that obtained in jams samples, iron content ranged between 0.97mg/kg recorded by pumpkin jam and 6.80mg/kg recorded by Godeim, the highest iron level in mixture jams 5.64mg/kg recorded by sample D, followed by samples C, B and A, the lowest level of iron 2.21mg/kg reported by sample A. these values are higher than values of pumpkin jam reported by (Haggar, 2004) and values of market pumpkin jam.
By comparison of samples results with attention to formulae constitute and referring to literature review in chemical composition of pumpkin (El-Awad, 1980) and Godeim (Elsiddig, 2002) and (Abdelsmuti, 1991), those authors reported a higher values of nutritional components in fresh material, but when exposed to cleaning, soaking, and cooking these treatments lead to loss of some nutritive components from fresh raw materials (El-Awad, 1980). In mixture samples under study, sample D has higher amount of nutrients components except in fiber.

When comparing the results of chemical analyzed for samples in Table (5), and the results in Table 7 reported from other pumpkin jam obtained from local market, and the sample of pumpkin jam analysis by (Haggar, 2007) it was reported that market jams have lower amounts of nutritive components values. From the energy values 116.23, 117.03, 118.79, 118.79, 113.27, 118.68 reported from pumpkin jam, A, B, C, D and godeim jam respectively seen in Figure 1 it was observed that samples B (40% godeim) and C (60% godeim) were have similar values of higher energy and sample D (80% godeim) have lower energy value, while godeim jam have higher energy value than energy value of pumpkin jam, these values reported according to protein, fat and carbohydrate energy count (Williams, 1992).
Table 5: Chemical composition of pumpkin, pumpkin mixed with godeim and godeim jam

<table>
<thead>
<tr>
<th>Sample</th>
<th>Parameters</th>
<th>Fat%</th>
<th>Protein%</th>
<th>Ash%</th>
<th>Fiber%</th>
<th>Carbohydrate%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumpkin jam</td>
<td></td>
<td>0.07&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.98&lt;sup&gt;f&lt;/sup&gt;</td>
<td>0.64&lt;sup&gt;f&lt;/sup&gt;</td>
<td>0.36&lt;sup&gt;a&lt;/sup&gt;</td>
<td>28.93&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>0.11&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2.97&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.52&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.26&lt;sup&gt;c&lt;/sup&gt;</td>
<td>26.04&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>0.15&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3.27&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2.17&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.29&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>26.09&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>0.19&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.94&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.21&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.33&lt;sup&gt;b&lt;/sup&gt;</td>
<td>25.33&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>D</td>
<td></td>
<td>0.23&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.96&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.56&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.31&lt;sup&gt;b&lt;/sup&gt;</td>
<td>22.84&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Godeim jam</td>
<td></td>
<td>0.28&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.98&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.32&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.35&lt;sup&gt;a&lt;/sup&gt;</td>
<td>23.06&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>LSD</strong></td>
<td></td>
<td>0.02</td>
<td>0.03</td>
<td>0.13</td>
<td>0.04</td>
<td>0.09</td>
</tr>
</tbody>
</table>

A ≡ mixture jams (20% godeim and 80% pumpkin)  
B ≡ mixture jams (40% godeim and 60% pumpkin)  
C ≡ mixtures jam (60% godeim and 40% pumpkin)  
D ≡ mixtures jam (80% godeim and 20% pumpkin)  
- The values of parameters are means of three values.  
- Probability of all parameters is (p ≤ 0.05), except the protein values is (p ≤ 0.01).  
- Means followed by similar superscript letters in columns are not significantly different.  
- LSD = Less Significant Different.
Table 6: Iron content of pumpkin, pumpkin mixed with godeim and godeim jam

<table>
<thead>
<tr>
<th>Samples</th>
<th>Fe mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumpkin jam</td>
<td>0.97^f</td>
</tr>
<tr>
<td>A</td>
<td>2.21^c</td>
</tr>
<tr>
<td>B</td>
<td>3.29^d</td>
</tr>
<tr>
<td>C</td>
<td>4.50^c</td>
</tr>
<tr>
<td>D</td>
<td>5.64^b</td>
</tr>
<tr>
<td>Godeim jam</td>
<td>6.80^a</td>
</tr>
<tr>
<td>LSD</td>
<td>0.05</td>
</tr>
</tbody>
</table>

A ≡ mixture jams (20% godeim and 80% pumpkin)
B ≡ mixture jams (40% godeim and 60% pumpkin)
C ≡ mixtures jam (60% godeim and 40% pumpkin)
D ≡ mixtures jam (80% godeim and 20% pumpkin)

- Means followed by different superscript letters in columns are highly significant different (p ≤ 0.01).
- LSD = Less Significant Different.
Table 7: Nutritional components in study sample and market samples:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mixture jam Sample D</th>
<th>Market jam1</th>
<th>Market jam2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash %</td>
<td>3.56</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Protein%</td>
<td>4.96</td>
<td>1.65</td>
<td>2.00</td>
</tr>
<tr>
<td>Fiber %</td>
<td>0.41</td>
<td>0.1</td>
<td>Nd</td>
</tr>
<tr>
<td>Fat %</td>
<td>0.23</td>
<td>0.09</td>
<td>Nd</td>
</tr>
<tr>
<td>Carbohydrate%</td>
<td>22.84</td>
<td>26.88</td>
<td>Nd</td>
</tr>
<tr>
<td>Iron mg</td>
<td>5.64</td>
<td>1.4</td>
<td>Nd</td>
</tr>
</tbody>
</table>

- Mixture jam sample D is (80% godeim and 20% pumpkin)
- Market jam 1 and Market jam 2 are pumpkin jam.
Nd ≡ Not determine
- P ≡ pumpkin jam.
- G ≡ Godeim jam.
- A ≡ mixture jams (20% godeim and 80% pumpkin)
- B ≡ mixture jams (40% godeim and 60% pumpkin)
- C ≡ mixtures jam (60% godeim and 40% pumpkin)
- D ≡ mixtures jam (80% godeim and 20% pumpkin)
Part three

4.3 Sensory evaluation

The effect of godeim addition to pumpkin in jam's formulae on the sensory properties was studied, the jam samples were evaluated for color, flavor, taste (sweetness), and consistency and overall acceptability, as shown in Table (8) the values were subjected to analysis of variance. It can be seen that a significant ($p \leq 0.05$) difference between samples was observed usually a higher score correlate to increased amount of added godeim, these results indicated that the panelist prefer the effect of godeim in products. So sample D has scored the superior grade within mixture samples under focus.
Table (8) organolaptic scores of pumpkin jam, mixture of pumpkin and godeim jam, and godeim jam

<table>
<thead>
<tr>
<th>Sample</th>
<th>Color</th>
<th>Flavor</th>
<th>Taste (sweetness)</th>
<th>Consistency</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumpkin jam</td>
<td>4.21&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.38&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.47&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.32&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.62&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>A</td>
<td>4.82&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.88&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.06&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.76&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.06&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>B</td>
<td>6.97&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.21&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.97&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.44&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>C</td>
<td>7.18&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.32&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.97&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.59&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>D</td>
<td>8.53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.44&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.68&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.15&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Godeim jam</td>
<td>8.74&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.76&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.65&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.12&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>LSD</td>
<td>0.85</td>
<td>0.96</td>
<td>0.90</td>
<td>0.87</td>
<td>0.63</td>
</tr>
</tbody>
</table>

A ≡ mixture jams (20% godeim and 80% pumpkin)
B ≡ mixture jams (40% godeim and 60% pumpkin)
C ≡ mixtures jam (60% godeim and 40% pumpkin)
D ≡ mixtures jam (80% godeim and 20% pumpkin)
- Means followed by similar superscript letters in columns are not significantly different.
- LSD ≡ Less Significant Different.
CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study aimed to establish the industrial and nutritional utilization of Godeim fruits and pumpkin pulp in jam processing.

The results of physicochemical analysis were in agreements with Sudanese specification, stated by Sudanese Standard and Metrology organization, SSMO (1989), and with that obtained by Saeed and Elmubark, (1974), who found that the optimum values of quality parameters should be follows: pH 3.2 to 3.4, total soluble solid 67-69°Birx, invert sugar 25- 30% with a best sweetness taste and attractive yellowish red color.

The results of chemical analysis of jams in protein, fat, ash, fiber and carbohydrate and iron parameters, showed the positive correlation between the amount of Godeim and the nutritive values, sample D (content 80% godeim) will have highest nutritive values than sample C, B and A. sample C (content 60% godeim) will have higher nutritive values than samples B and A, and so, when compared mixture jams with market jam the later reported to have lower nutritive values.

The panelists ensure that the best sample of jams was that which have higher amount of Godeim, sample D have highest scores in Jams for color, flavor, taste
(sweetness), and consistency and overall acceptability, samples C, B and A were have respectively lower scores.

5.2 Recommendation

- To improve the industrial and nutritional values of jam the processing technique utilized in heat treatment and preparation steps should be optimized.
- Commercialization of these local jams as national products.
- If the products are to be commercialized further work should be carried out to define the stability and validity date during storage.
- To encourage the research about other possible industrial utilization of Godeim, and to plan for a scientific study to determine the active components of Godeim.

Appendix 1

Food Energy
Unit of measurement of energy is a kilocalorie. In common usage the word calories refer to the amount of energy in foods expended in actions. In human nutrition, however, the term kilocalorie (1000 calories) is used to designate the large calorie unit used in nutritional science to avoid dealing with such large numbers. These units of measurement related to heat production. A kilocalorie, abbreviated as kcalorie or kcal, is the amount of heat required to raise 1 kg of water 1º centigrade (C). The international unit of measurement for energy is joule (J). The conversation factor for changing kilocalories (kcal) to kilojoules (kJ) is 4.184. Thus, 1 kcal equals 4.184 kJ. (Williams, 1992)

Appendix 2

Panel Taste Table
Please examine the following samples of jam presented in front of you, and give ranks to attributes shown on the form sheet, taking

Excellent 10- 9
V. good     8- 7
Good        6
Fair        5- 3
Poor        2- 1

<table>
<thead>
<tr>
<th>Sample</th>
<th>Color</th>
<th>Taste</th>
<th>Odor</th>
<th>Consistence</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

REFERENCES


Elsiddig, K., Sudan no need for iron supplement– eat fruits. Internet Publication, WWW. Tropentag.de/2003/abstract/links/El-Siddig


Biochemical and nutritional evaluation of famine foods of the Sudan.
Ph. D. thesis in Biochemistry and Nutrition Faculty of Agriculture,
University of Khartoum, Sudan.


Gebauer, J. E. Elsiddig, K., and Ebert, G. (2002). The potential of under
utilization fruits trees in central Sudan, Jens Gebauer, Humboldt
University Berlin, Department of Fruits Science, Albrecht. Thaer.
Weg 3, 14195 Berlin, Germany.


Hartmann, B. G. and Hilling, F. (1934). Acid Constituent of Food Products.

Herschoerdor, S. M. (1972). Quality Control in the Food Industry. Formerly
of T. Wall and Sons (Ice Cream) Ltd., London, England, vol.3. 285-


Lowa State University Press.


Tarr, L. W. (1923). The role of acids. Delaware University, Agriculture

Mc. Graw- Hill Publication in the Agriculture Science, London, P.538-
543.

and Hall ltd., London.

and uses of common trees and shrubs of the dry land Sudan. sahel
international (UK), 1671 pp.


quelle gegen eisenmangel.

