The nutritive constituents and potentiality of fruits from *Adansonia digitata* (Tabaldi), *Grewia tenax* (Guddeim), *Tamarindus indica* (Aradeib)

By

Nagat Nagm Eldin Hassan Eltom
B.Sc. Family Science, (Ahfad University)
M.Sc. Family Science, (University of Khartoum)

A thesis
Submitted in fulfillment of the requirements for the
Ph.D. degree to the University of Khartoum

Supervisor
Dr. Khogali Elnour Ahmed

Co-Supervisor
Dr. Abdel Gabbar Nasir Gumaa

Department of Family Science
Faculty of Education
University of Khartoum
October 2006
DEDICATION

To the soul of my father

And to

My mother, brothers and sisters

And to

All My Nephews
ACKNOLEDGEMENT

I would like to express my sincerely and deepest gratitude to Dr. Khogali Elnour Ahmed for his supervision, persistent encouragement, continuous support, advices indispensable help and guidance throughout the study of this work.

My most sincere thanks and appreciation go to Dr. Abdel Gabar Nasser Gumma co-supervisor of this study for his valuable guidance support and generous assistance.

Special thanks to technical staff of faculty of Education & Agriculture, university of Khartoum for their helpful gesture and friendly attitude during this study.

Finally, I wish to appreciate to the moral support of my friends and members of my family who have been always hoping to see this work finished.
# LIST OF CONTENTS

Dedication ................................................................. i
Acknowledgment .......................................................... ii
Abstract ................................................................. iii
Arabic Abstract ........................................................... v
List of Content .......................................................... vii
List of Tables ............................................................ xi
List of Figures ........................................................... xiii

**Chapter One** ...........................................................
Introduction ............................................................. 1

**Chapter Two:** ..........................................................

<table>
<thead>
<tr>
<th>Literature Review ........................................................</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.2 Uses</strong> .............................................................</td>
<td>4</td>
</tr>
<tr>
<td>Adansonia digitata .....................................................</td>
<td>4</td>
</tr>
<tr>
<td>Uses in food ............................................................</td>
<td>4</td>
</tr>
<tr>
<td>Uses in traditional medicine .........................................</td>
<td>4</td>
</tr>
<tr>
<td>Grewia tenax ............................................................</td>
<td>5</td>
</tr>
<tr>
<td>Uses in food ............................................................</td>
<td>5</td>
</tr>
<tr>
<td>Uses in traditional medicine .........................................</td>
<td>6</td>
</tr>
<tr>
<td>Tamarindus indica .....................................................</td>
<td>6</td>
</tr>
<tr>
<td>Uses in food ............................................................</td>
<td>6</td>
</tr>
<tr>
<td>Uses in traditional medicine .........................................</td>
<td>7</td>
</tr>
</tbody>
</table>
2.2 Nutritional values

Carbohydrate
Fat
Protein
Fiber
Ash
Moisture content
Mineral composition
Organic acid

2.3 Anti-nutritional factors

Phytic acid
Polyphenol
Tannins

Chapter Three:

3.1 Materials

3.2 Methods

Preparation of the raw materials
Moisture content
Ash content
Crude protein
Crude fiber
Fat content
Total carbohydrates
Sugar determination
(i) Reducing sugars
(ii) Total sugars ......................................................... 25
Total Pectin .............................................................. 25
Determination of mineral ............................................. 25
  (i) Preparation of samples for analysis ......................... 25
  (ii) Determination of Iron, Zinc, Copper, Magnesium, Calcium,
       Potassium, Phosphorus Sulphur and Sodium .................. 26
Determination of PH .................................................. 26
Determination of total acidity ...................................... 36
Determination of organic acid ..................................... 27
Determination of Antinutritional factors ......................... 28
  (i) Phytic acid ....................................................... 28
  (ii) Polyphenol ...................................................... 30
  (iii) Tannin ......................................................... 31
3.3 Statistical analysis ............................................... 32

Chapter Four Results and Discussion ............................ 33
4.1 Botanical description and distribution ....................... 33
Botanical description of Tabaldi .................................. 33
Distribution of Tabaldi ............................................... 34
Botanical description of Guddiem ................................. 34
Distribution of Guddiem ............................................. 35
Botanical description of Aradeib ................................. 35
Distribution of Aradeib ............................................... 36
4.2 Chemical composition ............................................ 36
Ash content ............................................................ 36
Moisture content ..................................................... 36
<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein content</td>
<td>38</td>
</tr>
<tr>
<td>Fat content</td>
<td>39</td>
</tr>
<tr>
<td>Fiber content</td>
<td>39</td>
</tr>
<tr>
<td>Carbohydrates content</td>
<td>40</td>
</tr>
<tr>
<td>Total sugars</td>
<td>47</td>
</tr>
<tr>
<td>Reducing sugar</td>
<td>47</td>
</tr>
<tr>
<td>Pectin</td>
<td>48</td>
</tr>
<tr>
<td>Mineral Composition of fruits</td>
<td>54</td>
</tr>
<tr>
<td>Ca</td>
<td>54</td>
</tr>
<tr>
<td>Mg</td>
<td>54</td>
</tr>
<tr>
<td>Na</td>
<td>55</td>
</tr>
<tr>
<td>K</td>
<td>55</td>
</tr>
<tr>
<td>Cu</td>
<td>56</td>
</tr>
<tr>
<td>Fe</td>
<td>57</td>
</tr>
<tr>
<td>P</td>
<td>58</td>
</tr>
<tr>
<td>S</td>
<td>58</td>
</tr>
<tr>
<td>Total acidity</td>
<td>65</td>
</tr>
<tr>
<td>pH</td>
<td>65</td>
</tr>
<tr>
<td>Organic acid</td>
<td>69</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>69</td>
</tr>
<tr>
<td>Oxalic acid</td>
<td>69</td>
</tr>
<tr>
<td>Citric acid</td>
<td>70</td>
</tr>
<tr>
<td>4.3 Some antinutritional factor of the fruits</td>
<td>76</td>
</tr>
<tr>
<td>Phytic acid</td>
<td>76</td>
</tr>
<tr>
<td>Polyphenol</td>
<td>76</td>
</tr>
<tr>
<td>Section</td>
<td>Page</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Chapter Five Summary, Conclusion and Results</td>
<td>83</td>
</tr>
<tr>
<td>5.1 Summary and conclusion</td>
<td>83</td>
</tr>
<tr>
<td>5.1.1 Chemical composition</td>
<td>83</td>
</tr>
<tr>
<td>5.1.2 Mineral composition</td>
<td>84</td>
</tr>
<tr>
<td>5.1.3 Organic acid</td>
<td>85</td>
</tr>
<tr>
<td>5.1.4 Anti-nutritional factors</td>
<td>86</td>
</tr>
<tr>
<td>5.2 Statistical Analysis</td>
<td>86</td>
</tr>
<tr>
<td>5.3 Recommendations</td>
<td>87</td>
</tr>
<tr>
<td>References</td>
<td>88</td>
</tr>
<tr>
<td>Appendix</td>
<td>103</td>
</tr>
</tbody>
</table>
Abstract

Fruit samples of three species namely: *Adansonia digitata* (Tabaldi), *Grewia tenax* (Guddeim) and *Tamarindus indica* (Aradeib) were collected from Darfur and Kordofan states separately.

Botanical and ecological descriptions have been provided for each of the collected species. The fruits were analyzed chemically. Mainly for nutrition value in terms of proximate analysis in addition to other specific properties and components like total sugar reducing, pectin, total acidity, PH, mineral Minerals, organic acids and some antinutritional factors. High performance liquid chromatography (HPLC) was employed for some of the analysis. The ash content of the fruits ranged from 2.4% (T. indica Darfur) to 5.7% (A. digitata Darfur). The moisture content ranged from 6.10% (T. indica Darfur) to 15.20% (T. indica Kordofan). The highest crude protein (8.97%) was found in G. tenax Darfur as compared to (4.20%) in T. indica Kordofan. The fat content was found to be 0.6% for A. digitata Darfur and 0.08% for T. indica Kordofan. The fiber content was recorded 4.2% for T. indica Kordofan and 0.08% for G. tenax Kordofan. The carbohydrate content was found to be (82.9%) for T. indica Kordofan and (66.00%) for G. tenax Darfur. The highest total sugars 27.44% for (G. tenax Kordofan) and the lowest value 14.73% ( A. digitata Kordofan ). The reducing sugars were 21.30% for G. tenax Kordofan and 11.37% for T. indica Kordofan. The pectin content was 58.05% for A. digitata Kordofan and 1.65% for T. indica Kordofan. The total acidity recorded the highest value (18.6%) for T. indica Darfur, whereas G. tenax Darfur recorded the lowest value (1.36%). The PH ranged from 2.86 (T. indica Darfur) to 4.41 (G. tenax Darfur). The results of
some of the important Minerals showed that the Ca content from 0.195 (T. indica Kordofan) to 0.55% (A. digitata Darfur).

The Na content ranged from 0.04% (T. indica Darfur) to 0.18% (A. digitata Darfur). The highest Fe content was 0.02485 for (T. indica Kordofan) and 0.0105% for (T. indica Darfur). The P content ranged from 0.10% for (T. indica Darfur) and 0.18% for (A. digitata Darfur). The results of organic acids showed that the highest value of ascorbic acid was 0.244% for (A. digitata Darfur) and the lowest value was 0.003% for (T. indica Kordofan). The oxalic acid ranged from 2.94% for (A. digitata Darfur) 0.4% for (T. indica Kordofan). The citric acid content of A. digitata Darfur was 4.63% while T. indica Darfur and Kordofan was not detected. Results of the antinutritional factors showed that phytic acid content were 0.031% for A. digitata Kordofan and 0.02% for A. digitata Darfur. The highest polyphenols were 1.655 for A. digitata Darfur and the lowest 0.92% for T. indica Kordofan. The Tannins were 1.29% for G. tenax Kordofan and 0.15% for T. indica Kordofan.

Generally some variations were found between the samples collected from Darfur and Kordofan for the same fruits indicating the ecological effect.
ملخص الظروف

Grewia  ) ديز اب (Adansonia digitata) ا فر مكرط ك 3 فور هجر أرتفاع ك والدر تاماريندوس إيدا) ي فز (تيناخ

. لم بي ديز ديز لغز ك عزة ك 3 3 فور هجر إيدا) ي فز (تيناخ

( ... ) ك 66 ) 40 ( ( ... ) ك 66 . 11 ( ( ... ) ك 66 . 14 . 73 ( ( ... ) ك 66

XI
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Chemical composition of fruits of Tabaldi, Guddeim and Aradeib.</td>
<td>42</td>
</tr>
<tr>
<td>Table 2</td>
<td>Total Sugars, Reducing Sugars and Pectin of Fruits Tabaldi, Guddeim and Aradeib.</td>
<td>49</td>
</tr>
<tr>
<td>Table 3</td>
<td>Mineral Composition of Fruits of Tabaldi, Guddeim and Aradeib.</td>
<td>60</td>
</tr>
<tr>
<td>Table 4</td>
<td>pH and Total acidity of fruits of Tabaldi, Guddeim and Aradeib.</td>
<td>66</td>
</tr>
<tr>
<td>Table 5</td>
<td>Some Organic Acids of Fruits of Tabaldi, Guddeim and Aradeib.</td>
<td>71</td>
</tr>
<tr>
<td>Table 6</td>
<td>Some Antinutritional Factors of the Fruits of Tabaldi, Guddeim and Aradeib.</td>
<td>78</td>
</tr>
<tr>
<td>Table 7</td>
<td>Summary of Results of the Chemical Analysis of Tabaldi, Guddeim and Aradeib.</td>
<td>82</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figures</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fig 1</td>
<td>Chemical composition of fruits of Tabaldi, Guddeim, Aradeib.</td>
<td>43</td>
</tr>
<tr>
<td>1.1</td>
<td>Chemical composition of Tabaldi fruits</td>
<td>44</td>
</tr>
<tr>
<td>1.2</td>
<td>Chemical composition of Guddeim fruits</td>
<td>45</td>
</tr>
<tr>
<td>1.3</td>
<td>Chemical composition of Aradeib fruits</td>
<td>46</td>
</tr>
<tr>
<td>Fig 2</td>
<td>Total Sugars, Reducing Sugars and Pectin of Fruits of Tabaldi, Guddeim, Aradeib.</td>
<td>50</td>
</tr>
<tr>
<td>2.1</td>
<td>Total Sugars, Reducing Sugars and Pectin of Tabaldi Fruits</td>
<td>51</td>
</tr>
<tr>
<td>2.2</td>
<td>Total Sugars, Reducing Sugars and Pectin of Guddeim Fruits.</td>
<td>52</td>
</tr>
<tr>
<td>2.3</td>
<td>Total Sugars, Reducing Sugars and Pectin of Aradeib Fruits.</td>
<td>53</td>
</tr>
<tr>
<td>Fig 3</td>
<td>Mineral Composition of Fruits of Tabaldi Guddeim, Aradeib</td>
<td>61</td>
</tr>
<tr>
<td>3.1</td>
<td>Mineral Composition of Tabaldi fruits</td>
<td>62</td>
</tr>
<tr>
<td>3.2</td>
<td>Mineral Composition of Guddeim fruits</td>
<td>63</td>
</tr>
<tr>
<td>3.3</td>
<td>Mineral Composition of Aradeib fruits</td>
<td>64</td>
</tr>
<tr>
<td>Fig 4</td>
<td>Total acidity of fruits of Tabaldi, Guddeim Aradeib.</td>
<td>67</td>
</tr>
<tr>
<td>4.1</td>
<td>pH of fruits of Tabaldi, Guddeim, Aradeib</td>
<td>68</td>
</tr>
</tbody>
</table>
Fig 5 Some Organic Acids of Fruits of Tabaldi Guddeim, Aradeib.

5.1 Some Organic Acids of the Tabaldi fruits Tabaldi Fruits.

5.2 Some Organic Acids of the Guddeim fruits

5.3 Some Organic Acids of the Aradeib fruits

Fig 6 Phytic acid of Fruits of Tabaldi, Guddeim Aradeib.

6.1 Polyphenols of the Fruits of Tabaldi, Guddeim Aradeib.

6.2 Tannins of the Fruits of Tabaldi, Guddeim Aradeib.

Fig 7 Ascorbic Acid Standard Curve

7.1 Ascorbic acid of Tabaldi Darfur

7.2 Ascorbic acid of Tabaldi Kordofan

7.3 Ascorbic acid of Guddeim Darfur

7.4 Ascorbic acid of Guddeim Kordofan

7.5 Ascorbic acid of Aradeib Darfur

7.6 Ascorbic acid of Aradeib Kordofan

Fig 8 Oxalic acid standard curve

Fig 9 Citric acid standard curve

Fig 10 Oxalic and Citric acid of Tabaldi Darfur

Fig 11 Oxalic and Citric acid of Tabaldi Kordofan

Fig 12 Oxalic and Citric acid of Guddeim Darfur

Fig 13 Oxalic and Citric acid of Guddeim Kordofan
Fig 14 Oxalic and Citric acid of Aradeib Darfur

Fig 15 Oxalic and Citric acid of Aradeib Kordofan

Fig 16 Phytic acid standard curve

Fig 17 Tannins standard curve
Chapter 1

Introduction

Sudan, as in many other African countries, is endowed with a range of edapho-climatic conditions that favour the establishment of many plant species, most of which are adapted to specific ecological zones. Among these plants are *Adansonia digitata*, *Grewia tenax* and *Tamarindus indica*, locally known as Tabaldi, Guddieum and Aradeib, respectively. These are found to grow in central Sudan and the states of Kordofan, Darfur, Blue Nile, the Upper Nile and Bahr Elghazal. Some of these plants are more prevalent at various areas of the Sudan. These trees provide shade, give an aesthetic sight, or offer fruits, tannins, gums, resins, oils or extracts and pharmaceutical products (Gebaure et al, 2002).

Tabaldi (*Adansonia digitata*) is important to the livelihood of the people in arid zones. Because of its great size, bizarre shape, extensive root system and high water holding capacity. It survives well in dry climates and zones with 100-1000 mm annual rainfall, but these trees are often stunted in the lower rainfall area. It characteristically occurs on free-draining sandy-textured soils but not on deep sand, where it is unable to get enough moisture or anchorage. It is insensitive to soil pH and tolerates shallow lateritic soil, on sites receiving run-off, or where water accumulates (FAO 1988). The uses of tabaldi tree are many: the bark and rind are used for cord fibers and fuel for the slow and hot poultry-baking processes; the young, tender leaves of all the tabaldi, particularly the dark-leaf vegetable types, are used as green or dried vegetable in sauces; the black and red trunk tabaldi are often preferred for their fruits and the white powdery pulp of the fruit capsule is extracted and used as a
flavoring in a variety of cool and hot drinks; in traditional medicine the pulp is used as febrifuge, painkiller, antidirrhoeal, antidysenteric and in the treatment of small box and measles (Sidible et al, 1996).

Guddeim (*Grewia tenax*), a fruit-producing shrub, is considered a prime candidate for domestication and commercialisation as a new crop for the semi-arid regions of the Sudan. It occurs on a large area, regenerates well, and is traditionally protected during clearing and favoured by farmers. Ecologically, it can withstand environmental stress more easily than annual crops and thus makes an important contribution to sustainable production without needing expensive inputs of water or fertilizer. The fruit is an important economic commodity. Locally, it is used as food and folk medicine and internationally, it has great export potential for use in food and pharmaceutical industries. However, most of fruit production results from gathering activities. Shrub population is wild and annual fruit yields are erratic and variable due to increased pressure from agriculture, drought, and predation (Elsidig et al, 2003).

Aradeib (*Tamarindus indica*) is well adapted to semiarid tropical conditions, although it does well in many humid tropical areas of the world with seasonally high rainfall. Young trees are very susceptible to frost, but mature trees will withstand brief periods of 28 Fº without serious injury. It is a slow grower but can live and remains productive for 150 years; it has a very deep and extensive root system, so it is not prone to come down easily. Aradeib may be eaten fresh, but they are most commonly used with sugar and water in the American tropics to prepare a cooling drink. The pulp is used to flavor preserves and chutney, to make meat sauces and pickle fish. Candy can be made by mixing the pulp with dry sugar and molding it into desired shapes. The fruit pulp is used in syrup, juice concentrates and exotic food. It is an ingredient in cardiac and blood sugar reducing medicines.
The plants are indigenous to the Sudan and their fruits are of economic importance and are commonly used by the locals in the Sudan. They have characteristic tastes and flavour which make them acceptable in the preparation of cool and hot drinks in rural areas. They have recently become a popular ingredient in home-made ice-creams in urban areas (Sidable et al, 1998). The fruits pulps of these trees play an important role in the diet of people in the savanna belt, during famines and food shortages. (Abdelmuti, 1999 and Gebauer, et al, 2002). Moreover, these fruits are used in traditional medicine for the treatment of different disease (EL Tahir and Gebauer, 2004).

Most of these fruits are dry and as such they have a very good storage capacity.

**Aims of this study:**

1. To provide detailed information on the Botany, Ecology, origin and main uses. of Tabaldi, Guddieum and Aradeib trees.
2. To study some of the nutritional values of fruits from these trees.
3. To study some of the antinutritional factors in the fruits of these trees.
4. To prepare analytical data for comparative study for the fruits of the three trees.
Chapter 2

Literature Review

2.1 Uses

**Adansonia digitata:**

**Uses in food:**

The fruit pulp is used as a refreshing drink when dissolved in water or milk or can be made into light porridge (nasha). Porridge is also prepared by mixing the acid pulp with milk (Palmer and Pitman, 1972). The pulp is commonly chewed or sucked. Unripe fruits are boiled and eaten as salad (Thiraul, 1984; Gabauer et al, 2002). Fruits pulp is also processed locally to obtain sweets (Ibiyemi et al 1988).

Young leaves are commonly used as a vegetable in soups or cooked and eaten as spinach (Venter and venter 1996). Dried green leaves are used throughout the year, mostly in soups served with the staple of millet (Delisle et al, 1997). Flowers can be eaten raw or used to flavour drinks. The seeds are characterized as potential protein source. In Sudan they are pounded whole into a coarse meal and added to soups and other dishes like "Burma" (Dirar, 1993). In some areas roasted seeds are used as a coffee substitute.

**Uses in traditional medicine:**

In the Sahel (Africa) some people call the tree “mother of the sahel”. More than thirty different uses are known. The fruit is used for management of malaria, febrifuge, smallpox, measles, dysentery, wound disinfection, eye lotion and general fatigue of children. For management of diarrhea in children, a study by Abdelgalil, (1996) was undertaken at Khartoum University. The aim was to evaluate the efficiency and acceptability of homemade baobab solution for management of diarrhea.
in children and prevention of dehydration. Baobab solution was compared to standard oral rehydration solution and was therefore recommended as a homemade treatment for management of diarrhea in children by the National Diarrhoea Disease Control Programs, Sudan. The baobab fruit pulp is currently widely used in traditional medicine.

The seed is used as an antidote and is also used for dental disorders. The leaves are used for treatment of gyine worm sores, insect bits, prophylactic against fever, cough, kidney and bladder diseases, dysentery, diarrhea, gastro enteritis, ulcers, inflammation, colics, fatigue, and as a diaphoretic. While the root is used for treatment of malaria, smooth skin for babies (Vonmydell, 1990).

Ramesh et al. (1992), reported that the root bark of tabaldi is used as antipyretic, febrifuge, astringent in diarrhea and dysentery and as a substitute for Cinchona.

The drinking of an aqueous extract of the bark of *Adansonia digitata* is used in Nigerian traditional medicine as a treatment for sickle cell anemia (Adensarya et al, 1988 and Vonmyd 1990).

**Grewia tenax:**

**Uses in food:**

Guddeim fruit, when ripe, is either eaten fresh or left to dry for consumption at a later date. In Sudan, a drink is prepared by soaking the fruit over-night, and then it is hand pressed, sieved and sweetened. A light porridge (nasha) is prepared by the addition of flour or custard to guddeim drink and served during the fasting month of Ramadan and is also fed to lactating mothers to improve their health and lactating abilities (FAO/WHO, 1988). Moreover, the fruit pulp, which is soft and sweet, is made into a fermented drink in Sudan and Southern Africa and a brandy
is distilled from an infusion of the fruits. Rashda et al (1998) reported that falsac *(Grewia asiatica)* produces a small purple berry which is consumed fresh. It also produces a highly nutritious juice, of very attractive colour, which is converted to a powder through spray drying.

**Uses in traditional medicine:**

In western Sudan, an aqueous mixture from fruits of two Guddeim trees *(Grewia villosa and G. tenax)* was used for the treatment of skin tuberculosis (Bashir et al, 1982). Guddiem fruit was reported to contain large amounts of Iron (Von Maydell, 1986) and as such is used for treatment of anemia and malaria (Suleiman and Eldoma, 1994). Parts of the plant are used as remedy for colds and chest complaints and as a chief constituent in remedy for typhoid. The park can be used as a medicine against parasites (Vogt, 1995).

**Tamarindus indica:**

**Uses in food:**

The fruit pulp was employed to make a refreshing drink which is widely used mixed with porridge. Abdelmuti (1991) reported that 21% of the interviewees in south Kordofan and 6% in south Darfur had eaten aradeib during famine. Rashda et al, (1998) reported that the brown viscous pulp from tamarind has a delicious sour taste and is used as an additive in many food preparations, while the seed endosperm is a good gelling agent. Tamarind is a good source of zinc and is used to make porridge (dawwa) commonly consumed during pregnancy (Lockett et al, 2000).
**Uses in traditional medicine:**

Ripe fruits of tamarind are used in traditional medicine to treat malaria, dysentery, rheumatism, hemorrhoids, snake bites and healing of wounds. The effect of the dietary intake of ripe fruits of tamarind (2%-10% in diet for 4 weeks) on the growth, Biochemistry and Histology of Brown Hisex chicks was examined. There was a decrease in body weight gains and efficiency of feed utilization and soft faeces. Hepatonephropathy due to consumption of 10% tamarind was confirmed by changes in serum enzyme activity and in total protein, cholesterol and uric acid concentrations. No hematological abnormality was observed in birds fed tamarind. The hepatocytes and the cells of the renal convoluted tubules had not completely reverted to normal at the end of a 2 week recovery period. (Mohamedain et al, 1996).

Ibrahim et al (1994) reported that tamarind is used as a laxative and as a tonic after infusion.

**2.2 Nutritional Value:**

**Carbohydrate**

Data cited in the literature indicated that tabaldi fruit pulp contains 79.50 % Nour et al, 1980, 81% Okaho, 1984 and 78.4% Almustafa, 2003 total carbohydrates. Gudeim fruits contain 68.10% Bourtor, 1995 and 71.50% Hamed, 1995. Ishola and Agbaji 1990 reported that tamarind fruits contain 66.80% of total carbohydrates.

Nour et al (1980) reported that the total sugar content of tabaldi fruit was 23.20 % while that of the reducing sugar was 18.90 %. Almustafa (2003) reported values of 29.30 % for the total sugars and 19.30% for the reducing sugars. Ishola and Agbaji (1990) reported that
Tamarind fruits grown in Nigeria contain 41.20% total sugars and 24.68% reducing sugars. Similar results obtained showing that tabaldi fruit contain 56% pectin. (Nour et al, 1980); and Abdelgalil, (1996).

**Fat**

Fat contents of tabaldi fruit pulp were reported by Nour et al 1981, Okaho1984, Abdelmuti 1991, Obizoba and Angika 1996, Abdelgalil 1996, Almustafa 2003 were 0.20%, 0.2%, 0.50%, 0.20%, 0.20% and 4.10% respectively. Guddeim fruit fat content were found to be 0.10% (Bourtors, 1986), 0.40% (Abdelmuti, 1991) and 0.30% (Hamed, 1995). Ishola and Agbaji (1990) reported that tamarinds contain 2.50% fat.

**Protein**

The protein contents of Tabaldi fruit pulp were found to be 2.60% (Nour et al, 1980), 2.00% (Okaho, 1984), 3.10% (Abdelmuti, 1991), 1.50% (Obizoba and Angika, 1986). Other guddeim values reported for the protein contents were 8.00% Bourtors, (1986), 6.30 % Abdelmuti, (1991) and 7.50% Hamed, (1995). Moreover, Rahamtalla (1999) studied the chemical composition of guddeim from wild plants obtained from south Kordofan state and cultivated ones from north Kordofan state. His results showed that the protein contents were 7.80% and (6.90%) respectively. Tamarind fruit pulp was found to contain 4.80% Abdelmuti, (1991) and 8.70% Abdelgalil, (1996) protein.
**Fiber**

According to Nour et al (1980), Okaho (1984), Abdelmuti (1991), Abdelgalil (1996) and Almustafa (2003) the tabaldi fruit pulp fiber contents were (5.70%), (9.00%), (9.20%), (5.70%) and (0.25%) respectively.

Guddeim fruits fiber was found to be 14.30% Bourtors, (1986), 8.10% Abdelmuti, (1991), and 9.50% Hamed, (1995) for the fiber contents. Results were reported that tamarinds fruit contain 6.60% Abdelmuti, 1991, and 2.20% Ishola and Agbaji, (1990).

**Ash**

Ash contents of tabaldi fruit pulp were studied by Nour et al (1980), Okaho (1984), Abdelmuti (1991) and Almustafa (2003). Were found as 5.30%, 7.00%, 5.80% and 5.60% respectively. Abdelmuti (1991) and Rahamtalla (1999) found that guddeim fruit contain 4.50% and 4.70%- 5.50% ash.

Ishola and Agbaji (1990), Abdelmuti (1991) reported that tamarind fruits contain (2.88%) and (3.80%) ash respectively.

**Moisture Content**

Moisture content of tabaldi fruit pulp reported by Nour et al (1980) and Almustafa (2003) were 6.70% and 8.23% respectively. Guddeim fruit moisture was 5.30% Bourtors, (1986) and 9.80%, 12.79% Rahamtalla, (1999). Ishola and Agbaji, (1990) reported a tamarind fruit moisture content of 18.90 %.
**Mineral Composition**

In Sudan, Abdelmuti, (1991) studied the Mineralal composition of the fruits pulp of tabaldi, guddeim and aradeib. His results were as follows:

<table>
<thead>
<tr>
<th>Mineralal Fruits</th>
<th>Ca%</th>
<th>Mg%</th>
<th>Na%</th>
<th>K%</th>
<th>Cu%</th>
<th>Zn%</th>
<th>Fe%</th>
<th>P%</th>
<th>S%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tabaldi</td>
<td>0.36</td>
<td>0.36</td>
<td>0.01</td>
<td>2.57</td>
<td>.0008</td>
<td>.0013</td>
<td>.0017</td>
<td>0.06</td>
<td>0.13</td>
</tr>
<tr>
<td>Guddeim</td>
<td>0.60</td>
<td>0.17</td>
<td>0.01</td>
<td>1.45</td>
<td>.0007</td>
<td>.0012</td>
<td>.0074</td>
<td>0.08</td>
<td>0.10</td>
</tr>
<tr>
<td>Aradeib</td>
<td>0.26</td>
<td>0.14</td>
<td>0.01</td>
<td>1.32</td>
<td>.0005</td>
<td>.0009</td>
<td>.0073</td>
<td>0.10</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Nour et al (1980) reported that tabaldi fruit pulp contained 0.065% Ca, 0.0086% Fe and 0.0508% P. Abdelgalil (1996) studied Mineralal composition of tabaldi fruit pulp. The results were as follows: 0.067% Ca, 0.450% K 0.001% Zn and 0.0053% Fe. Rahamtalla (1999) reported that guddeim fruit contained 0.0024%, 0.0010% Zn, 0.0088%, 0.0093% Fe. Tamarinds fruit pulp was found to contain 0.465% Ca, 0.072% Mg, 0.076% Na, 0.062% K, 0.00106% Zn, 0.0084% Fe and 0.091% P (Ishola and Agbaji, 1990).

**Organic acids**

Organic acids are important constituents which influence flavor, brightness of colour, stability and quality of food. The titrable fraction of fruit tissues varies from 0.2- 0.3%, in low- acid apples and bananas, to 2.00% in Logan berries and over 6.00% in lemon. Citric acid may constitute up to 60.00% of the total solids of the edible portion of the lemon. Organic acids reduce the sweetness and increase the tartness of
food in which they occur and in this way influence palatability. The sour taste of acids is influenced more by total acidity than by pH. The acids improve the palatability of many products and influence their nutritive value by playing a significant role in the maintenance of acid-base balance in the body. They also act as chelating agents for iron and copper and inhibit enzymes.

Organic acids are characterized by their carboxyl group \((-\text{COOH})\) which dissociates into a proton and a conjugate base and thus endows the organic acids with their acid properties. The acid properties of other food compounds arise from other functional groups such as the two enol groups of ascorbic acids. Organic acids can be classified according to the type of carbon chain (aliphatic, alicyclic, aromatic and heterocyclic) and the extent of unsaturation and substitution. The lowest mono-carboxylic aliphatic acids (with 1-4 carbon atoms) are pungent, rather volatile liquids, while those with five or more carbon atoms are oleaginous, slightly water-soluble liquids. Di-carboxylic acids are colourless crystalline solids with melting points about 100ºC. On the other hand, alicyclic acids which contain at least one non benzene cyclic hydrocarbon skeleton, are less water soluble than the previous ones. As such, all these acids form more or less soluble metal salts and esters. All organic acids occur naturally in a variety of vegetable and animal substrates (Leo, 1992).

Tabaldi fruit pulp was found to contain 0.300% ascorbic acid Nour et al, 1980). FAO, (1988) reported that tabaldi fruit pulp is a good source of Vitamin C. According to Agbessi Dos-Santos (1996) the tabaldi fruit contains 0.1690% compared with 0.1060% for fresh hot pepper. Sidibi et al (1996) determined the range of vitamin C in the capsule of Malin baobab which occurs in different regions and villages and have different bark colours. The results showed that the average vitamin C content is
0.2800% and that there were highly significant differences in vitamin C content either between regions or between types of trees. In Malawi the fruit pulp was found to have the highest ascorbic acid content 0.179% out of twenty-two wild species (Saka, 1992). Abdelgadir (1998) reported that the amounts of vitamin C found were more than that in other foods (0.355% compared to 0.080% in orange juice). Similar results obtained showing that the tabaldi fruit contains 0.337%, 0.337% and 0.325% respectively. (Eromosele et al, (1991); Terng, 1993) and Abdelgalil, 1996).

2.3 Antinutritional Factors

Many plants contain various natural active components, which affect their nutritional quality, such as phytic acid and polyphenolic compounds (Yegoub, 2003).

**Phytic acid:**

Phytic acid is a natural plant product (inositol hexaphosphate) which is a common constituent of plant tissues. It is commonly found in seeds and represents the principal form of stored phosphate. Besides the well-known adverse effects of reduced mineral bioavailability in human and animal nutrition, phytic acid may also react directly with protein and starch and reduce their solubility and digestibility. Thompson (1993) reported that phytic acid has hypocholesterolemic, anti-oxidative, anti-carcinogenic and hypolipidemic effects and has been suggested to have a role in the prevention of caries and platelet aggregation in the treatment of hypocalcaemia and kidney stones. Potter (1995), Dayi et al (1995), and Thompson (1993) found that the function of phytic acid is not only energy storage and anti-oxidation of fats of seeds but also protecting seed from fungal invasion.
Phytic acid and phosphorus levels in the seeds are largely a function of available soil phosphorus. Thus, 98% of the variation in phytic acid and phosphorus of soybeans was attributable to a positive linear effect of available soil phosphorus. (Miller et al, 1980; Raboy and Dickinson, 1993). Ishola and Agbaji, (1990) reported that aradeib fruits contain small amounts of phytic acid.

**Phytate-mineral interaction:**

The ability of phytic acid to complex with metals is well-known and is one of the nutritional concerns. Phytic acid and its derivatives can complex with essential dietary minerals, thus making them unavailable or only partially available for absorption (O'Dell, 1969). Phytic acid forms insoluble complexes with di and tri-valent cations at neutral pH, potentially rendering them unavailable. Vohra et al (1965) reported that the final combination of metals complexed with phytate when mixed in solution, depends upon the concentration of the metal, the pH of the solution, and the concentrations of cations. Phytate combines with Ca, Zn, Fe, and other divalent metals to form complexes with low solubility. (Harland and Harland, 1980). Oberleas et al, (1966) reported that phytate complexes with Fe, Zn, and Ca are highly insoluble and a combination of Ca and Zn forms an even less soluble complex. Vohra et al (1965) found that zinc and ferrous cations form the most stable metal-phytate complexes. At pH 7.4, the phytate anion binds the metal cations in the following decreasing order: cupric, zinc, nickel, cobaltic, manganic, ferric and calcium.

**Phytate-protein interaction:**

The rate of protein-phytate complex formation depends upon the pH and metallic ion concentration of the reaction medium (O'Dell and DeBoland, 1976). Serraino and Thompson (1984) concluded that the
extent of phytate-protein binding depends on both pH and/or the content of divalent ions while Thompson (1987) stated that the degree of protein-phytate interaction is influenced by the protein charges and the conformation and ionic strength of the solution at a given pH. Furthermore, Carnovale et al (1988) concluded that phytate-protein complexation is affected by the characteristics of the protein matrix.

At acidic pH, the protein has a net positive charge while phytic acid is negatively charged, thus a binary protein-phytate complex exists (Serraino and Thompson, 1984). Reddy and Salunkhe (1981) showed that at pH 2.8 complexation occurred between phytate and proteins. Thompson (1987) stated that at low pH, below the isoelectric pH of the protein, the positively charged groups of proteins such as terminal amino, e.g. amino group of lysine and imidazol group of histidine can directly form a binary complex with negatively charged phytic acid. Several investigations showed that phytate binding below isoelectric point of protein occurs as a result of strong electrostatic interaction between positively charged parts of proteins and negatively charged phosphate groups of phytate (Hill and Tyler, 1954; Okubo et al. 1975; Omosaiye and Cheryan, 1979). The binary complex is thought to dissociate in the presence of excess Ca ions by competing for phytate with cationic groups of proteins (Serraino and Thompson, 1984).

At alkaline pH, both protein and phytic acid are negatively charged, thus the complexation is mediated by multivalent cation to form a ternary protein-mineral-phytate complex (Serraino and Thompson, 1984). Reddy and Salunkhe (1981) found that interaction between phytate and proteins at pH 8.4 was mediated by divalent cations such as Ca, Mg and Zn.
Thompson (1987) reported that at intermediate pH (pH 5-10), above the isoelectric pH, the proteins have net negative charges and can form a ternary complex with multivalent cations and phytic acid. The binding site includes the ionized carboxylic group and unprotonated imidazol group of histidine. Some binary complexes may be present at intermediate pH because the lysyl and arginyl residues of the protein are still positively charged at this pH. Omosaiye and Cheryan (1979) postulated the following mechanism for multivalent cation participation in forming the ternary complexes.

$$\text{Cation} + \text{Phytic acid} \rightarrow (\text{Cation - Phytic acid}) \overset{1}{\rightarrow}$$

$$\text{Protein} + \text{Cation} + \text{Phytic acid} \rightarrow (\text{Protein - Cation - Phytic acid}) \overset{2}{\rightarrow}$$

(Abdullah, 1996)

**Polyphenols**

Polyphenolic compounds in plants are a complex group of substances with a wide range of molecular mass and are found either free or bound to protein or dietary fibre. Soluble or extractable polyphenols (EPP) are low or intermediate molecular mass phenolics that are extracted easily using different solvents, while non-extractable polyphenols (NEPP) are mainly condensed tannins (CT) of high molecular mass (over 5000) (Savra- Calixto et al., 1991; Terrill et al., 1992).

Polyphenols (PP) are present in almost all plant organs: leaves, roots, flowers etc, and they are common in most plant foods (fruits, legumes, cereals, etc) and that their level varies greatly even between the cultivars of the same species. Genetic factors, as well as environmental conditions, largely influence the presence of polyphenols in plant foods. In plants,
several functions have been attributed to polyphenols. They have anti-pathogenic, anti-herbivore and allelopathic properties (Brice and Morrison, 1982; Ray and Hastings, 1992). Phenolic compounds are partly responsible for the sensory and anti-nutritional quality of plant foods because they inhibit several digestive enzymes, lower protein and starch digestibility and hinder mineral absorption (Brovo, 1998).

Polyphenols have different effects in the intestine depending on their solubility. EPP appear to be absorbed from the digestive tract and produce systemic effects, such as reduction of the metabolic utilization of absorbed amino acids and elevated plasma levels of growth hormone (Martin-Tanguy et al., 1976; Barry et al., 1986). NEPP are not absorbed in the intestine and are recovered quantitatively in faeces (Bravo et al., 1992, 1993).

Traditionally, polyphenols have been considered antinutrients by animal nutritionists, because of the adverse effect of the tannins of one type of polyphenols on protein digestibility. However, recent interest in food phenolics has increased greatly, owing to their antioxidant capacity and their possible beneficial implications on human health, such as in the treatment and prevention of cancer and cardiovascular diseases.

**Tannins**

Tannins are polymers of phenolic compounds with higher molecular weights (Mol Wt 500-5000) containing large numbers of phenolic hydroxyl groups to permit formation of stable cross links between proteins and other macromolecules. Swain (1965) reported that the tannins may be classified as hydrolysable, that is, degradable by enzymes to yield a sugar residue and phenyl carboxylic acid and condensed tannin, which are polymeric flavoiods. Van Buren and
Robinson (1969) reported that tannins affect the growth of animals in three main ways:

1. They have a stringent taste, which affects palatability and decreases food consumption,
2. They form complexes with proteins and reduce their digestibility.
3. They act as enzyme activators.

Moneam (1990) investigated the effect of presoaking prior to cooking on tannins of eight varieties of Vicia faba and stated that cooking after soaking lowered tannin content significantly. Hassan and El-tinay (1995) stated that natural fermentation of sorghum dough caused a highly significant improvement of its nutritive value by decreasing the tannin content and improving in vitro protein digestibility.

Consumption of tannin in grain sorghum and other plant materials has been indicated in many areas of the world as a possible factor in the incidence of esophageal cancer. Tannins can cause gastrointestinal inflammation and are tumorogenic in experimental animals (Singleton and Kratzer, 1969). Although tannins have a high intrinsic toxicity, it seems likely that the main result of their presence in plant seed is to impair digestion and nutrient utilization. Tannins were long considered to be relatively thermostable and not inactivated by heat treatment but Ward et al (1977) reported that depressing effects of phenolic compounds can be reduced by heat treatment.

Hagerman and Bulter (1981) reported that the larger the protein, the stronger is the binding of tannin (if other factors were equivalent). Short peptides of two to four amino acids do not bind strongly enough to be detected. The interaction appears to be highly cooperative. They observed that the affinity of a protein for tannin is greatest at the isoelectric point of the protein, although some proteins bind strongly over
a wide pH range. In addition, they observed that the more open the structure, the stronger is the protein binding to tannins. Perhaps the most important factor controlling the affinity of a protein for sorghum tannin is the amount of protein that it contains. The hydrogen bond to the carbonyl oxygen of the peptide bond involving the alpha amino group of proteins is stronger than of any other amino acids (Hagerman, 1980).

**Tannin interaction with proteins**

Tannins are known to interact with Proteins and form tannin-protein complexes. Chemically, four bonds have been suggested to participate in the formation of tannin-protein complexes: 1) hydrogen bonding, formed between phenolic and ketoamide groups of the protein 2) ionic bonds, formed between the phenolate anion and the cationic site of the protein molecule 3) covalent links, formed by oxidation group (-NH₂, -SH) in the protein, and 4) hydrophobic interactions between the aromatic ring structure of phenolic compounds and hydrophilic patches of proteins (Kumar and Singh, 1984). The ability of polyphenols to form complexes with casein as well as with the enzyme proteins depends upon the number of hydroxyl groups of polyphenols and increases with the degree of polymerization. Salunkhe, et al (1989) reported that tannins affect accessibility to peptide carbonyl group of protein molecules as well as the relative concentration of reactants. The binding between tannins and protein consists of carbonyl group of the peptide bond of enzyme proteins. Martinez and Moyano (2003) reported that the presence of tannin-protein insoluble complexes could result in a reduction in protein availability, depending on the strength of the interactions and nature of both components. This indicates that a protein showing a high tannin affinity may be bound preferentially by tannin even in the presence of other low affinity proteins. Another factor is the molecule size. Proteins
less than 20 K Da show low tannin affinity. Proline content also affects affinity and the higher the proline content, the greater is the affinity. Martin et al (1985) reported that the solubility of protein combined or not to tannic acid, was assessed under a wide range of pH.
Chapter 3
Materials and Methods

3.1 Materials

Fruit samples of 3 tree species were collected from Darfur and Kordofan states during the season of 2003-2004. The plant species were:

1- Adansonia digitata –Tabaldi (Arabic)
2- Grewia tenax –Guddeim (Arabic)
3- Tamarindus indica –Aradeib (Arabic)

The three species have been fully subjected for: Botanical, Taxonomical and ecological description to the systematic plant classification (Andrews, 1956).

3.2 Methods:

1. Preparation of the raw material

The fruit pulp of each of the three tree species was separated from the fruit coat. The seeds were then separated from the pulp manually. Guddeim and aradeib were milled. All samples were mixed, packaged in polyethylene bags and kept in a freezer.

2. Moisture content

Moisture content of each sample was determined according to the method described by standard official methods of analysis (A.O.A.C, 1984). A sample weighing two grams of the fruit pulp was taken in a pre-heated crucible of known weight. It was then dried at 105°C overnight. The crucible was then transferred to a dessicator, allowed to cool to room temperature and was then reweighed. The moisture content of the sample was calculated according to the following equation:
Moisture % = \( \frac{A-B}{\text{Weight of sample}} \times 100 \)

Where:
A= weight of crucible + sample (before drying)
B= weight of crucible + sample (after drying)

3. Determination of Ash Content

Total ash of samples was estimated according to the standard official methods of analysis (A.O.A.C, 1984). 2 grams of the sample were put in a clean dry crucible of known weight and then dried in a Muffle Furnace at 550°C for 3 hours. The crucible was then cooled in a dessicator and reweighed at room temperature.

The ash content of the sample was calculated using the following equation:

\[ \frac{(W1) - (W2)}{W3} \times 100 \]

Where:
W1= (weight of crucible (g) +ash)
W2= (weight of empty crucible (g))
W3= (weight of sample (g))

4. Crude protein

The crude protein was determined by the semi-microkjeldahl method as described by Pearson (1976). 0.30 grams of sample were weighed in a semi-micro digestion flask. 1.00 gram of the catalyst (sodium sulphate + cupric sulphate 20:1 by weight) and 10 ml of concentrated sulphuric acid were added and the content was heated till a
clear solution was obtained. The solution was transferred to the distillation unit and the flask was rinsed with distilled water. The mixture was steam-distilled in a receiver containing 10ml of 20% boric acid and a few drops of mixed indicator (ethylene blue and methyl red). The distillate was titrated against, 0.20 N hydrochloric acid. The total nitrogen percentage was determined by the following equation:

\[ Total\ nitrogen\ % = \frac{V \times N \times 14}{W \times 1000} \times 100 \]

Where:
V = volume (ml) of hydrochloric acid
N = normality of hydrochloric acid
W = weight of original sample (in grams).

Total nitrogen was multiplied by the factor (6.25) to obtain crude protein, as shown by the following equation:-

\[ Crude\ protein = 6.25 \times total\ nitrogen \]

5. Crude fiber

The crude fiber content was determined according to (A.O.A.C. 1965). 2 grams of the sample were accurately weighed, transferred to an extraction apparatus and extracted with petroleum spirit. The air dried fat free sample was transferred to a dry 750 ml beaker and 200 ml of boiling 1.25% (0.255 N) sulphuric acid were added to the beaker. The mixture was boiled for 30 minutes, and the contents of the beaker were filtered through Whatman No.1, filter paper on a Buchner funnel. The residue was washed 3–4 times with 50 – 75 ml boiling distilled water. Suction was applied to dry the residue in the Buchner funnel. Then the residue
was transferred to the beaker 200 ml of 1.25% boiling sodium hydroxide was added and the contents were boiled for 30 minutes. The contents were then filtered and washed as before. The residue was dried for 2 hours at 130°C and ignited in a muffle furnace at 550°C to constant weight.

The percentage of crude fiber was determined by the following equation:-

\[
\text{Crude fiber} \% = \frac{W_1 - W_2}{S} \times 100
\]

Where:
W1 = weight of dry residue before ignition
W2 = weight of residue after ignition (ash)
S = original weight of sample

6. Fat content

Fat content was determined according to the method of Pearson (1970), by extracting the dry sample with petroleum ether at 60-80°C in a continuous soxhlet extracting apparatus. 2 grams of dry sample were accurately weighed in an empty thimble and plugged with a piece of cotton wool. The thimble and the material were then placed in soxhlet extractor. A dry accurately weighed (W1) soxhlet flask was fitted to the extractor, and petroleum ether was poured in until the flask was approximately two thirds filled. The solution was heated by an electric heater and extracted for 6–8 hours. The extract was evaporated to dryness in an air-oven overnight at 100°C. The flask was cooled in a dessicator and reweighed (W2). The fat percentage was calculated as follows:

\[
\text{Fat} \% = \frac{W_1 - W_2}{\text{Weight of sample}} \times 100
\]
7. Total carbohydrates

Total carbohydrates were determined by Pomeran and Meloan (1992) and calculated as a percent by the following equation:-

\[ Carbohydrates = 100 - (CP\% + CF\% + FC\% + Ash\% + MC\%) \]

Where:
CP = Crude Protein
CF = Crude Fiber
FC = Fat content
MC = Moisture content

8. Sugar Determinations

i. Reducing Sugars:

Reducing Sugar content was determined by the modified Schneier method described by the I.C.U.M.S.A (1979). A 10 gram sample of the material was extracted with ethanol (70%) for 6 hours in a soxhlet apparatus and the extract was evaporated to 100ml. the solution was clarified by a mixture of 2ml lead acetate and 3ml sodium oxalate solution. In a conical flask, 10ml of Fehling solution (Fehling A and B) were pipetted and about 15ml of the sugar solution were run in from a burette. The mixture was heated to boiling, and the sugar solution was then added drop by drop.

The flask was shaken until the colour changed to a rich green solution, then methylene blue was added. The end point of the titration was when the solution changed colour to red.

Reducing sugars were calculated from the Lane and Enyon table according to the following equation:
Reducing sugars % = \( \frac{\text{Mg of sugar/100ml of solution} \times \text{dilution} \times 100}{1000 \times \text{weight of the sample (g)}} \)

### ii. Total Sugars:
Total sugar content was determined by the modified Schneier method described by the I.C.U.M.S.A (1979). 10 ml of dilute HCL (1:1) was added to 50 ml of the sugar solution and left to stand for overnight. The solution was neutralized by NaOH (40%) using phenolphthaleine, as an indicator. The procedure was repeated and the total sugars were calculated, as in the reducing sugar, from the Invert sugar table.

### 9. Total pectin
Total pectin was estimated according to the method of Person (1976). 0.50 grams of sample was mixed with cold distilled water and the mixture was boiled, extracted and filtered. An aliquot of the filtrate was transferred to 300ml, and then 100ml of 0.1M sodium hydroxide were added and the solution was allowed to stand overnight, then 50ml acetic acid were then added and left to stand for 5 minutes and 50ml of CaCl\(_2\) were added. The solution was then left to stand for another one hour, boiled for few minutes and then filtered. The residue was washed with boiling water until it was free from chlorides, boiled with H\(_2\)O, filtered, dried and weighed as calcium pectate.

### 10. Determinations of Mineral Mineral:
#### i. Preparation of samples for analysis:
Samples were prepared according to the method described by Chapman and Prett (1961). 2 grams of fruit pulp were weighed in a clean dry crucible. The crucible was placed in a Muffle furnace (55°C) for 2 hours. The contents of the crucible were cooled and 10ml of 5N-HCl
were added. The crucible was heated in a hot sand bath for about 10-15 min. The contents were then filtered into a volumetric flask (100 ml) and the solution was made to volume.

ii. **Determination of Iron, zinc, copper, calcium, magnesium, potassium, phosphorus, sulphur and sodium:**

These were determined according to the method described by Stewart (1989), using an Atomic Absorption Spectrophotometer (Perkin Elmer, Model 2330). Different concentrations of standards were used. The cation percentage was calculated as follows:

\[
Cation (\%) = \frac{\text{Reading (ppm)} \times \text{Dilution factor}}{\text{Sample weight (g)}} \times 100
\]

11. **pH Determination**

The pH of 10% solution of calices extract was measured according to the method described by Ruck, (1963) using pH meter [Karl Kold Model Pusl-Munchenz] were calibrated with buffer solution at pH 4 and measurements were taken at room temperature.

12. **Determination of Total Acidity**

The total acidity of the sample was calculated according to the method described by Schilcher, (1979). 50 ml of distilled water were added to 1 g of sample then the mixture was heated in a water bath for five minutes under continuous shaking. The mixer was then filtered while hot through a fluted filter paper into 50 ml volumetric flask. The residue on the filter paper was washed with hot distilled water to a volume less than 50 ml extract. After cooling to room temperature the volume was made to 50 ml with distilled water. A sample volume of 10 ml was titrated against 0.1 N NaOH using
phenolphalein as indicator. The average volume of alkali from triplicate titration was recorded. Taking 1 ml of 0.1 N NaOH equivalent of dominant acid, the total acidity was calculated according to the following formula:

\[ \text{Total acidity} = \frac{V \times e \times D \times 100}{W} \]

Where:
- \( V \) = Average volume of 0.1 N NaOH solution used in titration.
- \( e \) = Milli equivalent weight of dominant acid.
- \( W \) = Weight of sample
- \( D \) = Dilution factor.

13. Determination of Organic acid (Ascorbic acid, Oxalic acid & Citric acid)

The organic acids content was determined by high-performance-liquid chromatography (HPLC) according to the method described by Marsil, et al (1981). Apparatus:-

HPLC (Hewlett pacierd 1050) ultraviolet/visible detector column laypersil ODS sum (4.0 × 250mm).

Reagents:-

Acetonitrile/water (15:25/v: ul were used as mobile phase.
Analatical grade organic acids were used as standards.
Grade acetonitrile was used in sample preparation.

Procedure:-

5 grams of samples were weighed. 0.5 ml distilled water, and 20 ml acetonitril were added in a 50 ml glass centrifuge tube, shaken for 1 min, and centrifuged at 7000 ×G for 5 min. The supernatant was injected into the 10 ul loop with 5 ml syringe fitted with swinney syringe filter holder containing 0.2 um Teflon membrane filters.
Complete duplicate analyses were performed on all samples to enable calculation of average deviations which were useful as a measure of extraction and chromatographic reproducibility.

Initially, aqueous standards of individual acids were chromatographed separately to determine the retention times of each acid. Samples of aqueous acids were then chromatographed (Appendix 1-15). The acid percentage was calculated as follows:

\[
C_i = \frac{C_2 \times Ar_1}{Ar_2}
\]

\[
Acid \% = \frac{C_i}{W} \times 100
\]

Where:

- \( C_i \) = Conc. Of sample
- \( C_2 \) = Conc. Of standard
- \( Ar_1 \) = Aria of sample
- \( Ar_2 \) = Aria of standard
- \( W \) = Weight of sample

14. Determination of some anti nutritional factors

i. Phytic acid:

Phytates of the samples were estimated according to the modified method of Wheeler and Ferrel (1971).

One gram of finely ground sample was weighed into a 100 ml conical flask. It was extracted with 50 ml 3% TCA solution (w/v), containing 10% (w/v) sodium sulphate, then shaken for an hour (Lajolo. et, al. 1991). The slurry obtained was centrifuged at 3000 rpm for 15
minutes. 10 ml aliquot of the supernatant was transferred into 50 ml boiling tubes. 4 ml of FeCl₃ (2 mg Fe³/ml 3% TCA solution) were added and the solution was centrifuged at 3000 rpm for 15 minutes and the clear supernatant was carefully decanted. The precipitate was then washed twice by dispersing well into 25 ml 3% TCA, heated in a boiling water bath (for 10 minutes) and then centrifuged. Washing was repeated once with water. The precipitate was cautiously dispersed in a few mls of distilled water enriched with 3ml 1.5 N NaOH. The volume was made to approximately 30ml with distilled water and heated in a water bath for 30 minutes. The contents of the tube were filtered hot (quantitatively) through Whatman No.1 filter paper and the filtrate was discarded. The precipitate was dissolved with 40ml hot 3.2 N HNO₃ into a 100ml volumetric flask. The filter was washed with several portions of distilled water. The contents in the flask were cooled and diluted to volume with distilled water. Five ml aliquots were transferred to another 100ml volumetric flask and diluted to approximately 70ml with distilled water. The contents in the flask were cooled and diluted to volume with distilled water. Then, 20 ml of 1.5M KSCN (potassium thiocynate) were added, completing the volume up to the mark. The intensity of colour was immediately assessed (within one minute) on a spectrophotometer (corning, 259) at 480 nm. A blank probe was run with each set of samples. The iron content was calculated from a prepared Fe (NO₃)₃ Standard curve. Phytic acid was: calculated from the assumption that it contains 28.20% P (De Boland et al, 1975) and phytate phosphorous from a molar ratio of 4: 6 Fe: P.
**Standard curve of phytic acid:**

The standard curve of phytate was obtained from the following procedure:

0.4321g of ferric nitrate [Fe (NO₃)₃] were dissolved in distilled water in a 1L volumetric flask and made up to mark. This represents a prepared stock solution of 100 µg/ml (i.e. ppm) Fe³⁺ concentration. Concentrations of 0,5,15,20 and 25 µg /ml Fe³⁺ ions were prepared by taking 0,5,15,20 and 25 ml respectively from stock solution into a series of 100 ml volumetric flasks. Distilled water was then added up to mark. 5 ml aliquots from the standards were pipetted into a 100 ml volumetric flask, and diluted up to 70 ml with distilled water. 20 ml of 1.5 M KSCN were then added, and the volume was completed with distilled water. The density of color was read at 480 nm (within one minute) on a spectrophotometer (Corning, 259). A standard curve was obtained by plotting concentrations against corresponding readings of absorbance giving a linear relationship (appendix NO.16).

The percentage of phytic acid was calculated according to the following equation

\[
\text{Phytic acid } \% = \frac{6 \times A \times \text{mean } K \times 20 \times 10}{4 \times 1000 \times 2} \times 100
\]

Where:

A = optical density.

K = concentration corresponding to the optical density.

**ii. Determinations of Polyphenols**

Total polyphenols were determined according to Price and Butler (1977). A 60 mg of sample were shaken manually for 1 min with 3 ml of methanol in a test tube, and then poured into a filter paper. The tube was
quickly rinsed with an additional 3 ml of methanol and the contents poured at once into the filter paper. The filtrate was diluted to 50 ml with distilled water, mixed with 3 ml 0.1 M FeCl₃ in 0.1 N HCl for 3 minutes, followed by the timed addition of 3 ml 0.008 MK₃Fe (CN)₆ . The absorption was read after 10 minutes at 720 nm on a spectrophotometer (Corning, 259) In all cases, tannic acid was used as a reference standard.

The polyphenol content was calculated as follows:-

\[
\text{Polyphenol \% (Tannic acid equivalent)} = \frac{C \times 56}{\text{Weight of Sample}} \times 100
\]

Where:

- \( C \) = Concentration corresponding to optical density
- 56 = Volume of extract

iii. Determination of tannins

Quantitative estimation of tannins was carried out using the modified vanillin – HCl - methanol according to Price and Butler (1978). The reagent was prepared by mixing equal volumes of 1% vanillin-methanol and 8% HCl-methanol. It was discarded if color appeared. Catechin was used to prepare the standard curve (appendix NO.14). This was done by adding 600mg of catechin to 100 ml of 1% HCl in methanol. From this stock solution various dilutions were prepared. 5ml of vanillin/HCl reagent were added to 1 ml of each dilution. The absorbance was read using spectrophotometer (DR/3 Spectrophotometer) at 500 nm after 20 min from addition of the reagent at 30°C. The absorbance was plotted against catechin concentration.

A weight of 0.20g of the sample was placed in a tube. Then 10 ml of 1% HCl/ methanol were added. The test tube was capped and continuously shaken for 20 min and then centrifuged at 2500 rpm for 5
min. 1 ml of the supernatant was pipetted into each of the tubes and the process was repeated as was described in the standard curve above. For zero setting prior absorbance was read, 1ml blank solution was mixed with 5ml of 4% HCl methanol and 5 ml of vanillin in a test tube. The absorption was read at 500nm and the concentration of condensed tannins as catechin equivalent was calculated as follows:-

\[
Tannin \% = \frac{C \times 10}{200}
\]

Where

\( C = \) Concentration corresponding to the optical density
\( 10 = \) Volume of extract
\( 200 = \) Sample weight (mg).

**3.3 Statistical Analysis:**

Statistical Analysis was done according to t-test with probability P=0.01.

(Steel and Torrey, 1960).
Chapter 4
Results and Discussion

4.1 Botanical Description And Distribution

Botanical Description of Tabaldi:

Family Name : Bombacaceae
Botanical Name : Adanasonia digitata
Local Name : Tabaldi
Other Name : Baobab

Tabaldi tree has been described as a large tree often of great girth, whitish bark, sometimes purplish, shining. There are variations for the leaf size and shape.
Leaves digitally 5-foliate, long-petiolate; leaflets sub sessile, oblong-elliptic to obovate, acutely acuminate at the apex, entire or denticulate, up to 10.5 cm long and 4.4 cm broad, stellate pubescent or nearly glabrous beneath. (Andrews, 1956; Wickens, 1987; Almustafa, 2003).
The flowers are, white large, pendulous on long stalks as reported by Dalziel, (1948); calyx deeply 5-lobed, very hirsute tomentose on both surfaces; petals setose outside. The flowering season is between June and September. Fruits ripen from October to January.
Fruits are capsules, ellipsoid, oblong or globular 20-30cm long and up to 10cm in diameter, covered on the outside with greenish-brown felted hairs; seeds numerous, hard, brownish, rounded or avoid, up to 15 cm long, embedded in a yellowish-white, floury acidic pulp, arranged in rows, in two to eight locales per fruit, attached to a fibrous stand from wall of the fruit. (Nour., et al, 1980; Almustafa, 2003)
**Distribution of Tabaldi:**

The habitat of tabaldi is the hot, dryer regions of tropical Africa and extends from northern Transvaal and Namibia to Ethiopia, Sudan and the southern fringes of the Sahara. (Wickens, 1980)

In Sudan the tree is found in the central regions with annual rainfall of 600-1000mm, sandy soils, and mountain khorsides in the short grass savanna. It forms a belt in central Sudan, Kordofan, Darfur, Blue Nile, Upper Nile and Bahr Elghazal. However, a good tree growth is found in southern Kordofan. (Elamin, 1990; Almustafa, 2003).

**Botanical Description of Guddeim:**

Family Name : Tiliaceae  
Botanical Name : *Grewia tenax*  
Local Name : Guddeim

Guddeim plant is found in different forms as a tree, a shrub or scrabbling with a height ranging between 2-3 meters; bark dark-brown to grey, smooth and dolled with small white spots. Leaves small, 1.5-4.0cm wide, dentate, wrinkled, glabrous or pubescent; petioles slender, about 1.0-1.5cm long. Inflorescence mostly cymose; flowers actinomorphic; sepalts and petals free, usually numerous, rarely connate, in 5-10 bundles; ovary syncarpous or very rarely apocarpous. (Baumier, 1983; Von Maydell, 1988; Elamin, 1990).

Fruits drupaceous or variously dehiscent, glabrous, smooth, shiny, fleshy, orange or red when ripe with 1-4 lobed in the size of a maize kernel. They are sweet scented and edible. Seeds are different in size, very hard hairy coated and have two locules in which two kernels are imbedded with one kilograms containing about 19000-21000 seeds (Von Maydell, 1988; Rahamtalla, 1999).
Distribution of Guddeim:
FAO/WHO (1988) reported that *Grewia tenax* distribution is discontinuous, being in arid zones from Morocco, Mauritania, Senegal to India, southern Algeria, northern Burkina Faso, Niger, Chad, Sudan, east Africa, south Africa, Namibia and Botswana. The habitat includes sandy depressions, dunes, clay soils, temporary pools and rocky soils.
In Sudan the plant is very common in the northern and central parts e.g. Blue Nile, White Nile, Darfur, Kordofan, Kasala, Upper Nile, Bahr Elghazal and Equatoria. The fruits appear from December to July. Guddeim is mainly found in Milleit and Kutum (northern Darfur) and limited amounts are produced in southern Darfur, northern and southern Kordofan.

Botanical Description of Aradeib
Family Name : Caesalpiniaceae
Botanical Name : *Tamarindus indica*
Local Name : Aradeib
Other Name : *Tamarind*

Aradeib plant has been described as an ever-green tree up to 15cm high with a stout pole and compact rounded crown, with dropping branches which often reach to within a few feet of ground; bark pale-grey with scales about 2.20cm in diameter; slash pale-red. Leaves up to 13cm long; leaflets usually in 10-15 pairs, opposite, oblong, rounded or emarginated at the apex, unequally rounded at the base, 1.10-2.20cm long, and 6-5 cm broad. Flowers about 2.20cm in diameter, in small slender dropping racemes, usually about 7cm long; bracteoles valvate, enclosing the flower-bud, falling early; sepals 4, yellow inside, reddish outside; petals 3, yellow streaked with red or orange. Pods pale-brown,
variable, more or less oblong, about 8cm long, usually curved, with a brittle shell; seeds 1-10, joined one to another by tough fibers running through the sticky pulp. (Andrews, 1956; and Abdelmuti, 1993).

**Distribution of Aradeib:**

Duke (1981) reported that the species of aradeib is a native of tropical Africa and India. It has now spread throughout the tropics and subtropics of the world and self-sown in all regions. This plant grows wild in most parts of the Sudan, especially south Kordofan and south Darfur.

**4.2 Chemical Composition:**

**Ash Content**

Table 1 shows that A. digitata, Darfur had the highest ash content (5.70%), where as T. indica, Darfur had the lowest value (2.40 %). The result obtained for A. digitata, Darfur was in agreement with that of Nour., et al (1980), Abdelmuti, (1991) and Almustafa, (2003) who found values of ash content of (5.30 %), (5.80 %) and (5.60 %) respectively. However the value was lower than the results reported by Okaho, (1984), who found that A. digitata, Darfur contained (7.00%) ash. The ash content of A. digitata, Kordofan (4.60%) was lower than that of A. digitata, Darfur and that a significant difference P=0.01 was found between A. digitata, Darfur and A. digitata, Kordofan. Ash content of G. tenax, Darfur (4.60%) was within the range given by Rahmatalla, (1990) and in agreement with that of Abdelmuti, (1991). The results obtained for G. tenax, Kordofan were lower than the results cited by Rahmatalla, (1990) and Abdelmuti, (1991). A significant difference
was found between the ash content of G. tenax, Darfur and G. tenax, Kordofan.

The ash content of T. indica, Darfur was lower than the results obtained by both Abdelmuti, (1991) and Ishola and Agbaji, (1990) but the result of T. indica, Kordofan was in agreement with that of Abdelmuti, (1991) and slightly higher than that of Ishola and Agbaji, (1991). A significant difference was found between the ash content T. indica, Darfur and T. indica, Kordofan.

**Moisture Content**

The lowest and highest moisture content were found to be (6.10%) for T. indica, Kordofan and (15.2%) for T. indica, Darfur respectively (Table 1). The results obtained for the moisture contents in A. digitata, Darfur (6.50%) and A. digitata, Kordofan (6.90%) were comparable to values reported by Nour et al (1980) but were lower than the results reported by Almustafa, (2003). A significant difference was found between the moisture contents of A. digitata, Darfur and A. digitata, Kordofan.

The moisture contents for G. tenax, Darfur (12.70%) and G. tenax, Kordofan (13.40%) were in agreement with those of Rahmatalla, (1999) but higher than those of Boutros, (1986). A significant difference was also found between the moisture contents for G. tenax, Darfur and G. tenax, Kordofan.

The moisture content of T. indica, Darfur was higher than T. indica, Kordofan and lower than that of Ishola and Agbaji, (1990). A significant difference was found between T. indica, Darfur and T. indica, Kordofan in their moisture content (table 1).
**Crude Protein Content**

The crude protein ranged from (2.30%) to (8.40%) and that the highest protein content was found in Gt.k and the lowest was in A. digitata Kordofan (Table 1). The protein content of A. digitata, Darfur was in agreement with that of Nour et al, (1980) and Abdelgalil (1996), but lower than those reported by Abdelmuti, (1990) and Almustafa, (2003). However, the results were slightly higher than those reported by Okaho, (1984) and Obizoba and Angha, (1996). An insignificant difference was found between A. digitata, Darfur and A. digitata Kordofan in the protein content.

The crude protein of highest value of fiber content was found to be (7.50%) which was in agreement with those reported by Hamad, (1995) and Rahmatalla, (1999). However, the value was lower compared to Bourtors, (1986) but higher than the values reported by Abdelmuti, (1991). The crude protein of G. tenax, Kordofan was found to be higher than the crude protein content of G. tenax, Darfur and higher than those reported by Bourtors (1986), Abdelmuti, (1991), Hamaed, (1995) and Rahmatalla, (1999). An insignificant difference was found between Gt.d and Gt.k in their crude protein contents.

The crude protein content of T. indica, Darfur was higher than that of T. indica, Kordofan but it was in agreement with the results reported by Abdelmuti, (1991). Nevertheless, the value was lower than that reported by Ishola and Agbaji, (1990). An insignificant difference between the crude protein content of T. indica, Darfur and T. indica, Kordofan was found.
**Fat Content**

A. digitata, Darfur had the highest value of fat content (0.60 %) and T. indica, Kordofan had the lowest value (0.08 %) (Table1). Fat contents of Ad.d and A. digitata, Kordofan were higher than those reported by Nour, et al, (1980); Okaho, (1984); Obizoba and Anglea, (1996) and Abdelgalil (1996) but significantly lower than those reported by Almustafa, (2003). The results reported by this study was comparable to the results obtained by Abdelmuti (1991). A Significant difference was found between A. digitata, Darfur and A. digitata, Kordofan in the fat contents.

Fat content of G. tenax, Darfur are similar to the result reported by Hamed (1995) and in the range cited by Rahmatalla, (1999). The fat content of Gt.k was in agreement with Bourtors, (1986) and slightly higher than those reported by Hamed (1995); Rahmatalla (1999) and Abdelmuti (1991). A significant difference was found.

T. indica, Darfur was found to contain (4.50 %) which is comparable to value reported by Abdelmuti, (1999) and lower than the value reported by Ishola and Agbaji (1990). T. indica, Kordofan was found to contain (3.20 %) which was lower than that of T. indica, Darfur. An insignificant difference was found between T. indica, Darfur and T. indica, Kordofan. in their fat contents.

**Fiber Content**

The highest value of fiber content was found for G. tenax, Darfur (8.97 %) and the lowest was found for T. indica, Kordofan (4.20 %) (table1) The fiber content of Ad.d was in agreement with the results obtained by Nour, et al (1980) and Abdelgalil (1996) but lower than the results reported by Okaho (1984) and Abdelmuti (1991). An insignificant difference was found between A. digitata, Darfur and A. digitata,
Kordofan. in their fiber contents. The fiber content of G. tenax, Darfur and Gt.k (8.82 %) were in agreement with the results reported by Abdelmuti, (1991) and Hamed, (1995) and lower than the result obtained by Boutros (1986). An insignificant difference was found between G. tenax, Darfur and G. tenax, Kordofan.

The fiber content of T. indica, Darfur was (5.95 %) which was comparable to the value reported by Abdelmuti (1991). T. indica, Darfur and T. indica, Kordofan had lower values compared to the results obtained by Ishola and Agbaji (1990). A significant difference was found between T. indica, Darfur and T. indica, Kordofan. in the fiber content.

**Carbohydrates Content**

The highest value of carbohydrates was found for T. indica, Kordofan (82.90 %) and the lowest was found for G. tenax, Darfur (66.00 %). The total carbohydrates contents of A. digitata, Darfur and A. digitata Kordofan were found to be (79.49 %) and (74.21 %) respectively. The values were comparable to those reported by Nour et al (1980) and Almustafa (2003) but slightly lower than the result reported by Okaho (1984). An insignificant difference was found between A. digitata, Darfur and A. digitata Kordofan. in the carbohydrates content.

Carbohydrate content of G. tenax, Darfur and G. tenax Kordofan was found to be (66.00 %) and (65.33 %) respectively. These values were in agreement with the results reported by Boutros (1986) and Hamd (1995). An insignificant difference was found between G. tenax, Darfur and G. tenax Kordofan. in their carbohydrates content.

T. indica, Kordofan carbohydrates content was found to be close to the value reported by Abdelmuti (1991). The carbohydrates content for T. indica, Darfur (71.80%) is higher than that reported by Ishola and Agbaji,
(1990). An insignificant difference was found between T. indica, Darfur and T. indica, Kordofan in the carbohydrates contents.
Table (1)

Chemical composition of fruits of (Tabaldi, Guddiem, Aradeib).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Ash Content %</th>
<th>Moisture Content %</th>
<th>Crude Protein %</th>
<th>Fat Content %</th>
<th>Fiber Content %</th>
<th>Carbohydrate Content %</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. digitata Darfur</td>
<td>5.7</td>
<td>6.5</td>
<td>2.5</td>
<td>0.6</td>
<td>5.97</td>
<td>79.27</td>
</tr>
<tr>
<td>A. digitata Kordofan</td>
<td>4.6</td>
<td>6.9</td>
<td>2.3</td>
<td>0.52</td>
<td>6.47</td>
<td>79.21</td>
</tr>
<tr>
<td>G. digitata Darfur</td>
<td>4.6</td>
<td>12.7</td>
<td>7.5</td>
<td>0.21</td>
<td>8.97</td>
<td>66.02</td>
</tr>
<tr>
<td>G. digitata Kordofan</td>
<td>3.7</td>
<td>13.4</td>
<td>8.4</td>
<td>0.35</td>
<td>8.82</td>
<td>65.33</td>
</tr>
<tr>
<td>T. digitata Darfur</td>
<td>2.4</td>
<td>15.2</td>
<td>4.5</td>
<td>0.15</td>
<td>5.95</td>
<td>71.8</td>
</tr>
<tr>
<td>T. digitata Kordofan</td>
<td>3.5</td>
<td>6.1</td>
<td>3.2</td>
<td>0.08</td>
<td>4.2</td>
<td>82.92</td>
</tr>
</tbody>
</table>
Chemical composition of fruits of (Tabaldi, Guddiem, Aradeib).
**Fig(1-1)**

Chemical composition of Tabaldi fruits.
Chemical composition of Guddeim fruits.

*Fig(1-2).*
Chemical composition of Aradeib fruits.

*Fig(1-3).*
**Total sugars**

The Total sugars ranged from the highest value (27.44%) for G. tenax, Kordofan to the lowest value (14.73%) for A. digitata, Kordofan. The results of A. digitata, Darfur and A. digitata, Kordofan were lower than the result reported by Nour et al. (1980) and Almustafa (2003). A significant difference was found between A. digitata, Darfur and A. digitata, Kordofan.

There was significant difference in the total sugars for G. tenax, Darfur (18.44%) and G. tenax, Kordofan (27.44%).

The total sugar of T. indica, Darfur (17.71%) was lower than T. indica, Kordofan (22.60%). A significant difference was found between the total sugar content of T. indica, Darfur and T. indica, Kordofan.

**Reducing sugars**

G. tenax, Kordofan (21.30%) has highest value reducing sugars while the lowest value for was found in T. indica, Kordofan (11.37%) (Table 2). The reducing sugars content in A. digitata, Darfur and A. digitata, Kordofan were found to be (12.54%) and (14.13%) respectively, and that the values were lower than those g. Nour et al (1980) and Almustafa, (2003). A significant difference was found between A. digitata, Darfur and A. digitata, Kordofan in the reducing sugars content.

Reducing sugars of G. tenax, Darfur were found to be lower than those sugars of G. tenax, Kordofan, and an insignificant difference was found, between them.

Reducing sugars of T. indica, Darfur was found to be (11.96%) which was comparable with the result of T. indica, Kordofan (11.37%) but the result of T. indica, Darfur and T. indica, Kordofan disagreed with those reported by Isholo and Agbaji, (1990) and an insignificant difference was found between them.
Pectin

T. indica, Darfur had the highest value of pectin content (58.05%), where T. indica, Kordofan had the lowest value (1.65%). A. digitata, Darfur was found to contain (55.73%) which is lower than A. digitata, Kordofan but agrees with the result reported by Nour, et al (1980) and Almustafa, (2003). An insignificant difference was found between A. digitata, Darfur and A. digitata, Kordofan in their pectin content.
G. tenax, Darfur was found to contain (15.74%) of pectin which is lower than the pectin in G. tenax, Kordofan (19.38%). A significant difference was found between G. tenax, Darfur and G. tenax, Kordofan in their pectin content.
T. indica, Darfur was found to contain (1.76%) while that of T. indica, Kordofan was found to contain (1.65%) and an insignificant difference was found between the pectin contents of the two species.
**Table (2)**

Total Sugars, Reducing Sugars and Pectin of Fruits of Tabaldi, Guddeim, Aradeib.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Total Sugar %</th>
<th>Reducing Sugar %</th>
<th>Pectin %</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. digitata. Darfur</td>
<td>15.49</td>
<td>12.54</td>
<td>55.73</td>
</tr>
<tr>
<td>A. digitata. Kordofan</td>
<td>14.73</td>
<td>14.24</td>
<td>58.05</td>
</tr>
<tr>
<td>G. digitata. Darfur</td>
<td>18.44</td>
<td>16.87</td>
<td>15.74</td>
</tr>
<tr>
<td>G. digitata. Kordofan</td>
<td>27.44</td>
<td>21.30</td>
<td>19.38</td>
</tr>
<tr>
<td>T. digitata. Darfur</td>
<td>17.71</td>
<td>11.96</td>
<td>1.76</td>
</tr>
<tr>
<td>T. digitata. Kordofan</td>
<td>22.60</td>
<td>11.37</td>
<td>1.65</td>
</tr>
</tbody>
</table>
**Fig (2).**

Total Sugars, Reducing Sugars and Pectin of Fruits of Tabaldi, Guddeim, Aradeib.
Fig (2-1).

Total Sugars, Reducing Sugars and Pectin of Tabaldi Fruits.
Total Sugars, Reducing Sugars and Pectin of Guddeim Fruits.

Fig (2-2).
Total Sugars, Reducing Sugars, and Pectin of Aradeib Fruits.

Fig (2-3).
Mineral Composition of Fruits:

Ca

A. digitata, Darfur had the highest value of Ca. content (0.54 %) where T. indica, Kordofan had the lowest value (0.19 %), as shown in Table 3. A. digitata, Kordofan was found to contain (0.46 %) compared to a (0.54 %) for value of A. digitata, Darfur. This result is close to the results reported by Egan (1981), Abdelmuti (1991) and higher than those reported by Nour et al (1980) and Abdelgalil (1996). An insignificant difference was found between the Ca contents of the two samples of Adansonia.

G. tenax, Darfur was found to contain 0.32 % Ca which was slightly lower than that found for G. tenax, Kordofan of 0.44 %. It was found to be lower than that reported by Abdelmuti (1991) but the difference between the two values for G. tenax, Darfur and G. tenax, Kordofan was insignificant.

T. indica, Darfur was found to contain 0.22 % Ca. This result is close to that of T. indica, Kordofan (0.19 %) and was in agreement with the values reported by Abdelmuti (1991). However, the result disagreed with those reported by Ishola and Agbji, (1990). An insignificant difference was found between the two values for T. indica, Darfur and T. indica, Kordofan.

Mg

T. indica, Darfur had the highest Mg content (0.21%) where as G. tenax, Kordofan had the lowest value (0.13 %) as shown in Table 3. Almost similar values for Mg were obtained for A. digitata, Darfur and A. digitata Kordofan (0.19 %) and (0.18 %) respectively. The values obtained were close to those reported by Egan (1981) and Abdelmuti, (1991).
insignificant difference was found between the two values for A. digitata, Darfur and A. digitata Kordofan.

G. tenax, Darfur was found to contain (0.16 %) which was slightly higher than that of G. tenax Kordofan (0.13%) and an insignificant difference was found forms between G. tenax, Darfur and G. tenax Kordofan.

T. indica, Kordofan was found to contain 0.16 %Mg which is slightly lower than that of T. indica, Darfur (0.21%) this result is slightly higher than those reported by Abdelmuti (1991) and varies much from the results reported by Ishola and Agbaji (1990).

**Na**

A. digitata, Darfur had the highest value of Na content (0.18 %), where T. indica, Darfur had the lowest value (0.04 %). (Table 3) A. digitata Kordofan was found to contain 0.14 % which was slightly lower than that of A. digitata Kordofan and disagree with the results reported by Abdelmuti (1991) and Egan (1981). The difference between the values of Na for A. digitata, Darfur and A. digitata Kordofan were significant. G. tenax, Darfur was found to contain 0.14 % which was slightly higher than that of G. tenax Kordofan 0.08% and higher than that reported by Abdelmuti (1991). An insignificant difference was found between the values of Na for the two Gt. studied.

T. indica, Kordofan was found to contain 0.07% which was higher than that reported by Abdelmuti (1991) and slightly lower than that reported by Ishola and Agbaji (1990). An insignificant difference was found between the values for T. indica, Kordofan and T. indica, Darfur.

**K**

A. digitata, Darfur had the highest value of K content (1.10 %) where as T. indica, Darfur had the lowest value (0.32 %) (Table 3) A.
digitata Kordofan was found to contain 1.08 % of K which is close to the K content of A. digitata, Darfur. These results were in agreement with those reported by Egan (1981) but disagreement with the values reported by Abdelmuti (1991) and Abdelgalil (1996).

G. tenax, Darfur was found to contain (0.92 %) which was higher than that of G. tenax Kordofan (0.58%). It was slightly lower than that reported by Abdelmuti (1991) and a significant difference was found between G. tenax, Darfur and G. tenax Kordofan.

T. indica, Darfur was found to contain (0.32 %) which was lower than that of T. indica, Kordofan These 0.54% results were in disagreement with values reported by Abdelmuti (1991) and Ishola and Agbaji (1990) and the difference was significant at P=0.01 between the values for T. indica, Darfur and T. indica, Kordofan.

Cu
A. digitata, Darfur had the highest value of Cu content (0.0015 %) while the values recorded for T. indica, Darfur and T. indica, Kordofan were 0.0006 %. This was the lowest value in the samples and was in agreement with the result reported by Abdelmuti (1991) an insignificant difference was found in the Cu content of T. indica, Darfur and T. indica, Kordofan.

A. digitata Kordofan was found to contain (0.0008 %) similar to that recorded by Abdelmuti (1991). A. digitata, Darfur was found to have the same value as that reported by Tiery, (1993) and the difference between A. digitata, Darfur and A. digitata Kordofan was found, to be insignificant.

G. tenax, Darfur was found to contain 0.0009 % which is slightly higher than that of G. tenax Kordofan 0.0007 % This is similar to the values
reported by Abdelmuti (1991) and an insignificant difference was found between G. tenax, Darfur and G. tenax Kordofan.

Zn

A. digitata, Darfur had the highest value of Zn content (0.0026 %), where as T. indica, Darfur had the lowest value (0.0012 %). (Table 3) A. digitata, Kordofan was found to contain 0.0021 % which was slightly lower than that of Ad.d. This result is higher than that reported by Abdelmuti (1991) and Abdelgalil (1996) and an insignificant difference was found, between A. digitata, Kordofan and A. digitata, Darfur. G. tenax, Darfur was found to contain 0.0017 % which was slightly higher than that of G. tenax, Kordofan (0.14%) This result is in the range reported by Rahmtalla, (1999), and an insignificant difference was found, between G. tenax, Darfur and G. tenax, Kordofan. The Zn content of T. indica, Darfur was found to be slightly lower than that of T. indica, Kordofan (0.0014%) and was in agreement with those reported by Abdelmuti (1991) and Ishola and Agbaji, (1990). An insignificant difference was found, between T. indica, Kordofan and T. indica, Darfur.

Fe

The highest Fe content was in T. indica, Kordofan 0.0248% and the lowest value obtained was in T. indica, Darfur 0.0105% (Table3). These were closely followed by G. tenax, Darfur (0.0208%) and A. digitata, Darfur (0.0109%) as the second highest and lowest values respectively. The other fruits showed values of G. tenax Kordofan (0.0128%) and A. digitata Kordofan (0.0154%). There was a significant difference found between A. digitata, Darfur and A. digitata Kordofan and also between T. indica, Darfur and T. indica, Kordofan.
An insignificant difference was recorded for G. tenax, Darfur and G. tenax Kordofan.

P

A. digitata, Darfur had the highest value of P content (0.18 %) where as T. indica, Darfur had the lowest value (0.10 %). A. digitata Kordofan was found to contain 0.14 % which was comparable to the value of A. digitata, Darfur This result was higher than that reported by Nour et al, (1980) and Abdelmuti (1991). An insignificant difference was found between A. digitata Kordofan and A. digitata, Darfur G. tenax, Darfur was found to contain 0.15 % which was close to that of G. tenax Kordofan These results were slightly higher than those reported by Abdelmuti (1991) and an insignificant difference was found, between G. tenax, Darfur and G. tenax Kordofan T. indica, Darfur was found to content 0.10 % and T. indica, Kordofan contains 0.11 % these values were similar to those reported by Abdelmuti (1991) but they disagreed with values reported by Ishola and Agbaji (1990).

S

The results presented in table 3 showed that there was a slight variation in the S content of the fruit samples. T. indica, Darfur had the highest value at 0.19% and the lowest value was for G. tenax Kordofan (0.12%). A. digitata, Darfur 0.18% S value and A. digitata, Kordofan had 0.17% S value and these values were very similar and that there was an insignificant difference, between A. digitata, Darfur and A. digitata, Kordofan.
G. tenax, Darfur had 0.15% S and that was slightly higher than that of G. tenax, Kordofan. An insignificant difference was found between the samples.
The S content for T. indica, Kordofan 0.15% was a little lower than that of T. indica, Darfur, and an insignificant difference for S was found, between the samples.
Table (3).

Mineral Composition of Fruits of (Tabaldi, Guddeim, Aradeib).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Ca %</th>
<th>Mg %</th>
<th>Na %</th>
<th>K %</th>
<th>Cu %</th>
<th>Zn %</th>
<th>Fe %</th>
<th>P %</th>
<th>S %</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.digitata.Darfur</td>
<td>0.54</td>
<td>0.19</td>
<td>0.18</td>
<td>1.1</td>
<td>0.0015</td>
<td>0.0026</td>
<td>0.0109</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>A.digitata.Kordofan</td>
<td>0.46</td>
<td>0.18</td>
<td>0.14</td>
<td>1.08</td>
<td>0.0008</td>
<td>0.0021</td>
<td>0.0154</td>
<td>0.14</td>
<td>0.17</td>
</tr>
<tr>
<td>G.digitata.Darfur</td>
<td>0.32</td>
<td>0.16</td>
<td>0.14</td>
<td>0.92</td>
<td>0.0009</td>
<td>0.0017</td>
<td>0.0208</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>G.digitata.Kordofan</td>
<td>0.44</td>
<td>0.13</td>
<td>0.08</td>
<td>0.58</td>
<td>0.0007</td>
<td>0.0014</td>
<td>0.0128</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>T.digitata.Darfur</td>
<td>0.22</td>
<td>0.21</td>
<td>0.04</td>
<td>0.32</td>
<td>0.0006</td>
<td>0.0012</td>
<td>0.0105</td>
<td>0.1</td>
<td>0.19</td>
</tr>
<tr>
<td>T.digitata.Kordofan</td>
<td>0.19</td>
<td>0.16</td>
<td>0.07</td>
<td>0.54</td>
<td>0.0006</td>
<td>0.0014</td>
<td>0.0248</td>
<td>0.11</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Mineral Composition of Fruits of (Tabaldi, Guddeim, Aradeib).

Fig (3-1).
Mineral Composition of Guddeim Fruits.

Fig (3-2).
Mineral Composition of Aradeib Fruits.

Fig (3-3).
Total Acidity and pH:

Total Acidity

Table 4, showed that the T. indica, Darfur had highest value of total acidity (18.60%) and G. tenax, Darfur had the lowest value (1.36%). A. digitata, Darfur was found to contain 8.83% which was slightly higher than that of A. digitata, Kordofan (8.41%). This result was in agreement with the result reported by Almustafa (2003), and the difference was found, to be insignificant.

G. tenax, Kordofan was found to contain (1.84%) which was slightly higher than total acidity of G. tenax, Darfur and an insignificant difference was. T. indica, Kordofan was found to contain (15.50%) which was lower than that for T. indica, Darfur and a significant difference was found between the T. indica, Kordofan and T. indica, Darfur samples.

pH

Table 4, showed that the Gt.d (4.41) had highest pH value and T. indica, Darfur had the lowest value (2.86). The pH value of A. digitata, Darfur (3.14) and A. digitata, Kordofan (3.21), were in agreement with the results reported by Almustafa (2003). An insignificant difference was found between A. digitata, Darfur and A. digitata, Kordofan pH value of Gt.d was value of Gt.k (4.325) and an insignificant difference was found.

The T. indica, Kordofan was found to have a pH of (3.05) which similar to the value of T. indica, Darfur and an insignificant difference was found between the samples.
Table (4).

pH and Total acidity of fruits of Tabaldi, Guddeim, Aradeib.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pH</td>
<td>3.14</td>
<td>3.21</td>
<td>4.41</td>
<td>4.32</td>
<td>2.86</td>
<td>3.05</td>
</tr>
<tr>
<td></td>
<td>Total acidity %</td>
<td>8.83</td>
<td>8.41</td>
<td>1.36</td>
<td>1.84</td>
<td>18.6</td>
<td>15.5</td>
</tr>
</tbody>
</table>
Fig (4-1).

pH of fruits of Tabaldi, Guddeim, Aradeib.
Total acidity of fruits of Tabaldi, Guddeim, Aradeib.

Fig(4-2)
Organic Acids:

Ascorbic Acid

Table 5 shows the values of ascorbic acid contents obtained for the different types of fruit pulps, ranging from 0.0029% to 0.2436%. The highest value of ascorbic acid was found for A. digitata, Darfur, while the lowest was found for T. indica, Kordofan. A. digitata, Darfur and A. digitata, Kordofan were found to contain almost similar amounts which was in agreement with those reported by Nour et al (1980); Sidibi et al (1996) and slightly lower than those reported by Eromosde et al (1991), Tierng, (1993), Abdelgalil, (1996), Abdelgader; (1991). The values were higher than those reported by Agbissi-Dos-Satos, (1987) and Saka, (1992). An insignificant difference was found between A. digitata, Darfur and A. digitata, Kordofan.

The ascorbic acid of G. tenax, Darfur was found to be 0.0101% which is comparable to values reported by Rahmatalla, (1999). G. tenax, Kordofan content of ascorbic acid (0.055%) was slightly higher than the result recorded by Rahmatalla, (1990). T. indica, Darfur was found to contain 0.0079% of ascorbic acid which was higher than that recorded for T. indica, Kordofan.

Oxalic Acid

In table 5, the oxalic acid of the fruits pulp was found to range from 0.4090% to 2.9432%. The highest value was found for A. digitata, Darfur and the lowest was found for T. indica, Kordofan.

Oxalic acid of the A. digitata, Darfur was higher than A. digitata Kordofan (2.01837%).

The Oxalic acid of G. tenax, Darfur was 0.5950% this value was higher than that of G. tenax Kordofan (0.5040%). Moreover the oxalic acid
content of *T. indica*, Darfur was found to be 0.4260% which was comparable to the value for *T. indica*, Kordofan.

**Citric Acid**

From table 5, it could be observed that Ad.d had a higher value of citric acid (4.6275%) while *T. indica*, Darfur had no citric acid content at all. Citric acid content in *A. digitata*, Darfur was found to be higher than that of *A. digitata* Kordofan (2.8710%) while citric acid in *G. tenax*, Darfur (3.8285%) was higher than that of *G. tenax* Kordofan (2.9394%).
Table (5).

Some of the Organic Acids of Fruits of Tabaldi, Guddeim, Aradeib.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Ascorbic acid %</th>
<th>Oxalic acid %</th>
<th>Citric acid %</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A. digitata. Darfur</em></td>
<td>0.2436</td>
<td>2.9432</td>
<td>4.6275</td>
</tr>
<tr>
<td><em>A. digitata. Kordofan</em></td>
<td>0.2334</td>
<td>2.01837</td>
<td>2.8710</td>
</tr>
<tr>
<td><em>G. digitata. Darfur</em></td>
<td>0.0101</td>
<td>0.5950</td>
<td>3.8285</td>
</tr>
<tr>
<td><em>G. digitata. Kordofan</em></td>
<td>0.0550</td>
<td>0.5040</td>
<td>2.9354</td>
</tr>
<tr>
<td><em>T. digitata. Darfur</em></td>
<td>0.0079</td>
<td>0.4260</td>
<td>0.000</td>
</tr>
<tr>
<td><em>T. digitata. Kordofan</em></td>
<td>0.0029</td>
<td>0.4090</td>
<td>0.000</td>
</tr>
</tbody>
</table>
Fig (5).

Some of the Organic Acids of Fruits of Tabaldi, Guddeim, Aradeib.
Some Organic Acids of Tabaldi Fruits.
Some Organic Acids of the Fruits of Guddeim

Fig (5-2).

Some Organic Acids of the Fruits of Guddeim.
Some Organic Acids of the Aradeib Fruits.

*Fig (5-3).*
4.3 Some antinutritional factors of the fruits

Phytic Acid

Table 6 showed that the highest value of phytic acid content was found in A. digitata Kordofan (0.031%) and the lowest one was found for A. digitata, Darfur (0.019 %). An insignificant difference was found between A. digitata, Darfur and A. digitata Kordofan.

Phytic acid content was found to be 0.023% for G. tenax, Darfur which was comparable to the value for G. tenax Kordofan (0.021%) and an insignificant difference was found between G. tenax, Darfur and G. tenax Kordofan.

Similar result were obtained for T. indica, Darfur and T. indica, Kordofan as 0.027% 0.029% respectively and an insignificant difference was found between the two samples.

Polyphenol

From table 6, it could be inferred that A. digitata, Darfur has the highest value of polyphenols (1.650%) while T. indica, Kordofan has the lowest value (0.920%). Polyphenols in A. digitata Kordofan were found to be 1.480%. It is comparable similar to that of A. digitata, Darfur and an insignificant difference was found between A. digitata Kordofan and A. digitata, Darfur.

The polyphenols content of G. tenax, Kordofan (1.400%) was close to the polyphenol content of G. tenax, Darfur (1.260%) and an insignificant difference was found between them.

Polyphenols content of T. indica, Darfur (1.080%) was slightly higher than that of T. indica, Kordofan and a significant difference was found between T. indica, Darfur and T. indica, Kordofan.
Tannins

Table 6, showed that G. tenax Kordofan had the highest value of tannins (1.290%) and the lowest value was in T. indica, Kordofan (0.150%). It could be inferred from the table that the A. digitata, Darfur content of tannins (1015%) was higher than that of A. digitata, Kordofan (0.780%) and a significant difference was found between A. digitata, Kordofan and A. digitata, Darfur. The tannins value of G. tenax, Kordofan was found to be slightly higher than that of G. tenax, Darfur (0.810%) and an insignificant difference was found. Tannins content of T. indica, Darfur (0.270%) was more than that of Ti.k but an insignificant difference was found between the samples.
### Table (6).

Some Antinutritional Factors of the Fruits of Tabaldi, Guddeim, Aradeib

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Phytic Acid</th>
<th>Polyphenols</th>
<th>Tannins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td><em>A. digitata</em> Darfur</td>
<td>0.019</td>
<td>1.650</td>
<td>1.150</td>
</tr>
<tr>
<td><em>A. digitata</em> Kordofan</td>
<td>0.031</td>
<td>1.480</td>
<td>0.780</td>
</tr>
<tr>
<td><em>G. digitata</em> Darfur</td>
<td>0.023</td>
<td>1.260</td>
<td>0.810</td>
</tr>
<tr>
<td><em>G. digitata</em> Kordofan</td>
<td>0.021</td>
<td>1.400</td>
<td>1.290</td>
</tr>
<tr>
<td><em>T. digitata</em> Darfur</td>
<td>0.027</td>
<td>1.080</td>
<td>0.270</td>
</tr>
<tr>
<td><em>T. digitata</em> Kordofan</td>
<td>0.029</td>
<td>0.920</td>
<td>0.150</td>
</tr>
</tbody>
</table>
Phytic acid of the Fruits of Tabaldi, Guddeim, Aradeib.

Fig(6)
Fig (6-1).

Polyhenols of the Fruits of Tabaldi, Guddeim, Aradeib.
Fig (6-2).

Tannins of the Fruits of Tabaldi, Guddeim, Aradeib.
Table (7) Summary of Results of the Chemical Analysis of Tabaldi, Guddeim and Aradeib

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Tabaldi</th>
<th>Guddeim</th>
<th>Aradeib</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Darfur</td>
<td>5.7</td>
<td>4.6</td>
<td>4.6</td>
</tr>
<tr>
<td>Kordofan</td>
<td>4.0</td>
<td>3.7</td>
<td>2.4</td>
</tr>
<tr>
<td>Ach content %</td>
<td>6.5</td>
<td>6.9</td>
<td>12.7</td>
</tr>
<tr>
<td>Moisture content%</td>
<td>2.5</td>
<td>2.3</td>
<td>7.5</td>
</tr>
<tr>
<td>Crude Protein%</td>
<td>0.6</td>
<td>0.52</td>
<td>0.21</td>
</tr>
<tr>
<td>Fat content %</td>
<td>5.97</td>
<td>6.47</td>
<td>8.97</td>
</tr>
<tr>
<td>Fiber content %</td>
<td>79.27</td>
<td>79.21</td>
<td>66.02</td>
</tr>
<tr>
<td>Carbohydrate %</td>
<td>15.49</td>
<td>14.73</td>
<td>18.44</td>
</tr>
<tr>
<td>Total Sugar %</td>
<td>12.54</td>
<td>14.24</td>
<td>16.87</td>
</tr>
<tr>
<td>Reducing Sugar %</td>
<td>55.73</td>
<td>58.05</td>
<td>15.74</td>
</tr>
<tr>
<td>Pectin%</td>
<td>0.54</td>
<td>0.46</td>
<td>0.32</td>
</tr>
<tr>
<td>Ca %</td>
<td>0.19</td>
<td>0.18</td>
<td>0.16</td>
</tr>
<tr>
<td>Mg %</td>
<td>0.18</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>Na %</td>
<td>1.1</td>
<td>1.08</td>
<td>0.92</td>
</tr>
<tr>
<td>K %</td>
<td>0.0015</td>
<td>0.0008</td>
<td>0.0009</td>
</tr>
<tr>
<td>Cu %</td>
<td>0.0026</td>
<td>0.0021</td>
<td>0.0017</td>
</tr>
<tr>
<td>Zn %</td>
<td>0.0109</td>
<td>0.0154</td>
<td>0.0208</td>
</tr>
<tr>
<td>Fe %</td>
<td>0.18</td>
<td>0.14</td>
<td>0.15</td>
</tr>
<tr>
<td>P %</td>
<td>0.18</td>
<td>0.14</td>
<td>0.15</td>
</tr>
<tr>
<td>S %</td>
<td>0.019</td>
<td>0.031</td>
<td>0.023</td>
</tr>
<tr>
<td>pH</td>
<td>3.14</td>
<td>3.21</td>
<td>4.41</td>
</tr>
<tr>
<td>Total acidity %</td>
<td>8.83</td>
<td>8.41</td>
<td>1.36</td>
</tr>
<tr>
<td>Ascorbic acid %</td>
<td>0.2436</td>
<td>0.2334</td>
<td>0.0101</td>
</tr>
<tr>
<td>Oxalic acid %</td>
<td>2.9432</td>
<td>2.01837</td>
<td>0.5950</td>
</tr>
<tr>
<td>Citric acid %</td>
<td>4.6275</td>
<td>2.8710</td>
<td>3.8285</td>
</tr>
<tr>
<td>Phytic acid %</td>
<td>0.0079</td>
<td>0.0029</td>
<td>0.0000</td>
</tr>
</tbody>
</table>
Chapter 5

Summary, Conclusions and Recommendations

5.1 Summary and Conclusions:

This work is a comparative study of the fruits of three plants, namely: Tabaldi (*Adansonia digitata*), Guddeim (*Grewia tenax*) and Aradeib (*Tamarindus indica*). For each type, fruit samples were collected separately from Darfur and Kordofan states. The samples were described botanically & ecologically and then chemically analyzed.

5.1.1 Chemical Composition

**Ash Content**

A. *digitata*, Darfur had the highest value (5.70%) and T. *indica*, Darfur had the lowest value (2.40%) for the ash content.

**Moisture**

With regard to the moisture; T. *Indica*, Kordofan had the highest value (15.2%) while T. *indica*, Darfur had the lowest one.

**Crude Protein**

The highest crude protein content was found in G. *tenax* Kordofan (8.40%) and the lowest was in A. *digitata* Kordofan (2.30%).

**Fat content**

A. *digitata*, Darfur had the highest value of fat content (0.60%) and T. *indica*, Kordofan had the lowest (0.08%).

**Fiber content**

The highest value of fiber content was found for G. *tenax*, Darfur (8.97%) and the lowest was found for T. *indica*, Kordofan (4.20%).

**Carbohydrates content**

The highest value of carbohydrates was found for T. *indica*, Kordofan (82.90%) and the lowest was found for G. *tenax*, Darfur (66.00%).
Total sugars
The total sugars ranged from the highest value in G. tenax, Kordofan (27.44%) to the lowest value in A. digitata, Kordofan (14.73%).

Reducing sugars
G. tenax, Kordofan has the highest value for reducing sugars (21.30%) while the lowest value was found in T. indica, Kordofan (11.37%).

Pectin content
The highest pectin content was in A. digitata, Kordofan (58.05%), whereas the lowest was reported in T. indica, Kordofan (1.65%).

Total Acidity
T. indica, Darfur had highest total acidity (18.60%) and G. tenax, Darfur had the lowest (1.36%).

PH
G. tenax, Darfur had the highest PH value (4.41%) while T. Indica, Darfur had the lowest (2.86%).

5.1.2 Mineral composition:

Ca
A. digitata, Darfur had the highest content (0.54%) where T. indica, Kordofan had lowest (0.19%).

Mg
T. indica, Darfur had the highest Mg content (0.21%) where as G. tenax, Kordofan had the lowest one (0.13%).

Na
A. digitata, Darfur had the highest value of Na content (0.18%) whereas T. indica, Darfur had the lowest Na content (0.04%).

K
A. digitata, Darfur had the highest value of K content (1.10%) whereas T. indica, Darfur had the lowest value (0.32%).
**Cu**

A. digitata, Darfur had the highest value of Cu content (0.0015%) while T. indica, Darfur and T. indica, Kordofan had the same lowest value (0.0006%).

**Zn**

A. digitata, Darfur had the highest value of Zn content (0.0026%) whereas T. indica, Darfur had the lowest (0.0012%).

**Fe**

The highest Fe content was in T. indica, Kordofan (0.0248%) and the lowest value was in T. indica, Darfur (0.0105%).

**P**

A. digitata, Darfur had the highest P content (0.18%) whereas T. indica, Darfur had the lowest (0.10%).

**S**

A. digitata, Darfur had the highest value of S content (0.19%) while G. tenax, Kordofan had the lowest value (0.12%).

### 5.1.3 Organic acids:

**Ascorbic Acid**

The highest value of Ascorbic acid was found for A. digitata, Darfur (0.244%) while the lowest was found for T. indica, Kordofan (0.003%).

**Oxalic acid**

The highest value of Oxalic acid was found for A. digitata, Darfur (2.94%) whereas the lowest was found for T. indica, Kordofan (0.4%).

**Critic acid**

The citric acid content of A. digitata, Darfur was 4.63% while T. indica, Darfur had no citric acid.
5.1.4 Antinutritional factors:

Phytic Acid

The highest value of Phytic acid content was found in A. digitata, Kordofan (0.03%) and the lowest was found for A. digitata, Darfur (0.02%).

Polyphenols

A. digitata, Darfur had the highest value of Poly Phenols (1.65%) while T. indica, Kordofan had the lowest (0.92%).

Tannins

G. tenax, Kordofan had the highest value of Tannins (1.29%) and the lowest value was in T. indica, Kordofan (0.15%).

5.2 Statistical Analysis:

The results of chemical analysis were statistically analysed using the t-test (P=0.05). Here is a summary of the results of the Statistical analysis:

A significant difference was found between A. digitata, Darfur and A. digitata, Kordofan in the Ash, Moisture, Fat, Total sugar, Reducing sugar, Pectin, Cu, and Fe.

An insignificant difference was found between A. digitata Darfur A. digitata Kordofan in the crude protein, Fiber, Carbohydrate, Ca, Mg, Na, K, Zn, P, S, pH, Total acidity, Ascorbic acid, Oxalic acid, Citric acid, Phytic acid, and Tannins.

A significant difference was found between G. tenax, Darfur and G. tenax, Kordofan in Ash, Moisture, Fat, Total sugar, Pectin, and K.
An insignificant difference was found between G. tenax, Darfur and G. tenax, Kordofan in Crude protein, Fiber, Carbohydrate, Reducing sugar, Ca, Mg, Na, Zn, Cu, Fe, P, S, pH, Total acidity, Ascorbic, Oxalic acid, Citric acid, Phytic acid, Polyphenol, and Tannins.

A significant difference was found between T. indica, Darfur and T. indica, Kordofan in Ash, Moisture, Fiber, Carbohydrate, Total sugar, Pectin, K, Fe, and pH.

An insignificant difference was found between T. indica, Darfur and T. indica, Kordofan in Crude protein, Fat, Reducing sugar, Ca, Mg, Na, K, Zn, Cu, Fe, P, S, Total acidity, Ascorbic acid, Oxalic acid, Phytic acid, Polyphenol, and Tannins.

5.3 **Recommendations:**

- Domestication of plant values is needed to improve and insure sustainability of the fruit by cultivated agriculture to secure availability of product.

- To encourage the use of fruits on daily basis, much effort is needed to increase the general awareness of people on the nutritional and economic importance of fruits. This can be done through all available information media.

- More researches should be encouraged on nutritional, nature and level of antinutritional substances and industrial values of local fruits which represent promising cheap sources of local foods.
REFERENCES


• **Abdel-Galil, A. K.** (1996). Evaluation of Baobab (Gonglase) solution for home management of diarrhea in Sudan children Ph. D thesis University of Khartoum, Sudan..


• **Baumier, M.** (1983). In "Note on tree and shrub in arid and semiarid region" EMASAR phase 11, FAO, Rome.


• **Dalzeil, J.M.** (1948). The useful plants of west Tropical Africa Grown Agents for Overseas Governments and Administrations, 4 Mill bank, London, SWI.


• **Elsiddig, K.; Ebert, G.; Inanaga, S. (2003).** Drought Toleranco of Grewia tenax-Apotential New small fruit for the
Sudan an conference on international agricultural research for development.


- **Harland, B.F. and Harland, J.** (1980). Formative reduction of
phytate in rye, white and whole wheat breads, cereal chem. 57:26 -229.


(Adansonia digitata L. J : a review on a multipurpose tree with Promising future in the Humboldt University Berlin, Department of Fruit Science, Germany. Agricultural Research Corporation, Gezira Research Station, Sudan.


• **Raboy**, V.; Dickinson, D.B. (1993). Phytic acid levels in


• **Von maydell, H. J. V.** (1986). In "Tree and shrubs of the sahel" 2nd ed. Muhlstrbeg Hamburg, Deusche Gesellschaft fur Technische Zusammenarbeil (GTZ) Gmbtt, Germany.

• **Von maydell, H. J. V.** (1988). In "Tree and shrubs of the sahel" 2nd ed. Muhlstrbeg Hamburg, Deusche Gesellschaft fur Technische Zusammenarbeil (GTZ) Gmbtt, Germany


chem.(48)312-320.


APPENDIXES
APPENDIX 1

Fig 7 Ascorbic Acid Standard Curve
APPENDIX 2

Fig 7.1 Ascorbic Acid of Tabaldi Darfur
APPENDIX 3

Fig 7.2 Ascorbic Acid of Tabaldi Kordofan
APPENDIX 4

Fig 7.3 Ascorbic Acid of Guddeim Darfur
Data File C:\HPCHD\1\DATA\KHALED1\003-0301.D  
Sample Name: 2

Injection Date : 30/07/2005 02:23:24 &  
Sample Name : 2  
Acq. Operator : Dr Saib  
Acq. Method : C:\HPCHD\1\METHODS\PHENOL.M  
Last changed : 27/07/2005 07:33:43 & by Dr Saib  
Analysis Method : C:\HPCHD\1\METHODS\PHENOL.M  
Last changed : 30/07/2005 03:49:37 & by Dr Saib  
(modified after loading)

---

APPENDIX 5

Fig. 7.4 Ascorbic Acid of Guddeim Kordofan

---

### Area Percent Report

<table>
<thead>
<tr>
<th>#</th>
<th>RetTime</th>
<th>Type</th>
<th>Width [min]</th>
<th>Area [mAU*s]</th>
<th>Height [mAU]</th>
<th>Area %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.563</td>
<td>BV</td>
<td>0.2732</td>
<td>1122.87683</td>
<td>55.69600</td>
<td>8.808</td>
</tr>
<tr>
<td>2</td>
<td>2.903</td>
<td>VV</td>
<td>0.1546</td>
<td>693.33311</td>
<td>57.13813</td>
<td>5.4843</td>
</tr>
<tr>
<td>3</td>
<td>3.345</td>
<td>VV</td>
<td>0.2130</td>
<td>2102.10510</td>
<td>137.03841</td>
<td>16.6254</td>
</tr>
<tr>
<td>4</td>
<td>3.456</td>
<td>VV</td>
<td>0.0907</td>
<td>774.49167</td>
<td>122.61954</td>
<td>6.1247</td>
</tr>
<tr>
<td>5</td>
<td>3.547</td>
<td>VV</td>
<td>0.1644</td>
<td>1283.03411</td>
<td>121.26862</td>
<td>10.1478</td>
</tr>
<tr>
<td>6</td>
<td>3.798</td>
<td>VV</td>
<td>0.1752</td>
<td>1283.61934</td>
<td>97.13099</td>
<td>10.1537</td>
</tr>
<tr>
<td>7</td>
<td>4.686</td>
<td>VB</td>
<td>0.4548</td>
<td>2000.75818</td>
<td>141.71703</td>
<td>33.2236</td>
</tr>
<tr>
<td>8</td>
<td>6.000</td>
<td>BV</td>
<td>0.0725</td>
<td>662.02673</td>
<td>10.67517</td>
<td>5.2359</td>
</tr>
<tr>
<td>9</td>
<td>7.602</td>
<td>VB</td>
<td>0.9590</td>
<td>337.28462</td>
<td>4.12279</td>
<td>2.6678</td>
</tr>
<tr>
<td>10</td>
<td>11.968</td>
<td>BF</td>
<td>0.8349</td>
<td>184.21739</td>
<td>2.58219</td>
<td>1.4562</td>
</tr>
</tbody>
</table>

Totals : 1.26439e4  749.98295

Results obtained with enhanced integrator!

*** End of Report ***

---

Instrument 1 30/07/2005 03:50:21 & Dr Saib
APPENDIX 6

Fig 7.5 Ascorbic Acid of Aradeib Darfur
APPENDIX 7

Fig 7.6 Ascorbic Acid of Aradeib Kordofan
APPENDIX 8

Fig 8 Oxalic acid standard curve
APPENDIX 9

Fig 9 Citric acid standard curve
APPENDIX 10

Fig 10 Oxalic and Citric acid of Tabaldi Darfur
APPENDIX 11

Fig 11 Oxalic and Citric acid of Tabaldi Kordofan
APPENDIX 12
Fig 12 Oxalic and Citric acid of Gudeim Darfur
APPENDIX 13

Fig 13 Oxalic and Citric acid of Guddeim Kordofan
APPENDIX 14

Fig 14 Oxalic and Citric acid of Aradeib Darfur
APPENDIX 15

Fig 15 Oxalic and Citric acid of Aradeib Kordofan
APPENDIX 16

Fig 16 Phytic acid standard curve
APPENDIX 17

Fig 17 Tannins standard curve