PHYSICO-CHEMICAL AND NUTRITIONAL PROPERTIES OF NIGERIAN TAMARIND (*Tamarindus indica L*.).

By

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INTRODUCTION

•Wild indigenous plants are important in the nutrition of sub-saharan population for several reasons (Balogun, 1982 ;Prakash and Misra, 1988 ; Glew *et al.*, 1997).

•First, the leaves, flowers, seed and fruits of many indigenous plants are staples of populations who inhabit the savanna region of Africa and they serve to supplement the nutrients provided by the cereals and tubers (Khulien 1989 ; Glew *et al.,* 1997).

•Second, the sub-Saharan region of Africa suffers from drought and other weather-related calamities such as floods, which reduce traditional grain staples (Paarlberg,1996).

•Third, the indigenous wild plants are well adapted to adverse environmental conditions, highly resistant to diseases and pests and exhibit good nutritional qualities (Maikhuri *et al.*,1995).

INTRODUCTION (Cont'd)

- Fourth, world grain markets have tightened in recent years and world grain reserves are approaching their lowest levels in 20 years (Glew *et al.*,1997).

- Hence, food insecurity in Africa will remain if efforts are not made towards finding alternative and cheap sources of food such as the under-utilised indigenous wild plants.

- Tamarind (*Tamarindus indica L.*) is a fruit tree that grows wild in the savanna region of Nigeria. It is one of the numerous under-utilised, lesser-known crops in Nigeria with considerable industrial potentials.

- Tamarind tree is most well known for its fruits which have one of the highest levels of protein and carbohydrate of any fruit (BAIF,2002). A tamarind tree can produce an annual fruit yield of between 150-500kg/tree and has a life span of about 200 years (Gunasena and Hughes, 2000; BAIF,2002).

Fig. 1: Tamarind Tree

Ripe tamarind fruit is filled with a sticky pulp, with colours varying from reddish-brown to black-brown.
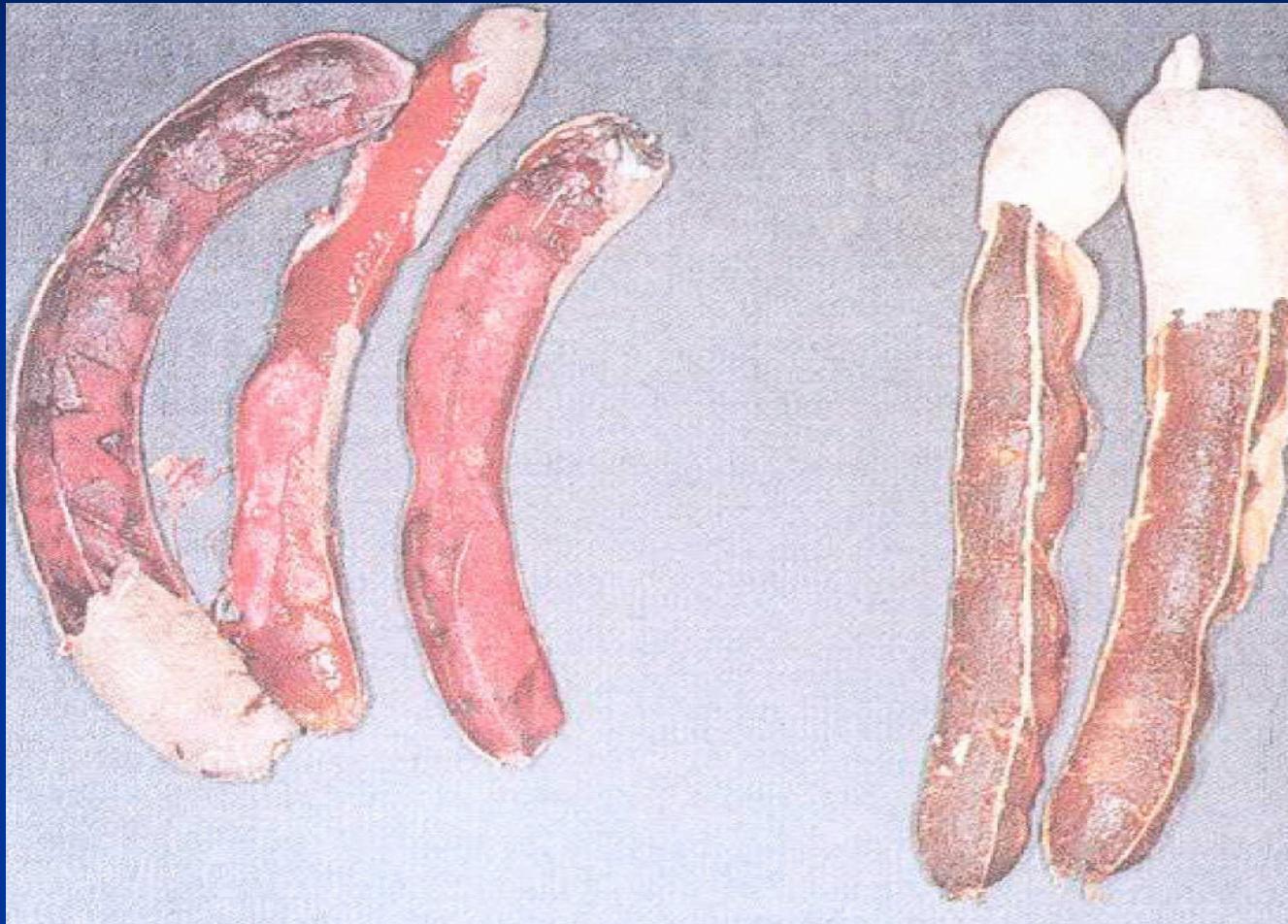
Fig. 2: Variation in pulp colour

OBJECTIVE

- Evaluate the physical and chemical attributes of tamarind fruits in Nigeria.

MATERIALS AND METHODS

1. **Sources of raw materials**: **Mature tamarind fruits were collected from 19 towns, which were randomly selected from the major towns of the twenty savanna states of Nigeria. The collection was done between the months of March and May.**

2. **Proximate composition,pH, total acidity and soluble solids A.O.A.C. (1995)**

3. **Dietary fibre: - Neutral detergent fibre (Hopkins *et al.,* 1995)**

   - Acid detergent fibre (van Soest and Wine, 1967)

   - Acid detergent lignin (A.O.A.C., 1990)

   - Cellulose (Silva *et al.*, 2005)

   - Hemicellulose (Silva *et al.,* 2005)

5. **Total carotenoids (Chan and Cavaletto, 1982)**

6. **Colour: Salem and Hegazi, with modification**
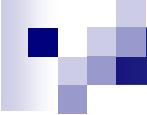
MATERIALS AND METHODS

7. **Ascorbic acid (A.A.V.C., 1971)**

8. **Total sugar and starch (I.I.T.A., 1991)**

8. **Amino acid (Spackman *et al.*, 1958)**

9. **Sugar identification (Harbone, 1991)**

10. **Anti-nutritional factors: - Tannin (Griffiths and Jones, 1977)**

       - Trypsin inhibitor (Hammerstrand *et al.*, 1981)

       - Phytates (Wheeler and Ferrel, 1971)

       - Oxalate (Onifade, 1986)
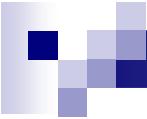
Statistics

- All data were assessed by Analysis of Variance (ANOVA) and Least Significance Difference (LSD) tests (Steel &Torrie , 1980).

Results

Table 1: PHYSICO-CHEMCIAL PROPERTIES OF TAMARIND (Tamarindus indica L.) PULP

Location	Colour, absorbance at 325nm	Soluble solids, °brix	pH	Total acidity, %	Moisture, %	Protein, %	Fat, %	Crude fibre,%	Ash,%	Sugar,%	Starch %	Ascorbic acid, mg/100g	Total Carotenoids, µg/100g
Abuja	0.93[b] ±0.00	6.1[b] ± 0.10	2.9[d] ±0.01	1.4[ef] ±0.03	32.4[h] ±0.01	4.9[d] ±0.03	3.1[g] ±0.01	3.4[cde] ±0.36	4.1[f] ±0.25	5.1e±0.04	0.3[b]±0.03	7.4[e] ±0.06	16.2[h] ±0.17
Azare	1.41[a] ±0.07	6.1[b] ± 0.12	2.9[d] ±0.01	1.3[h] ±0.01	33.5[e] ±0.02	4.3[g] ±0.01	3.1[g] ±0.02	3.7[bcd] ±0.30	4.4[e] ±0.01	4.3i±0.04	0.3[b] ±0.04	6.5i±0.01	18.5[f] ±0.47
Bauchi	0.84[cd] ±0.00	6.1[b] ±0.12	2.9[d] ±0.01	1.3[h] ±0.02	38.2[c] ±0.02	4.5[f] ±0.02	3.1[g] ±0.02	3.8[abc] ±0.36	4.5[d] ±0.02	2.2o±0.03	0.4[b] ±0.05	5.0i ±0.01	19.5[e] ±0.18
Bichi	0.35[k] ±0.01	6.0[bc] ± 0.06	2.9[d] ±0.01	1.4[e]±0.01	39.9 ±0.02	4.0[h] ±0.01	3.1[g] ±0.02	4.0[ab] ±0.35	3.2[m] ±0.01	5.3a±0.06	0.2[d] ±0.04	8.6[b] ±0.02	22.5[b] ±0.43
Birni kebbi	0.36[k] ±0.03	6.3[a] ± 0.15	2.9[d] ±0.01	1.2[i]±0.02	31.2[j] ±0.02	3.5[l] ±0.01	3.2[c] ±0.02	3.8[abc] ±0.36	3.2[m] ±0.01	4.7h±0.05	0.2[d] ±0.04	6.0i ±0.02	20.4[cd] ±0.43
Funtua	0.66[h] ±0.00	5.9[cde] ± 0.12	2.9[d] ±0.01	1.4[e] ±0.01	32.6[g] ±0.02	3.5[l] ±0.01	3.2[c] ±0.01	4.1[a] ±0.26	3.8[h] ±0.01	3.5k±0.03	0.2[d] ±0.04	5.2[k] ±0.04	0.8[c] ±0.07
Gombe	0.77[f] ±0.01	6.1[b] ± 0.01	3.0[a] ±0.02	1.2[i] ±0.02	38.6[b] ±0.01	5.2[b] ±0.02	3.1[c] ±0.02	3.0[abc] ±0.26	4.9[a] ±0.01	5.8a±0.04	0.4[b] ±0.04	4.3o±0.04	19.0[e] ±0.13
Gwarzo	0.62[i] ±0.03	6.1[b] ± 0.15	3.0[a] ±0.01	1.4[e] ±0.03	30.2[l] ±0.02	2.8[p] ±0.02	3.1[g] ±0.02	4.1[a] ±0.17	3.2[l] ±0.01	5.4c±0.03	0.3[b] ±0.03	7.7[d] ±0.04	120.8[c] ±0.47
Jega	0.35[f] ±0.00	6.2[ab] ± 0.01	3.0 ±0.02	1.1[jif]±0.01	33.4[e] ±0.01	3.4[m] ±0.01	3.1[g] ±0.01	4.0[a] ±0.30	3.4[i] ±0.01	4.8g±0.02	0.2[d] ±0.03	6.5i ±0.05	20.5[cd] ±0.43
Jos	0.82[de] ± 0.00	5.6[f] ± 0.06	2.8[e] ±0.01	1.4[e] ±0.03	30.9[k] ±0.01	2.8[p] ±0.03	3.1[g] ±0.01	3.1[e] ±0.15	3.1[n] ±0.01	5.7b±0.05	0.3[b] ±0.04	6.5i ±0.05	15.4[i] ±0.22
Kaduna	0.79[ef] ± 0.00	6.0[bc] ± 0.06	2.9[d] ±0.01	1.7[c] ±0.01	32.6[g] ±0.02	4.8[c] ±0.01	3.1[g] ±0.01	3.5[bcde] ±0.30	3.3[i] ±0.02	3.4l±0.04	0.3[b] ±0.05	7.3[f] ±0.01	16.3[h]±0.32

Table 1: PHYSICO-CHEMCIAL PROPERTIES OF TAMARIND (Tamarindus indica L.) PULP (Cont'd)

Kano	0.71^g ± 0.00	5.8^e ± 0.06	3.0^a ±0.01	1.4^e ±0.02	30.9^k ±0.01	3.4^n ±0.02	31^g ±0.02	3.9^{abc} ±0.10	3.1^o ±0.02	5.3^d ±0.05	0.2^d ±0.04	7.0^g ±0.03	20.8^d ±0.40
Katsina	0.66^h ± 0.00	5.1^g ± 0.12	2.9^d ±0.01	1.3^h ±0.01	32.9^f ±0.32	3.6^j ±0.01	3.1^g ±0.02	4.2^a ±0.44	3.9^g ±0.01	3.0^m ±0.05	0.3^b ±0.02	8.2^c ±0.04	20.2^d ±0.08
Langtang	0.87^c ± 0.00	5.4^f ± 0.10	2.8^e ±0.04	1.5^g ±0.01	32.1^i ±0.02	3.0 ±0.02	3.2^c ±0.01	3.0^e ±0.17	3.1^n ±0.20	4.9^f ±0.05	0.3^b ±0.01	4.20 ±0.04	15.7^i ±0.04
Maiduguri	2.6^l ± 0.01	5.8^{de} ± 0.17	2.9^d ±0.01	1.3^h ±0.01	31.2^j ±0.02	3.6^k ±0.01	3.2^c ±0.01	4.1^a ±0.26	3.8^h ±0.02	3.7^j ±0.03	0.3^b ±0.02	15.0^l ±0.04	15.3^l ±0.14
Mallamsidi	0.41^i ± 0.01	5.8^{de} ± 0.10	3.0^a ±0.01	1.2^i ±0.01	35.2^d ±0.01	5.1^c ±0.01	3.1^g ±0.01	4.0^{ab} ±0.44	4.8^b ±0.01	5.3^d ±0.03	0.3^b ±0.03	4.5^n ±0.04	18.2^f ±0.06
Minna	30^a ± 0.01	6.0^{bc} ± 0.10	2.5^g ±0.03	3.1^b ±0.03	18.3^n ±0.02	3.8^i ±0.05	3.0^g ±0.03	3.1^{de} ±0.40	2.9^p ±0.03	4.9^f ±0.04	0.3^b ±0.02	4.8^m ±0.03	17.1^g ±0.08
Shaki	0.67^h ± 0.01	6.0^{bc} ± 0.15	3.0^a ±0.02	1.5^d ±0.16	14.8^m ±0.15	9.4^a ±0.06	4.9^a ±0.03	4.3^a ±0.20	3.3^k ±0.03	5.7^d ±0.07	0.2^d ±0.03	11.3^a ±0.03	26.2^a ±0.22
Sokoto	3.0^a ± 0.02	6.0^{bc} ± 0.17	2.6^f ±0.03	3.3^a ±0.03	6.0^{bcd} ±0.17	2.7^q ±0.02	3.2^b ±0.03	4.1^a ±0.30	4.5^c ±0.02	2.6^n ±0.02	0.3^b ±0.04	6.7^h ±0.04	18.3^f ±0.09

Means in the same column with different letters are significantly (p< 0.01) different.

Means ± standard deviation of three determinations.

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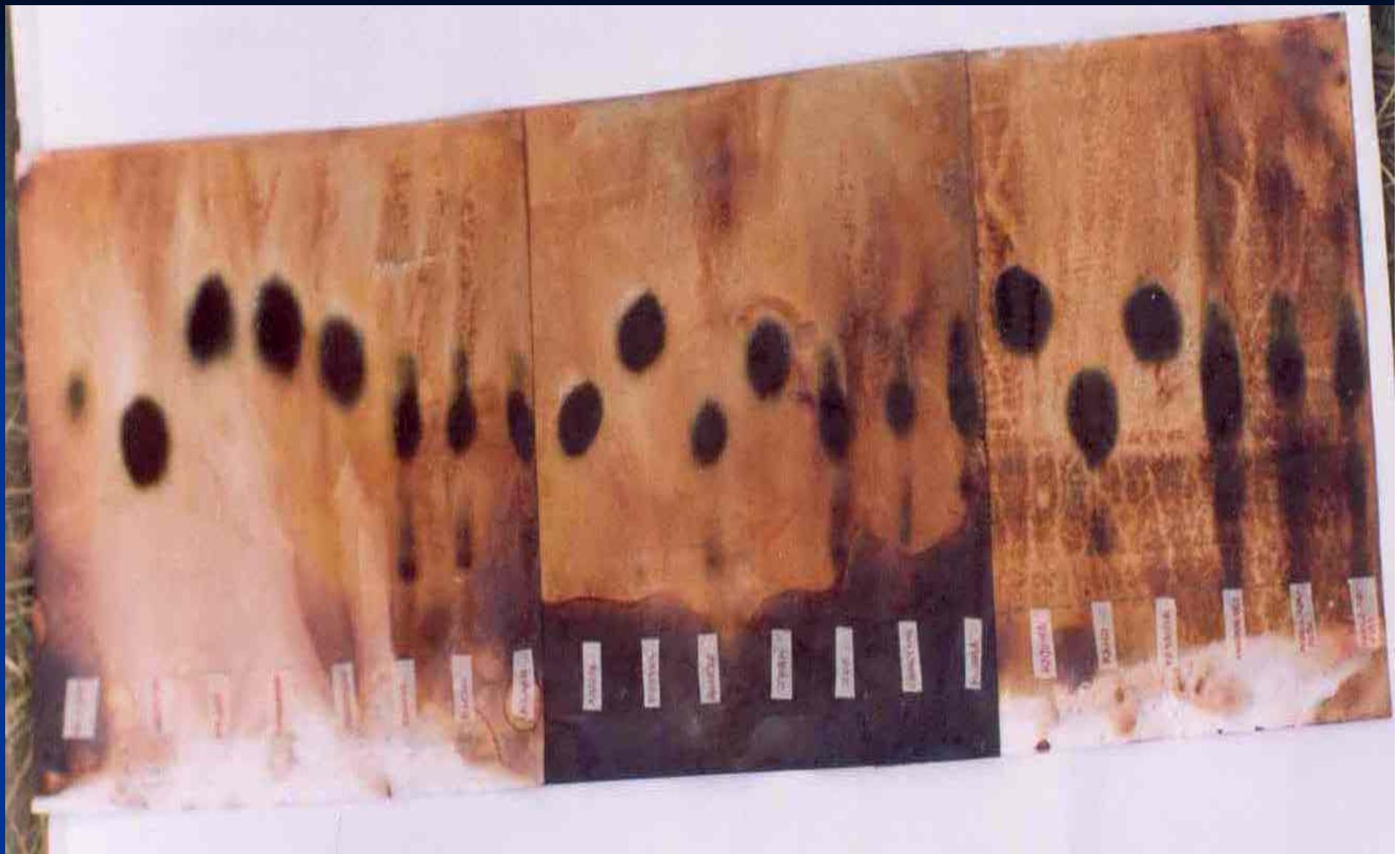
**Fig. 3: Chromatogram showing the identified sugars**

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Table 2: SUGARS IDENTIFIED IN TAMARIND (*Tamarindus indica L.*) PULPS

Location	Glucoses, %	Galactose, %	Fructose, %	Arabinose,%	Xylose, %
Abuja	2.1[e] ±0.04	0.2[cde] ±0.002	1.12[b] ±0.04	0.1[de] ± 0.002	0.2[a] ± 0.03
Azare	1.79[g] ±0.04	0.3[bcd] ±0.03	1.5[c] ± 0.04	0.2[cd] ±0.04	0.2[a] ±0.02
Bauchi	1.1[k] ± 0.03	0.1[f] +0.05	0.7[h] ±0.03	0.01[de] ±0.03	0.2[a] ±0.54
Bichi	2.5[d] ± 0.04	0.2[cde] ±0.04	1.8[b] ±0.07	0.1[cde] ±0.04	0.2[a] ±0.03
Birni - kebbi	1.93 ± 0.05	0.3[bcd]±0.03	1.7[cd] ±0.04	0.2[cd] ±0.04	0.2[a] ±0.02
Funtua	1.4[hi] +0.05	0.3 ±0.04	1.1[g] ± 0.04	0.13[cd] ±0.03	0.2[a] ±0.02
Gombe	2.8[b] ± 0.06	0.4[a] ±0.01	1.8[c] ±0.04	0.23de ± 0.04	0.3[a] ±0.03
Gwarzo	2.4[s] ± 0.04	0.2[cde]±0.04	1.7[cd] ±0.03	0.12[de] ±0.02	0.3[a] ±0.03
Jega	1.9[f] ± 0.05	0.2[cde] ±0.01	1.6[d] ± 0.04	0.22[cd] ±0.05	0.2[a] ±0.03
Jos	2.6[c] ± 0.03	0.3[ab]±0.03	1.8[b] ±0.06	0.1[de] ±0.03	0.2[a] ±0.03
Kaduna	1.4[h] ± 0.05	0.3[bcd] ±0.02	1.0[a] ±0.04	0.[de] ±0.03	0.2[a] ± 0.03
Kano	2.0[d] ± 0.07	0.25[bcd] ±0.04	1.8[b] ± 0.04	0.14[de] ±0.02	0.2[a] ± 0.03
Kastina	1.2[a] ± 0.05	0.2[de] ±0.04	0.7[h] ± 0.05	0.10[de] ±0.01	0.8[a] ±0.03
Langtang	2.0[k]± 0.03	0.2[cde] ±0.04	1.6[d] ± 0.03	0.25[cd] ±0.03	0.2[a] ±0.03
Madiuguri	1.4[h] ± 0.05	0.3[bcd] ±0.04	1.1[g] ± 0.04	0.21[cd] ±0.03	0.2[a] ±0.04
Mallam Sidi	2.4[d] ±0.04	0.3[bcd] ±0.05	1.8[b]± 0.05	0.12[de] ±0.03	0.2[a] ±0.04
Minna	1.9[f] ± 0.08	0.3[bcd] ±0.05	1.7[bc] ± 0.05	0.24[cd] ±0.05	0.4[a] ±0.04
Shaki	4.4[a] ±0.13	0.3[bcd] ±0.04	3.2[a] ± 0.05	0.24[cd] ±0.04	0.3[a] ±0.04
Sokoto	1.2 ±0.02	0.2[cde] ±0.04	0.7[b] ± 0.03	0.1[de] ± 0.02	0.0.4[a] ±0.53

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Means in the same column with different letters are significantly ($p < 0.01$) different.
Means ± standard deviation of three determinations.
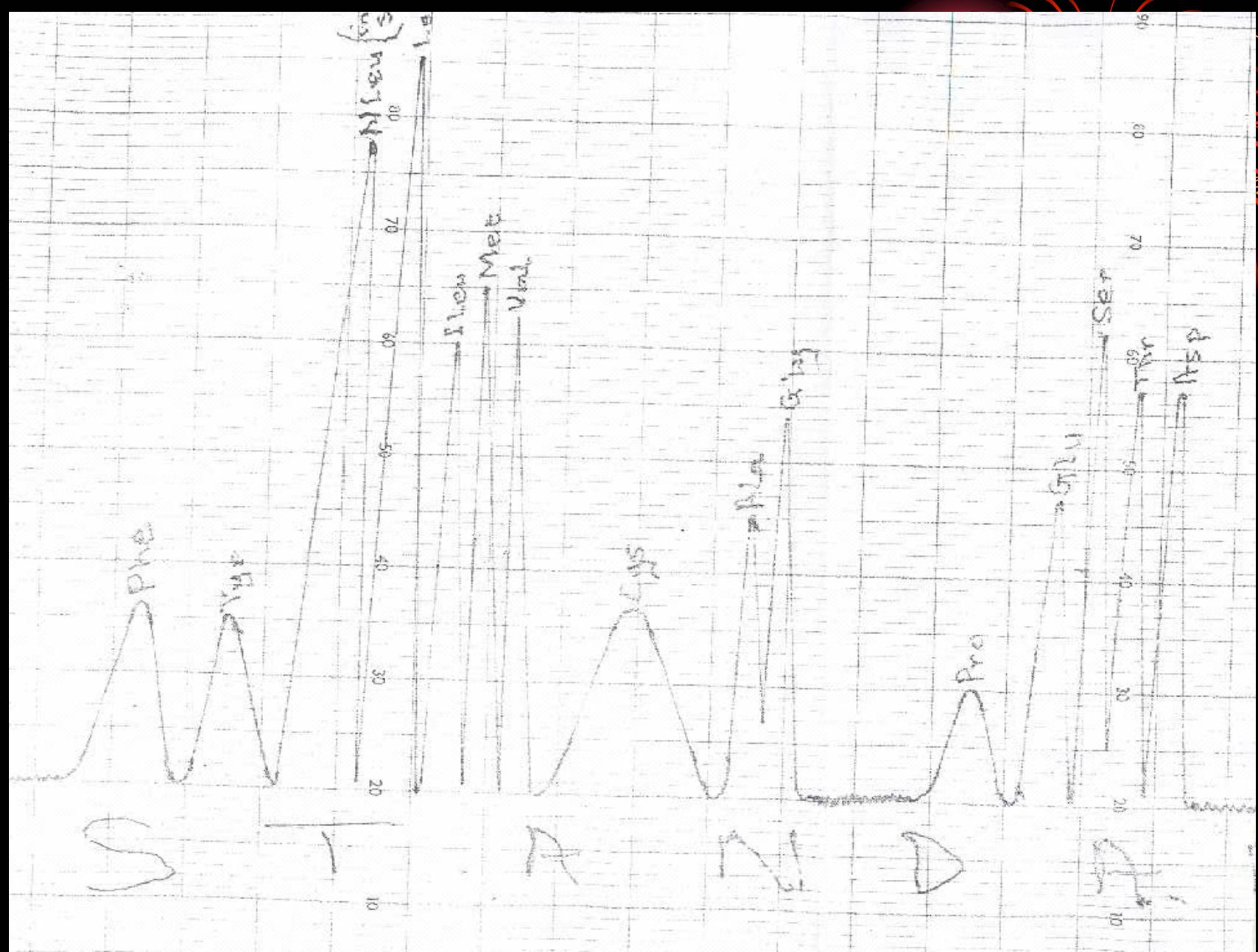
Fig. 4: Spectra of amino acids standard
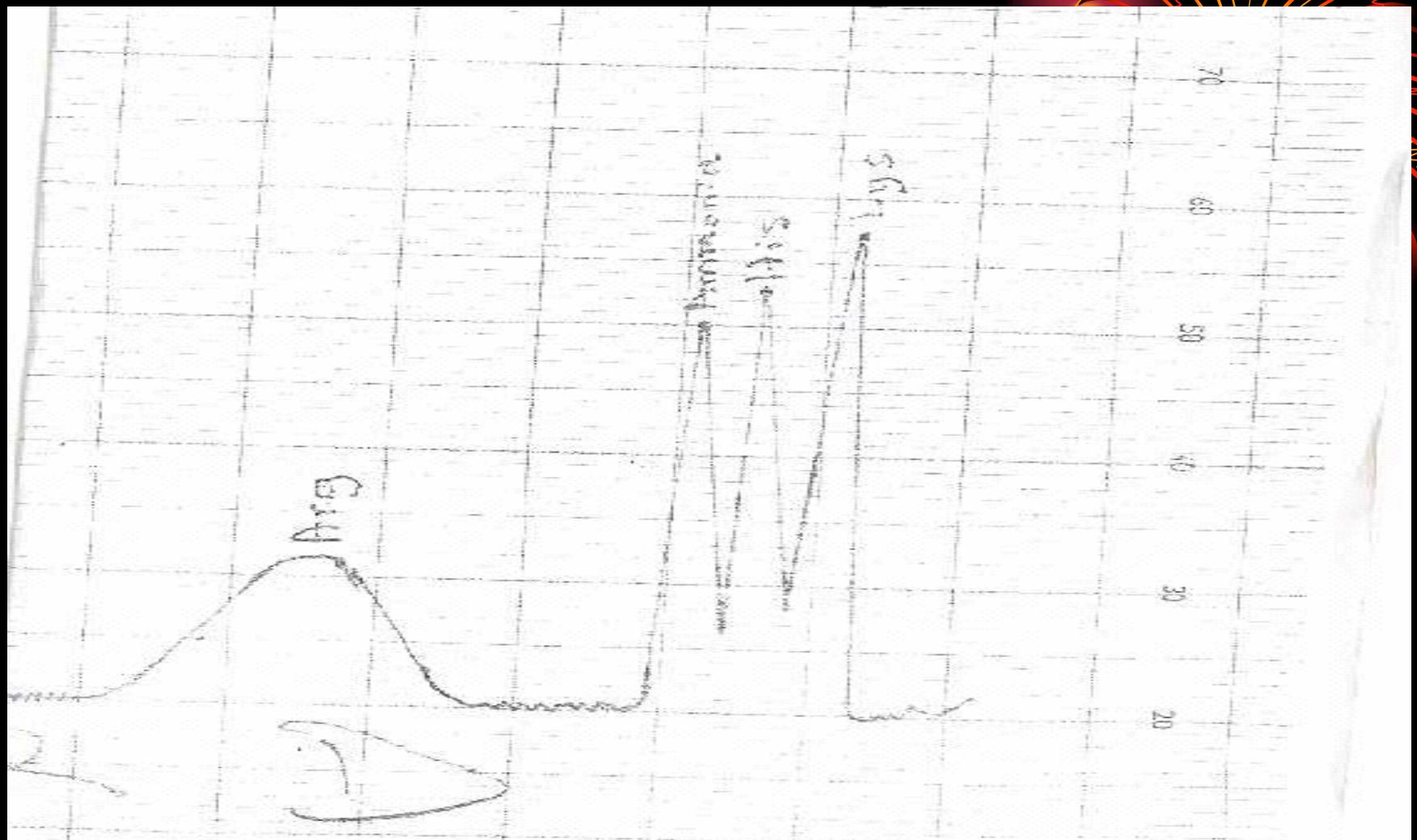
Fig. 4: Spectra of amino acids standard (Cont'd)
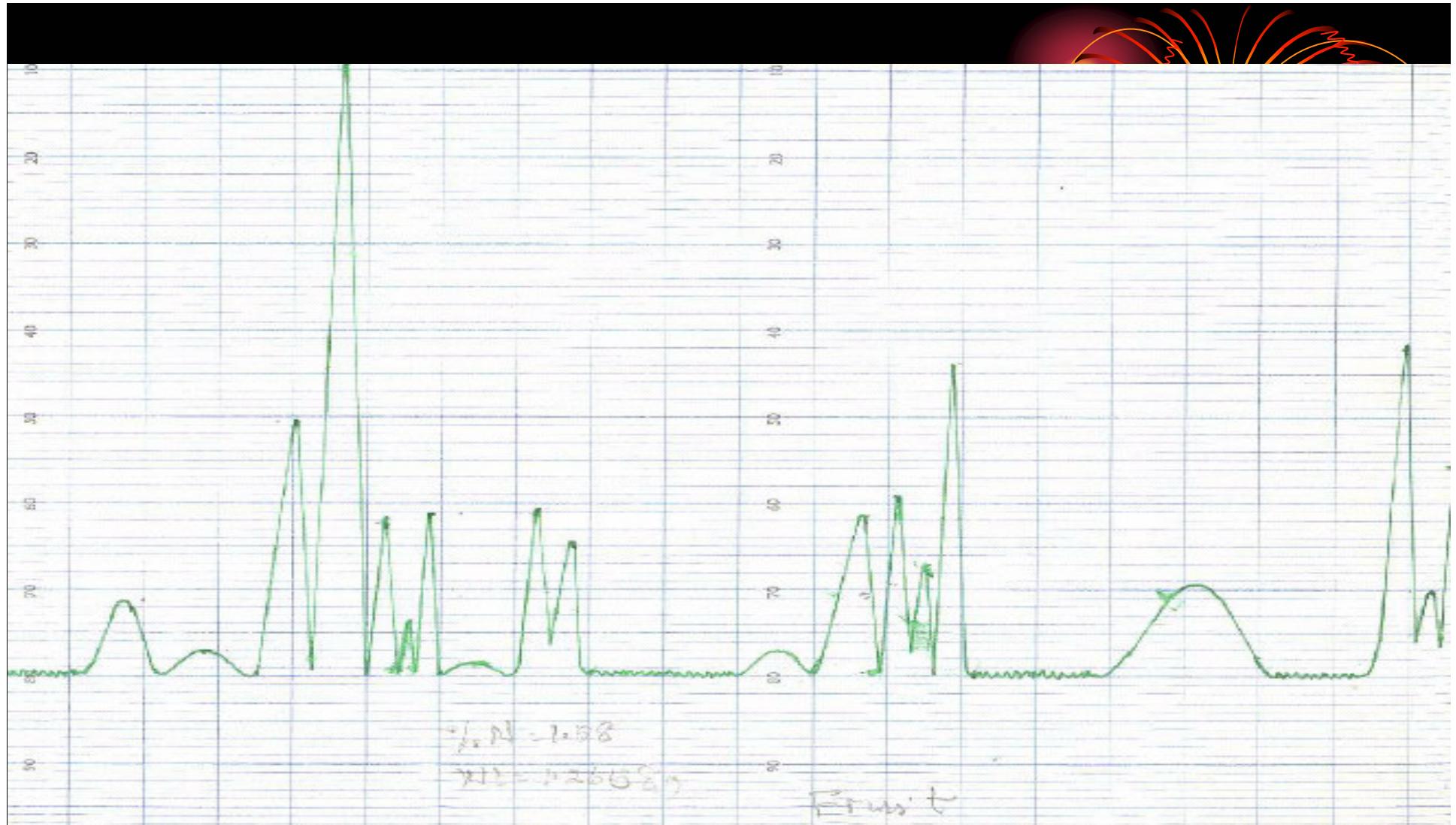
Fig. 5: Spectra of amino acids in Tamarind pulp

Table 3: AMINO ACID COMPOSITION OF TAMARIND (*Tamarindus indica L.*) PULP

Amino Acid	Concentration g/100g protein
Alanine	3.11 ±0.01
Arginine	4.01 ± 0.01
Aspartic acid	5.30 ± 0.10
Cystine	0.62 ± 0.01
Glutamic acid	6.58 ± 0.06
Glycine	1.75 ± 0.15
Histidine	1.61 ± 0.01
Isoleucine	2.30 ± 0.16
Leucine	6.71 ± 0.20
Methionine	0.71±0.01
Phenylalanine	3.50 ±0.40
Proline	1.80 ± 0.10
Serine	2.36 ± 0.04
Threonine	1.70 ± 0.02
Tyrosine	2.05 ± 0.01
Valine	2.26 ± 0.02

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Means ± standard deviation of three determinations.

Table 4: Mineral composition of Tamarind Pulp

Location	Calcium (%)	Magnesium (%)	Potassium (%)	Na	Lead %	Phosphorus (%)	Iron (%)	Zinc (%)	Copper, (%)
Abuja	1.08^b ±0.01	0.56b ±0.01	0.62^b ±0.00	0.35^a ±0.01	NS	0.38^a ±0.00	0.20^a ±0.01	0.02^a ±0.01	0.01^a ±0.00
Azare	0.97^b ±0.01	0.59^b ±0.01	0.39^c ±0.00	0.21^g ±0.00	0.01^a±0.00	0.38^b ±0.01	0.17^b±0.00	0.01^c ±0.00	0.01^a ±0.00
Bauchi	0.91^b ±0.01	0.54 ±0.01	0.42^b ±0.00	0.21^g ±0.00	NS	0.25^f ±0.00	0.11^f ±0.00	NS	0.01^a ±0.00
Bichi	0.87^b ±0.01	0.38^b ±0.00	0.39^b ±0.01	0.28^d ±0.01	NS	0.24^g ±0.00	0.00^g ±0.00	NS	0.01^a ±0.00
Birni kebbi	0.90^b ±0.01	0.42^b ±0.00	0.62^b ±0.00	0.34^b ±0.00	0.01 ±0.00	0.29^{cd} ±0.00	0.15^c ±0.00	0.01^c ±0.00	NS
Funtua	1.28^b ±0.01	0.61^b ±0.00	0.45^b ±0.01	0.19^h ±0.00	NS	0.31^c ±0.00	0.10^{cf} ±0.00	0.01^c ±0.00	NS
Gombe	0.75^b ±0.00	0.42^b ±0.01	1.43^a ±1.85	0.19^h ±0.00	NS	0.27^{ef} ±0.04	0.15 ±0.00	0.01^c ±0.00	NS
Gwarzo	1.01^b ± 0.01	0.61^b ±0.01	0.43^b ±0.00	0.24^c ±0.00	NS	0.28^{de} ±0.00	0.16^b ±0.00	0.01^b±0.00	0.01^a ±0.00
Jega	3.24^a ±0.04	2.07^a ± 2.70	0.61^b ±0.00	0.34b ±0.00	NS	0.30^{cd} ±0.00	0.16^b ±0.00	0.01^c ±0.00	0.01^a ±0.00

Means in the same column with different letters are significantly (p< 0.01) different.

Means ± standard deviation of three determinations.

Jos	0.83[b] ±0.01	0.41[c] ±0.00	0.38[b] ±0.00	0.19[i] ±0.01	NS	0.33[b] ±0.00	2.15[d] ±0.00	0.01[c] ±0.00	0.00
Kaduna	0.76[b] ±0.00	0.42[b] ±0.00	0.22[b] ±0.00	0.11[k] ±0.00	NS	0.29[cd] ±0.00	0.08[i] ±0.00	0.01[c] ±0.00	0.00
Kano	0.76[b] ±0.00	0.41[b] ±0.01	0.21[b] ±0.01	0.11[k] ±0.00	NS	0.29[cd] ±0.00	0.09[h] ±0.00	0.01[c] ±0.00	NS
Katsina	0.99[b] ± 0.01	0.50[b] ±0.00	0.44[b] ±0.00	0.19[i] ±0.00	NS	0.31[c] ± 0.00	0.13[e] ±0.00	0.01[c] ±0.00	NS
Langtang	0.87[b] ±0.01	0.52[b] ±0.01	0.41[b] ±0.00	0.19[i] ±0.00	NS	0.30[cd] ±0.09	0.13[c] ±0.01	0.01[c] ±0.00	NS
Maiduguri	0.76[b] ±0.01	0.40[b] ±0.00	0.23[b] ±0.00	0.11[k] ±0.00	NS	0.30[cd] ±0.00	0.08[j] ±0.00	0.01[c] ±0.00	NS
Mallam-sidi	0.46[b] ±0.00	0.29[b] ±0.00	0.37[b] ±0.00	0.01[f] ±0.00	NS	0.30[cd] ±0.00	0.07[j] ±0.00	0.01[c] ±0.00	NS
Minna	0.90[b] ±0.00	0.54[b] ±0.00	0.24[b] ±0.00	0.13[j] ±0.00	NS	0.30[cd] ±0.00	0.02[k] ±0.00	0.01[c] ±0.00	0.01[a] ±0.00
Shaki	0.19b ±0.00	0.30[b] ±0.00	0.72[b] ±0.03	0.04[m] ±0.00	NS	0.25[fg] ±0.00	0.02[k] ±0.00	0.01[c] ±0.00	NS
Sokoto	0.85b ±0.00	0.64[b] ±0.00	0.26[b] ±0.01	0.22[c] ±0.00	NS	0.34b ±0.00	NS	0.01[c] ±0.00	0.01[c] ±0.00

Means in the same column with different letters are significantly (p< 0.01) different.
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Table 5: Anti-nutritional Factors of Tamarind (*Tamarindus indica L.*) Pulp

Location	Tannin (%)	Phytate (%)	Oxalate	Trypsin inhibitor Tμ/mg protein
Abuja	0.07[ef] ±0.01	1.32[ab] ±0.12	0.48[a] ±0.04	0.70[ab] ±0.01
Azare	0.03[ef] ±0.01	0.56[d]±0.07	0.28[g] ±0.04	0.35[e] ±0.01
Bauchi	0.03[ef] ±0.00	0.57[d]±0.11	0.29[fg] ±0.02	0.39[de] ±0.02
Birini-kebbi	0.03[ef] ±0.03	0.49[d] ±0.08	0.32[defg] ±0.07	0.79[a] ±0.04
Funtua	0.46[b] ±0.00	1.32[ab] ±0.03	0.44[abcd] ±0.07	0.42[de] ±0.02
Gombe	0.08[e] ±0.02	0.50[d] ±0.05	0.42[abcde] ±0.08	0.34[e] ±0.01
Gwarzo	0.08[e] ±0.01	0.55[d] ±0.05	0.34[efg] ±0.04	0.37[de] ±0.02
Jega	0.04[ef] ±0.01	0.48[d] ±0.04	0.30[efg] ±0.03	0.76[ab] ±0.01
Jos	0.40[ef] ±0.02	1.38[a] ±0.07	0.46[efg] ±0.03	0.40[de] ±0.01
Kaduna	0.02[ef] ±0.00	1.41[a] ±0.07	0.42[abcde] ±0.08	0.63[bc] ±0.01
Kano	0.07[ef] ±0.01	1.23[b] ±0.07	0.29[g] ±0.03	0.45[de] ±0.03
Katsina	0.05[ef] ±0.02	0.45[de] ±0.10	0.33[cdefg] ±0.05	0.78[ab] ±0.01
Langtang	0.07[ef] ±0.01	0.45[de] ±0.09	0.43[abcd] ±0.08	0.33[e] ±0.01
Maiduguri	0.58[a] ±0.09	1.19[b] ±0.10	0.44[abc] ±0.010	0.52[cd] ±0.02
Mallam-sidi	0.07[ef] ±0.02	0.54[d] ±0.04	0.36[abcdefg] ±0.05	0.39[de] ±0.02
Minna	0.14[d] ±0.04	0.48[d] ±0.04	0.45[abc] ±0.01	0.42[de] ±0.01
Shaki	0.04[ef] ±0.02	0.33[e] ±0.03	0.28[g] ±0.03	0.05[f] ±0.01
Sokoto	0.02[f] ±0.01	0.70[e] ±0.13	0.35[bcdefg] ±0.05	0.13[f] ±0.01

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Means in the same column with different letters are significantly ($p < 0.01$) different
Means ± standard deviation of three determinations.

Table 6: Dietary Fibre Components of Tamarind (*Tamarindus indica L.*) Pulp

Location	Neutral detergent fibre (%)	Acid detergent fibre (%)	Lignin (%)	Hemicellulose (%)	Cellulose (%)
Abuja	4.9[cdefg] ±0.26	6.6[defg] ± 0.36	3.1[cde] ± 0.31	1.7[def] ± 0.20	3.4[def] ± 0.36
Azare	5.1[cde] ± 0.17	6.7[cdefg] ± 0.26	3.4[bc] ± 0.10	1.6[ef] ± 0.10	3.3[ef] ± 0.30
Bauchi	4.9[cdefg] ± 0.26	7.0[abcde] ± 0.17	3.4[bcd] ± 0.30	2.1[bc] ± 0.17	3.6[cdef] ± 0.26
Birini - kebbi	5.4[b] ± 0.17	7.2[abc] ± 0.20	3.7[b] ± 0.17	1.8[cdef] ± 0.20	3.5[cdef] ± 0.20
Funtua	5.0[bcdef] ± 0.10	6.9[bcdef] ± 0.10	3.5[bc] ± 0.17	1.9[bcde] ± 0.17	3.4[def] ± 0.26
Gombe	5.3[bc] ± 0.17	7.2[abc] ± 0.30	3.3[bcde] ± 0.44	1.9[bcde] ± 0.10	3.9[abc] ± 0.30
Gwarzo	5.0[bcdef] ± 0.10	6.8[cdefg] ± 0.17	3.3[bcde] ± 0.10	1.8[cdef] ± 0.10	3.5[cdef] ± 0.17
Jega	5.2[bcd] ± 0.26	7.2[abc] ± 0.20	3.4[bcd] ± 0.36	2.0[cdef] ± 0.10	3.8[abcde] ± 0.10
Jos	5.3[bc] ± 0.17	7.1[abcd] ± 0.10	3.4[bcd] ±0.36	1.8[cdef] ± 0.20	3.7[bcde] ± 0.10
Kaduna	4.7[efgh] ± 0.20	6.5[efgh] ± 0.56	2.9[ef] ± 0.17	1.8[def] ±0.20	3.5[def] ± 0.17
Kano	4.6[fgh] ± 0.10	6.3[gh] ± 0.17	3.1[cde] ± 0.30	1.7[def] ± 0.20	3.2[fg] ± 0.10
Katsina	4.8[defgh] ± 0.17	7.0[abcde] ± 0.30	3.7[b] ± 0.26	2.2[ab] ± 0.20	3.3[ef] ± 0.26
Langtang	4.5[gh] ± 0.50	7.4[a] ± b0.017	3.3[bcde] ± 0.17	2.1[bc] ± 0.17	4.1[ab] ± 0.26
Maiduguri	4.4h ± 0.26	6.5[h] ± 0.20	2.9[ef] ± 0.17	1.6[ef] ± 0.10	3.6[cdef] ± 0.20
Mallam-sidi	4.9[cdefg] ± 0.06	6.9[bcdef] ± 0.20	3.2[cde] ± 0.12	2.0[bcd] ± 0.17	2.8[g] ± 0.26
Minna	4.9[cdefg] ± 0.26	6.4[fgh] ± 0.17	3.0[def] ± 0.20	1.5[f] ± 0.17	3.7[bcde] ± 0.30
Shaki	5.8[a] ± 0.30	7.5[a] ± 0.30	4.5[a] ± 0.26	2.4[a] ± 0.10	3.4[def] ± 0.26
Sokoto	5.1[bcde] ± 0.17	6.8[cdefg] ± 0.30	2.6[f] ± 0.26	1.7[def] ± 0.20	4.6[b] ± 0.12

Means in the same column with different letters are significantly (p< 0.01) different. Means ± standard deviation of three determinations.

THANK YOU