CHEMICAL ANALYSIS OF TEA AND COFFEE IN THE CAMEROON MARKET

BY

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FACULTY OF SCIENCE
AHMADU BELLO UNIVERSITY
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JUNE, 1994

DECLARATION

I hereby declare that this thesis contains the report of my research work and has not been presented in any previous application for a higher degree. All information from other sources have been acknowledged by means of references.

NDIFOR-ANGWAFOR, NCHE GEORGE

DATE

CERTIFICATION

This thesis entitled "*Chemical Analysis of Tea and Coffee in the Cameroon Market*" by NCHE George Ndifor-Angwafor, meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, Zaria, Nigeria, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to my parents Mr. & Mrs. NDIFOR-ANGWAFOR FRU, the entire exploited, oppressed and down-trodden masses of Cameroon, and to all those who love knowledge.

ACKNOWLEDGEMENTS

I wish to express my profound gratitude to my supervisors, Professors J.Y. Olayemi and S.A. Thomas for their valueable assistance, suggestions and constructive criticisms throughout the course of my work.

I would also like to express my sincere appreciation for the guidance Dr. J.A. Nok of the Department of Biochemistry offered me, which did not culminate only in the attainment of my academic goal, but also in developing and moulding out of me a fine personality.

My thanks go to the department which despite the difficult financial situation still made my research work possible by providing the necessary facilities and materials. I am highly indebted to Dr. James Bale of NAPRI in Shika for his kind assistance. I also very much appreciate the assistance rendered to me by my friends and all well-wishers, especially Engr. Ghogomu Yeyung who brought some of my samples from Cameroon.

Finally, my utmost gratitude goes to my brothers, sisters and relatives especially Mr & Mrs Samuel Fru Wamucho for their financial and moral help throughout my courses.

ABSTRACT

Analysis was performed on some tea and coffee samples sold on the Cameroon markets. The tea and coffee samples were processed and packed in Cameroon Development Corporation (C.D.C), North West Co-operative Association Limited (N.W.C.A) and "Union Centrale des Co-operative Agricoles de L'Ouest" (U.C.C.A.O) . They were analysed for their caffeine, tannin, water-soluble ash, moisture content, ash content, alkalinity of the soluble ash and for the inorganic elements phosphorus, magnesium, potassium, calcium, copper, zinc, manganese, iron and sodium. Some physico-chemical studies were carried out on the samples.

Atomic absorption spectrophotometer was used for the determination of the mineral elements except phosphorus which was determined by the yellow method. Conventional methods of chemical analysis were used for the determination of mositure content, ash content, water-soluble ash, alkalinity of soluble ash, water extractive, caffeine and tannin contents of the samples.

The results showed that for the tea samples moisture content ranged from 4.94 to 7.91 per cent, ash content 5.48 to 7.87 per cent, water-soluble ash 2.22 to 4.56 per cent, alkalinity of soluble ash 0.09 to 0.29 per cent, total organic matter 92.13 to 94.52 per cent, total nitrogen 3.60 to 9.09 per cent. Water extractive for particle size with

highest extraction using sachets ranges from 30.75 to 34.77 per cent while water extractive for particle size with highest extracton without using sachets ranges from 31.00 to 35.4 per cent. Tannin content for the whole samples ranges from 45.07 to 72.03 mg/g while for peak particle sizes it ranges from 43.40 to 62.60 mg/g and for particle sizes with highest extraction ranges from 44.20 to 73.33 mg/g. Caffeine content for the peak particle sizes range from 2.66 to 5.76 per cent while for the particle sizes with highest extraction, it ranges from 3.14 to 5.79 per cent. The mineral elements determined have values ranging from 1.02 x 10^2 to 3.90 x 10^4 mg/g.

For the coffee samples moisture content ranges from 0.55 to 7.48 per cent, ash content ranges from 4.14 to 6.73, per cent water-soluble ash ranges from 3.10 to 5.40 per cent, alkanility of soluble ash ranges from 0.59 to 0.89 per cent, total organic matter ranges from 93.27 to 95.86 per cent and total nitrogen ranges from 4.09 to 5.58 per cent. Water extractives for particle size with highest extraction using sachets ranges from 24.58 to 28.96 per cent while that for particle size with highest extraction without using sachets ranges from 22.26 to 24.83 per cent. Tannin content for whole samples ranges from 45.73 to 79.04 mg/g and that for peak particle sizes ranges from 35.87 to 43.74 mg/g while that for particle size with highest extraction ranges

from 40.05 to 45.07 mg/g. Caffeine content for the whole samples ranges from 3.15 to 4.47 per cent, that for particle sizes with highest extraction ranges from 3.62 to 4.62 per cent while that for peak particle sizes ranges from 3.18 to 3.98 per cent. Mineral elements determined have concentration ranging from 30.00 to 9.80×10^4 mg/g.

The results of the physico-chemical studies showed that the percentage of maximum extraction of the blue tea labels that occurred at 5 minutes ranges from 87.42 to 95.20 while for the red labels it ranges from 81.08 to 84.36. For the coffee samples it ranges from 77.98 to 83.33 for the unblended coffee while for the blended ones it ranges from 74.19 to 83.87. This could probably justify the 5 minutes of infusion in hot water recommended by the producers since for both tea and coffee samples more than 70 per cent of the maximum extraction was obtained during the first 5 minutes.

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ABBREVIATION AND SYMBOLS

D.D.T	-	Dichloro-diphenyl-trichloroethane
>	-	Greater than
<	-	Less than
AAS	-	Atomic Absorption Spectrophotometer or Spectrophotometer
mm	-	Millimetres
Conc.	-	Concentration
mins	-	Minutes
mg/g	-	Milligramme per gramme
mg	-	Milligramme
g	-	Gramme
cm	-	Centimetres
v	-	Volume
%	-	Per cent
s	-	Seconds
C.E	-	Catechin equivalent
l	-	Litres
C.D	-	Café delice
C.FI	-	Café force I
C.FII	-	Café force II
A.G.C	-	Arabica ground coffee
R.C	-	Robusta coffee
A.C	-	*Arabica coffee*
N.W.C.A	-	North-West Co-operative Association Limited

U.C.C.A.O	-	Union Centrale des Co-operative Agricoles de l'Ouest
D.B.L	-	Djuttitsa tea blue label
D.R.L	-	Djuttitsa tea red label
T.B.L	-	Tole tea blue label
N.B.L	-	Ndu tea blue label
N.R.L	-	Ndu tea red label
C.D.C	-	Cameroon Development Corporation
ISCA	-	International Scientific Coffee Association

Equity amongst individuals depends on who owns what while equity amongst nations depends on who knows what. The progress of a nation depends mostly on the qualities of its researchers, which are mostly promoted by any government that considers development as a priority. The authorities of the Cameroon Government and private corporation have neglected this vital project under the cover of economic crisis. They should know that nothing succeeds like success even though there are times when nothing is dangerous than success.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Coffee

Coffee is a member of the large *Rubiaceae* family, within which it constitutes the coffee genus that was created by C. Linnaeus. The coffee tree had previously (1717) been considered to be a Jasmine (Jasminum arabicum Laurifolio), by A de Jussieu, who is responsible for its first botanical description.

The two main species exploited in the world today are *Coffea arabica L.* and *Coffea canephora* pierre. Other species of coffee are being cultivated less extensively, namely *Coffea liberia* Bull ex Hiern, *Coffea abeokutae* Cramer, *Coffea dewerrei* De wild and Durand and *Coffea froh* (Leroy, 1980).

Coffea robusta, is very widespread, and is considered to be a variety or form of *Coffea canephora*. *Coffea excelsa* is one of the many strains of *Coffea dewerrei* De wild and Durand (Berthand and Anthony, 1984). The different species of the Coffea genus have very diverse appearances and behaviour. This applies to their development up to the adult stage starting from the sub-shrub stage when they are a few decimetres tall, until they become 12 to 15 metres tall trees and to the characteristics of their branches,

leaves, flowers, fruits and beans which are also disparate. Some of these species are different from the cultivated coffee trees and can only be identified by botanists.

1.2 Tea

Tea is made from the young leaves and unopened leaf buds of the tea plant, *Camellia sinensis* (L) O. Kuntze, a specie which includes some distinct varieties (Harler, 1963a). The use of infusion of dried tea leaves as a beverage has its origin in antiquity. Tea was first cultivated and the leaf prepared for infusion in China. The leaf is rich in the alkaloid caffeine which constitutes 4 per cent of the dry matter in young leaf. It is also rich in polyphenols which consitutes almost one-third of the dry matter in the younger leaves (Harler, 1963a).

In its commercial production, leaves and buds are oxidized and then condensed to form bodies having tanning properties. Tea is taken for its comforting warmth and the stimulus given by the caffeine. Drinkers of tea have acquired a liking for the taste of the brew and for the briskness and strength imparted to the liquor by the condensed polyphenols. Tea is a pleasure to drink, but does not necessarily add to the caloric intake (Wellman, 1961a).

1.3 Objectives of the Research

Tea and coffee are accepted drinks in Cameroon. All brands of tea and coffee are produced and processed in Cameroon. The tea samples are processed and distributed in the United Republic of Cameroon by the Cameroon Development Corporation (C.D.C), while the coffee samples are processed and distributed by "Union Centrale des Co-operative Agricoles de L'Ouest", (U.C.C.A.O) and "North-West Co-operative Association Limited" (N.W.C.A).

Analysis of these beverages have not been reported done in Cameroon on the brands in the market. The aim of this project is to provide a reliable information on some of the brands in the Cameroonian market. It is hoped that useful recommendation as regards quality, price and time of infusion will be made to the companies in-charge of the production of these beverages at the end of the work.

In this work, the tea and coffee samples sold in the Cameroonian markets were analysed for their major constituents. The results of the analyses of these beverages will be compared with similar analyses recorded in literature.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Coffee

2.1.1 Geographical Distribution of the Main Species

The distribution of the cultivated species throughout the world is as follows:

Coffea arabica (Coste 1991a)

Africa: Higher altitude zones of Kenya, Tanzania, Uganda, Zaire, Cameroon, Ethiopia, Burundi Madagascar.

Asia: High altitude zones of *Arabica* (Yemen), India, Phillippines, Indonesia (Java, Sumatra), Vietnam.

Central and South America: High altitude zones of Mexico, Guatemala, Honduras, San Salvador, Nicaragua, Costa Rica, Panama, Columbia, Venezuela, Ecuador, Paraguay, Peru, Middle altitude zones of Brazil and the Caribbean Islands.

Coffea Canephora (Coste 1991a)

Africa: Low altitude zones of Zaire, Angola, Ivory Coast, Nigeria, Ghana, Central African Republic,

Madagascar, Togo, middle altitude zones of Cameroon, Uganda and Tanzania.

Asia: Low and middle altitude zones of Indonesia, India, Phillippines and new Caledonia.

Hot regions of Northern Brazil.

Other species: *Coffea liberica* is represented by vestiges of plantations in Africa. Some large estates still exist in Surinam and Indonesia. *Coffee excelsa* has been the object of extension efforts in Central African Republic, to identify resistant types after the destruction caused by trachaeomycosis. The production of *Coffea abeokutae*, known in Ivory Coast by the Commercial name of "Gros Indénié" has now been mostly abandoned in favour of *Coffea canephora*. The serious damage caused by trachaeomycosis is mostly responsible for the situation.

2.1.2 Pests and Diseases (Coste, 1991a)

i. Branch and Leaf Disease

(a) *Coffee leper*: It is caused by a micro-alga, *Cephaleuros virensceus* Kze, and causes velvetly, reddish-brown spots to appear on the leaves. These spots often turn green due to the combined presence of a lichen and fungus. It is therefore not a true disease.

(b) Sooty mould: It appears as a blackish coating on the leaves and is produced by a fungus that develops from the sugary secretions of mealy bugs. This mould screen affects the efficient functioning of the chlorophyll. The sooty mould will disappear when the mealy bugs are destroyed.

(c) Pink disease: It is caused by *Corticuim salmicolor* B and Br and appears as a pink membrane or filament on the bark of the branches, causing the branches to wither.

ii. Disease of the Fruit

The "Brown eye spot" or "leaf spot" disease, caused by *Cercospora coffeicola* can also attack fruits where it is known as "Grey blotch" (Lavabre, 1962). *Fusarium* infections are responsible for reducing coffee harvests in Brazil, Africa and other countries (Coste, 1991a). Verrucose disease is caused by *Sclerotinia fluckeliana* (de Bar) FUCK, mealy pod disease is caused by *Trachyspaera fructigena* Tab and Bunt. (Lavabre, 1962). Reddish brown spots are first observed on the fruits, a white or pinkish floury coating then develops and the fruit dies out. *Coffea liberica* and *Coffea abeokutae* appear to be the most sensitive species.

iii. Pests of Flowers and Fruits

The Hemiptera (bugs and aphids) include a number of flower and fruit pests which affect coffee. The most serious are *Volumnus obscurus* popp, *Lygus* species and the rainbow-coloured coffee bug (*Antestiposis lineaticolis intricata* Ghesq and Car) mirids (*Volumnus obscurus* popp and *Lygus* species). The flower buds and flowers of coffee are most severely attacked together with very young shoots, although to a lesser degree. These attacks cause the flowers to abort. Massive attacks have been reported in Gabon and Cameroon.

iv. Rainbow-Coloured Coffee Bug (Antestiopsis Lineaticolis Intricata Ghesq and Car)

This insect was formerly classified in the *Antestia* genus and is one of the most formidable pests of arabica coffee in Africa and South East Asia. It causes damage in East Africa (Kenya, Uganda, Tanzania).

2.1.3 Production Processes

The ripe fruits of coffee go through a number of operations, the objectives of which are to extract the beans from their covering pulp, mucilage, parchment, film, and to improve their appearance (Coste 1991b). The following techniques are used to obtain clean coffee beans.

(a) Wet processing: In this process the fresh fuit is processed in three stages.

i) Removal of the pulp (pulping) and mucilage (mucilage removal) washing.

ii) Drying of parchment coffee.

iii) Removal of the inner coverings, parchment and film (hulling).

(b) Dry processing: This consists of two stage:

i) Drying of the fruit (Coffee berries or cherry coffee).

ii) Removal of the dried coverings in a single mechanical operation (hulling).

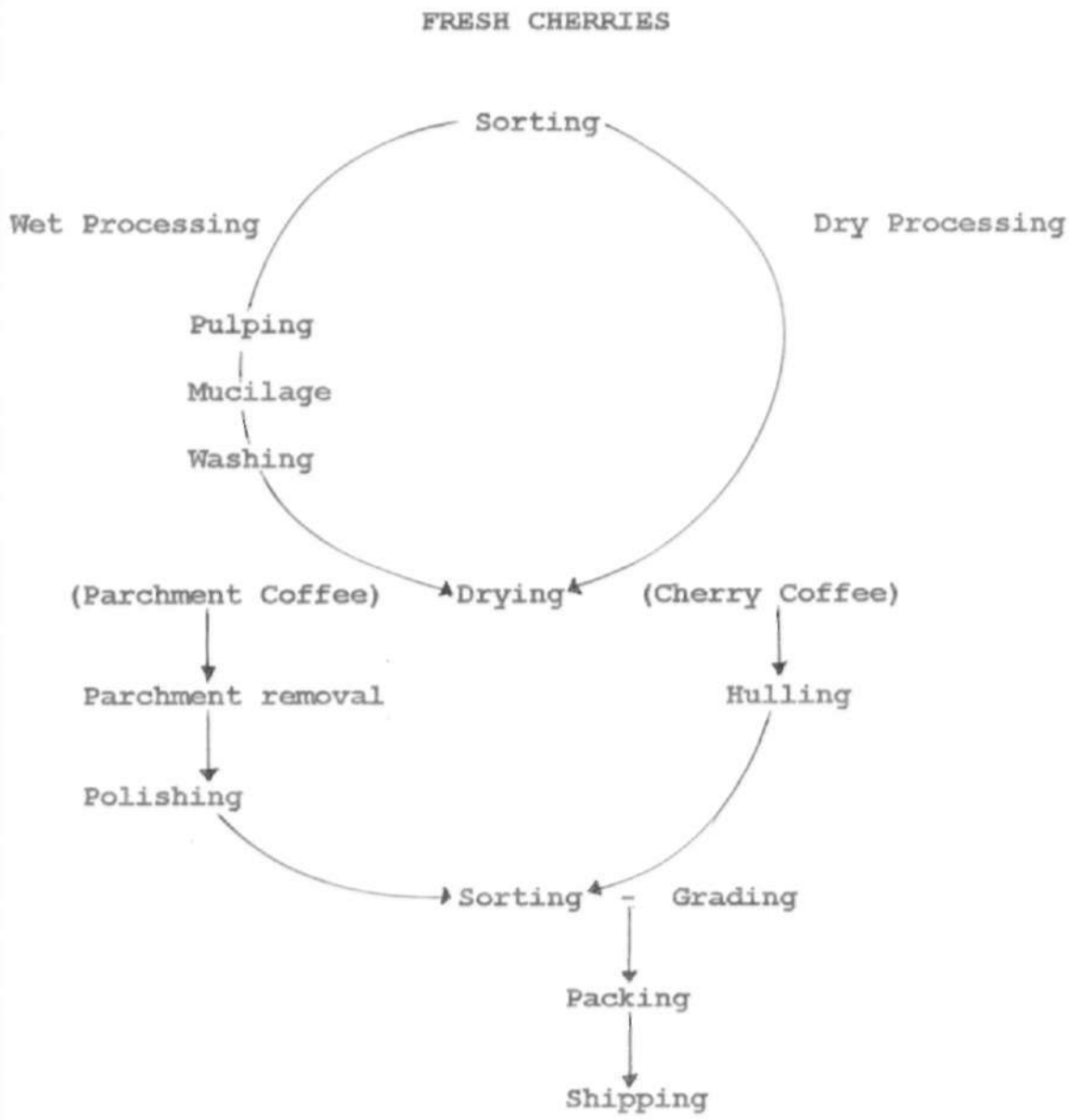


Figure 1.1 Operations in the Wet and Dry Processing of Coffee

There are five stages in the manufacture of coffee, these are:

(a) Pulping

Pulp removal must be done as soon as possible after harvesting to avoid the production of stinker beans (beans with a disagreeable taste and smell). During pulping the seeds are separated from the mucilaginous substance by using pulpers (Coste, 1991b).

b) Fermentation

This involves placing the pulped Coffee in appropriate environmental conditions, so that the pectin of the mucilagineous coating of the beans decomposes due to a lactic fermentation. The pectinolysis is accelerated by the presence of micro-organisms such as yeast and bacteria (Coste, 1991b). The duration of the process is varibale. It depends upon the principal elements involved such as the volume or the mass of beans, the species or variety of Coffee, the maturity of the fruits, the ambient temperature and altitutde. For arabicas, it is between 12 and 48 hours (Kenya: 12 to 18 hours; Indonesia, 18 to 24 hours; Mexico 18 to 40 hours; Cameroon 12 to 24 hours) and for robustas it is between 12 and 36 hours. Excelsa and liberica coffees, which are wet processes, may have to

be fermented for 40 to 60 hours. The slippery, shiny covering to the bean is no longer present when fermentation is complete (Haarer, 1962a).

(c) Drying

The drying of the parchment coffee is promoted by draining when it leaves the washing channels. During this operation water accounting for 5-10 per cent is largely removed by gravity. Drainage towers are often used for these purposes. Drying requires care and supervision especially if artificial methods are used. If the procedure is too rapid or too lengthy moisture from rain or dew may condense on the beans during the course of the operation, altering the quality of the beans. They may become discoloured, mottled, brown or reddish-brown. Excessive drying leads to weight loss which cannot be compensated commercially. According to Wilbaux (1970) drying induces a volume contraction of the bean by 12 to 15 per cent. Two drying techniques used are the natural (or solar) and artificial drying. Sometimes both are used as a technique which is referred to as mixed drying. After drying the Coffee is allowed to cool before it is bagged and stored in bulk or before it is polished.

(d) Sorting, Polishing and Grading

The objective of sorting is to remove misshapen, unsuitable, black, discoloured, or spotted beans, in addition to broken ones of which there are normally a rather high percentage (Coste, 1991b). Both the appearance and the quality of the Coffee is improved by this procedure, since some of these defects can give it an off flavour. The objective of polishing is to cover the beans with a thin film of non-hygroscopic material to conserve the aroma and enhance the appearance of the bean. Polishing is used often to conceal low quality coffees.

(e) Roasting and Grinding

Coffee roasting is preceeded by various operations including cleaning and dusting to remove the foreign matter from the beans (pieces of husk or parchment, stones, earth, string, nails). The most suitable equipment for the roasting of coffee is the pneumatic separator (Coste, 1991b). Roasting gives Coffee its taste and aroma and also changes the bean in certain ways. The bean loses weight called a "less in the fire" due to the evaporation of water from the green coffee; the extreme limits of this evaporation are between 14 and 23 per cent of original moisture content (Illy, 1980).

In coarsely ground coffee, water will filter through too quickly and the beverage, which is not sufficiently charged with the aroma will taste rather bland. When the powder is too fine, particles will be carried by the water and deposited at the bottom of the cup. Fine grinding prolongs filtering process and cools water, rendering the beverage muddy and bitter. Coffee should be ground somewhere between these two extremes depending on the nature of the equipment used. Grinding is divided into two categories: The first category is very regular, made up of uniform particles of average size from which small powdery particles have been sperated (Illy, 1980). The second category consists of grounds made up of particles of various sizes and contains up to 50 per cent of very small, powdery particles (less than 0.02 mm and 50 per cent medium-sized and larger particles.

2.1.4 Components of Coffee

(a) Water

Marketed green Coffee has a moisture content of between 10 and 13 per cent. French law (Decree of 3 September, 1965) has set moisture content level at 12.5 per cent. Above this level, the storage of Coffee is

affect the ability of moist coffee beans to provide tasty and aromatic roasted products. However he estimated that this alteration can be avoided if the water content of the bean is below 10 per cent.

(b) Minerals

Green Coffee contains 3 to 4 per cent as (Coste, 1991c). This comprises mostly potassium, sodium, calcium, magnesium, phosphorus and sulphur. Numerous trace elements have also been found including: iron, aluminium, copper, iodine, fluoride and boron.

(c) Protein

Green Coffee contains 1 to 3 per cent nitrogen, present in various combinations; the main ones being proteins and alkaloids. Several aminoacids and certain sulphur aminoacids (particularly Cysteine and Methionine (Figures 1.2 and 1.3) contained in Coffee proteins play a major role in the formation of the aroma of roasted coffee, since they are involved in the strecker reactions.

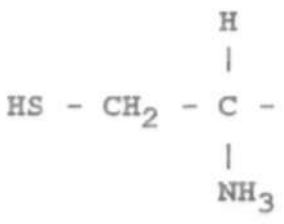


Fig. 1.2 Cysteine

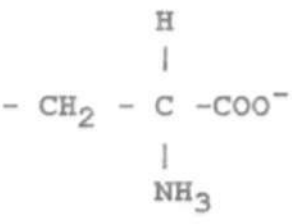


Fig. 1.3 Methionine

(d) Alkaloid and Other Non-Protein Nitrogeneous Substances

The main alkaloid in Coffee is Caffeine. It is accompanied by other nitrogenous compounds in lesser quantities including Choline and Trigonelline (Illy, 1980). Green Coffee generally has a Caffeine content of between 1 and 2.5 per cent. Arabicas contain the lowest amount of Caffeine with average of 0.8 to 1.5 per cent, whereas with the Canephoras (Robusta, Kouilou) the content varies between 1.6 and 2.2 per cent. Some varieties contain 2.8 per cent and even exceed 3 per cent Liberica and Excelsa are intermediary position of about 1.5 per cent.

In green Coffee the Caffeine occurs as a double salt, Caffeine chlorogenate and Potassium (Ullman, 1986). The Caffeine or 1,3,7-trimethylxanthine, is a major counterpart of theobromine (3-7 dimethylxanthine). Its formula is $C_8H_{10}O_2N_4H_2O$ (anhydrous caffeine) but it crystallises with water in the form of a monohydrate $C_8H_{10}O_2N_4H_2O$ (Ullman, 1986). Its improved formula is illustrated in Figure 1.4 below.

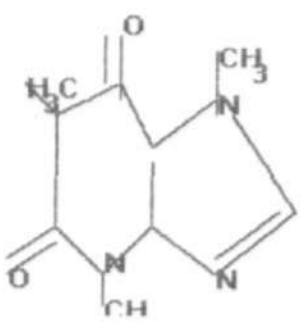


Figure 1.4: Caffeine; 1,3,7-trimethylxanthine

This compound looks is a white, frayed, silky crystal which melt at 234-237^{o}C, but are slightly sublimated at about 100^{o}C, and to a greater extent at 180^{o}C. This partially explains the loss of aroma and flavour observed during roasting.

(e) Lipids

Coffee beans contain fat. Some authors estimated that the presence of various lipids may affect the preservation of its organoleptic qualities which are odour, colour, taste and appearance (Navellier, 1959). The fat is rich in unsaponified substances, which are not eliminated during the common refining procedures. This renders it unsuitable for certain uses, such as food. The characteristics of the oil in coffee grounds (Navellier, 1959) are shown in the Table 2.1.

Navellier (1959) classified Coffee lipids into three categories:-

i) Fatty-acids and their derivatives, glycerides and phospholipids.

ii) Components of the unsaponified substances; carbides, sterols, di and tri-terpenes, tocopherols.

Table 2.1

Property	Value
Iodine index	97.6
Saponification index	180.6
Peroxide index	5.2
Free acidity in Oleic acid	0.27%
Unsaponified substances	5.84%

iii) The components of the outer wax of the beans.

Arabicas are rich in oil (12 to 18 per cent).

Robustas contain less oil (9 to 14 per cent).

(f) Carbohydrates

They represent more than half of the dry matter of green coffee beans (Coste, 1991b). Among these, the polysaccharides are largely represented (over 40 per cent), whereas the oligosacharides and monosaccharide is 5 and 1 per cent respectively. They do not play an essential role in determining the qualities of the beverages, but impart its "Caramel" colour and flavour characteristic of other roasted products such as barley and chicory root. Green coffee contains small quantities of free reducing sugars (especially glucose) and sucrose (5 to 8 per cent).

(g) Aliphatic and Polyphenolic Acids

The coffee beans contain different organic acids especially phenolic acids which have the characteristics of tannins. Hydroxycinnamic acids are particularly common in the beans, especially in the form of chlorogenic acids (4 to 8 per cent) at double the chlorogenate level of caffeine and potassium (Clifford, 1985). These components are mostly destroyed during roasting with the release of the

alkaloid. In addition to chlorogenic acids, the usual non-volatile and volatile organic acids also identified include oxalic, malic, citric, tartaric and acetic acids.

(h) Volatile Principles and Aromatic Components

The volatile principles in green coffee are represented by water and about 180 other substances, among which are methoxy-pyrazines, aliphatic hydrocarbons, carbonyls, acids, alcohols and thiols, puranes, pyreols, pyridines, quinolines, phenols, aromatic amines and carbonyls (Clifford, 1985). The aromatic complex of roasted coffee is formed during roasting and develops from substances that are still largely unknown called "Precursors".

2.1.5 Coffee in the United Republic of Cameroon

The cultivation of coffee in Cameroon dates back to 1925 - 35 with *Coffea arabica* on the high plateaux of Bamiléké and Bamoun, and *Coffea canephora* in the middle-altitude regions of the west. In later years, robusta growing expanded to the east in Abongmbang.

Presently approximately 350,000 hectares of land are used for coffee growing, about 50 per cent of which is occupied by arabica (Coste, 1991c). The predominant characteristic of coffee growing in Cameroon is the special

care taken, particularly in regions where arabica is grown. This is the result of a rather strict technical discipline imposed on the African planters when coffee first started to be grown in the country and which has persisted. Several co-operatives operate satisfactorily, the oldest being "Cooperative of Bamoun Planters of Arabian Coffee". This Co-operative was first established in 1932. The arabica coffee produced by Cameroon is of a high quality and is very popular. Most of the coffee produced is exported. Three types of coffee are produced in Bafoussam by "Union Centrale des Co-operatives agricoles de l'ouest". They are "Café delice" (C.D) made up of 100 per cent arabica coffee, "Force I" (C.FI) made up of 80 per cent arabica coffee and 20 per cent robusta, "Force II" (C.FII) made up of 70 per cent arabica coffee and 30 per cent robusta coffee. Arabica ground coffee is also produced in the United Republic of Cameroon by the North West Co-operative Asssociation Limited (N.W.C.A).

The prices of the various coffees manufactured by "Union Centrale des Co-operatives agricoles de l'ouest", are shown on Tables 2.3, 2.4 and 2.5. The prices depend on the type of coffee and the distance from the production centre to the source of supply to the consumers.

Table 2.2: Main destinations of coffee exported from Cameroon in 1987

Destination	Tonnage
France	19967
Netherlands	6648
West Germany	7761
Italy	20617
United States	1881
Japan	3955
Belgium	2532
United Kingdom	758
Switzerland	2216
Total	66335

(Source: Le Café No. 440, March, 1988)

Table 2.3: Prices of "Café delice" (100 per cent arabica coffee) in the United Republic of Cameroon (1993)

Location in Cameroon	Gross price in C.F.A			Retail price in C.F.A		
	1000g	500g	250g	1000g	500g	250g
Western Province	1370	730	370	1760	930	485
North West Province	1410	750	380	1810	955	495
Littoral Province	1440	765	390	1850	975	510
Centre Province	1440	765	390	1850	975	510
South Province	1440	765	390	1850	975	510
South West Province	1440	765	390	1850	975	510
Eastern Province	1510	820	415	1950	1045	540
North Province	1510	820	415	1950	1045	540
Adamaoua Province	1510	820	415	1950	1045	540
Extreme North Province	1510	820	415	1950	1045	540

(The Prices are in "*Communauté Financiére Africaine*" (C.F.A)

Table 2.4: Prices of "Café force I" (80 per cent Arabica coffee and 20 per cent robusta coffee) in the United Republic of Cameroon (1993)

Location in Cameroon	Gross price in C.F.A			Retail price in C.F.A		
	1000g	500g	250g	1000g	500g	250g
Western Province	1310	680	360	1710	875	475
North West Province	1350	700	370	1760	900	485
Littoral Province	1380	715	380	1800	920	500
Centre Province	1380	715	380	1800	920	500
South Province	1380	715	380	1800	900	500
South West Province	1380	715	380	1800	920	500
Eastern Province	1450	770	405	1910	990	535
North Province	1450	770	405	1910	990	535
Adamaoua Province	1450	770	405	1910	990	535
Extreme North Province	1450	770	415	405	1910	535

(The Prices are in "*Communauté Financiére Africaine*" (C.F.A)

Table 2.5: Prices of "Café force II" (70 per cent Arabica coffee and 30 per cent robusta coffee) in the United Republic of Cameroon (1993)

Location in Cameroon	Gross price in C.F.A			Retail price in C.F.A		
	1000g	500g	250g	1000g	500g	250g
Western Province	1280	670	355	1690	855	470
North West Province	1320	690	365	1740	880	480
Littoral Province	1350	700	375	1780	900	490
Centre Province	1350	700	375	1780	900	490
South Province	1350	700	375	1780	900	490
South West Province	1350	700	375	1780	900	490
Eastern Province	1420	760	400	1900	970	530
North Province	1420	760	400	1900	970	530
Adamaoua Province	1420	760	400	1900	970	530
Extreme North Province	1420	760	400	1900	970	530

(The Prices are in "*Communauté Financiére Africaine*" (C.F.A)

Source: "Bulletine de l'union Centrale des Co-operatives agricoles de l'ouest: January 1993 issue.

2.1.6 Coffee Beverage as Related to Health

Coffee has a physiological effect on the consumer particularly with regard to the nervous and circulatory systems. In coffee the component recognised for its stimulating effect is caffeine. Coffee stimulates cerebral activity and is consumed to prolong wakefulness (Coste, 1991c). A 250.0 cm^3 with a 3.0g of coffee is reported to contain between 100 and 150mg of caffeine (Timson, 1978). Coffee is a heart stimulant by nature of its caffeine content which also has diuretic properties. Caffeine has a bitter taste in higher concentrations but is virtually without taste in dilute proportions. According to medical studies, coffee is a mildly addictive drug with a good effect that is both temporary and transitory (Timson, 1978).

Coffee was first introduced about 300 years ago and has had many adversaries. It was originally denounced by the Church as being conducive to amoral behaviour, since it was often consumed in association with alcoholic beverages. When caffeine is taken in reasonable amounts, it reduces a craving for sweets, by stimulating the production of those adrenal hormones that cause blood sugars to be increased (Davis, 1954). Caffeine is easily absorbed from the gut and it is rapidly distributed to all the tissues and organs of the body (Timson, 1978). The half-life of caffeine in man varies from one person to another but is usually three to

five hours. The drug disappears from the body almost completely overnight and there is no day to day accumulation of it. Excesses of coffee are known to give unpleasant tremors, nervousness, heart palpitation and other temporary discomforts (Wellman, 1961c). The medical fraternity have over the years voiced several legitimate objections to the consumption of coffee which has often been grossly exaggerated by the media. In response to this potentially damaging media coverage, the ISCA (International Scientific Coffee Association) encouraged several eminent doctors and physiologists to carry out research in order to disprove the theories which linked coffee consumption with such conditions as hypertension and cardiac disorders. These studies which were backed by scientific and medical findings, suggest that moderate coffee consumption of four to five 250.cm^3 cups with a 3.0g coffee in each in a day for an adult presents no danger.

Caffeine is an active drug and an overdose can be fatal. According to Timson (1978), lethal dose is 10 grams and this requires a rapid consumption of 80 to 100 250.0 cm^3 cups with a 3.0 grams coffee which is an almost impossible feat.

Tannins are also present in coffee. They are known for their astringent taste which is important in foods (Bate-Smith 1954 a, b and Joslyn *et al*, 1964). They are

clinically observed to have constipating effect in the control and treatment of diarrhoea (Jones, 1965 and Sollman, 1957). There is actually no reason to assume a relationship between coffee consumption and development of cancer in the ovary, prostrate, pancreas, bladder or the gastrointestinal tract, nor is the development of leucaemia considered to be related to coffee consumption (Yamanishi *et al*, 1972).

2.17 Methods of Coffee Improvement

The basic (haploid or "n") chromosome number is 11. However, while most species, including *Coffea canephora*, are diploids 2n = 22 chromosomes. Nevertherless although of little practical importance, there are some exceptions to this role with polyploid varieties, such as *Coffea arabica*, Var bullata cramer; 6n = 66 and 8n = 88 (Charrier, 1985). The genetic differences between the two main species *Coffea arabica* and *Coffea canephora*, explain why it is practically impossible under natural conditions to create fertile hybrids between the two. In laboratory studies geneticists resort to a technique which consists of doubling the number of chromosomes of the diploid species (2n = 22) by treatment with colchicine in order to facilitate crossings with tetraploid varieties of *Coffea arabica* (4n = 44).

From a practical point of view, there is also a fundamental difference between the tetraploid *Coffea arabica*

and all other species, in that it is, infact self-fertile, whereas *Coffea canephora* like other diploid species is self-sterile and must be cross-pollinated. In other words, *Coffea arabica* coffee flowers can be fertilised by their own pollen while those of *Coffea canephora* have to fetilised by pollen from flowers on other shrubs, in principle of the same species. This dominant trait involves the use of the two main species of Coffee. Some initial operations however, are common to the two main species. For example, for the original parent material, the plant breeder must have a sample collection from all the trees found in regional plantations. If necessary, these plants may be subjected to observations for several years, depending upon the selection criteria being used. The operations that follow differ, depending upon whether a self-fertilising *Coffea arabica*, or other cross-pollinated species is being used as parent material.

Gene manipulation holds a great deal of promise today, not only in the area of quality improvement, but also with regard to most of the inherited factors which distinguish a specie or a clone. The increase in the understanding of the genetic constitution of coffee which has taken place during the past few years certainly upholds this opinion. However, caution should be displayed regarding the success of these extreme difficult and delicate operations, and the length of

time it takes to carry them out (Charrier, 1985). The specialists estimate that, based on current state of knowledge and work, possibly 15 to 20 years or more may elapse before the first concrete results obtained. It should also be noted that at the plantation level, the real value of the new plant material must first be established through experiments conducted systematically in the field under realistic cropping conditions and under diverse ecological situations. Some of the important characteristics that need to be tested are potential yield, which will require a certain number of harvests, tolerance to most harmful pests and diseases, classification of bean, characteristics and, of course, the aromatic qualities of the processed beverage. These essential investigations, will take at least five, possibly 10 or 15 years and will thus increase the period that elapse before the new coffee hybrids can be exploited for example the hybrid Arabusta. The potential of genetic manipulation will undoubtedly also be involved in revolutionising coffee growing in the future. The high cost of research, together with the fact that results will not be available in the immediate future should not be discouraging.

2.2 Tea

2.2.1 Geographical Distribution of the Main Species

Tea is produced in india, Ceylon, Java, Japan, Cameroon, Nigeria and China just to name a few countries. The requirements of the tea crop are good climate, soils and land configurations.

i) Climate

Tea grows best in humid conditions at moderate temperatures. Tea naturally grows under forest shade (Eden, 1976a) hence high incidence of sunshine is not of importance. Rainfalls between 70 and 150 inches will generally produce good cropping conditions.

ii) Soils

According to Eden (1976a), tea thrives on soils that are distinctly acidic, well-drained and of sufficient depth to give the expanding root system of the perennial plant adequate room for development, both in volume and range. Highly compacted soils are disadvantageous because although tea roots grow rapidly in a good medium they have feeble powers of penetration into dense soils. The periodic prunning operations that control the growth of tea confer some benefits to soil fertility.

iii) Land Configurations

For ease of working and soil protection tea is grown only on land where the slopes are moderate and where the configuration in general shows that dependable conservation measures such as contour planting can and will be carried out (Eden 1976a).

2.2.2 Pests and Diseases

Tea is subject to attack by many insect pests and fungus diseases. The most widespread pests are the red spider, *Metatetramychus bioculatus* which can be controlled by lime sulphur spraying (Harler, 1956b). A few years ago the tea mosquito bug, *Helopeltis theivora* was the most serious pest but this has been brought under control by D.D.T. spraying. Crickets, beetles, borers, caterpillars, bugs thrips and mites do damages at certain times. The tea plant is attacked by many fungi which bring diseases to the leaves, stems and roots. A fungus disease, Black root due to *Corticium invisum* attacks the leaves and blackens both fresh and older leaves. Control is obtained by Copper fungicide sprays Blister blight, *Exobasidium vexans* attacks the young leaves and may kill pruned bushes which are just putting on foliage.

2.2.3 Production Processes

Tea leaves are rich in pectase and polyphenols oxidase enzymes and polyphenols. They play an important role during the production process. There are six stages in the production of tea and these are:

(a) Withering

(b) Rolling

(c) Roll-breaking and green leaf sifting

(d) Fermentation

(e) Firing

(f) Grading and sorting

(a) Withering

This is the first stage in processing tea. This is carried out by spreading thinly on banks of trays or "tats" made of tightly stretch jute hessian or wire netting. Two or three square metres per kilogramme of fresh leaf is a normal density of spread (Eden, 1976b). The tats are spaced 14cm apart, to allow free access of air, with alley ways between each bank to allow distribution and removal of leaf. the primary object in withering is to prepare the leaf for rolling by making its tissues flacid and permeable to the juices which the rolling will wring out and spread evenly upon the surface (Eden, 1976b).

(b) Rolling

It twists the leaf, breaks it open and expresses the juices. The machines used vary in size and design but their principles are alike; they compress and turn the leaf over, keeping it in continual motion, in a manner that is similar to the operation of rubbing leaf between the palms of the hand. As a result of rolling polyphenols, the enzymes become thoroughly mixed and exposed to the atmosphere (Pearson, 1976a).

(c) Roll-breaking and Green Leaf Sifting

On discharge from the roller the leaf mass is compressed into lumps. These are broken up in the sifting process by the machine which usually combines the operation of the roll-breaker and sifter. The roller discharge is fed into a hopper in which beaters revolve to break up the mass, after which the tea falls onto the sieve and slowly travels to the other end for discharge.

The roll-breaker and green leaf sifter performs three essential functions. In the first instance it cools the leaf and thus prevent the retention of excessive heat. Second, it aerates the mass and third by sieving out particles of small size, it separates leaf into portions that will be reasonably uniform in their rate of fermentation.

(d) Fermentation

Fermentation starts in the rollers but is continued in the dhool stage. The sifted dhools are spread out in thin layers in order to continue the oxidative processes. There is great variety in the materials that are used to accomodate this spread-out leaf. Tiles, cement and aluminium are most commonly used, the essential point being that they should be easily cleaned. The thickness of spread controls three important factors, the temperature of the leaf, the rate of moisture loss and the access of oxygen (Harler, 1963b).

During fermentation the leaf changes colour and becomes a dark copper colour (Pearson, 1976a). The typical aroma develops and by subjective judgement of its intensity, the period necessary for completion is judged. As fermentation progresses the soluble content capable of extraction in the brew decreases. Over-fermented tea lose strength even though they appear to increase in colour. Fermentation time is made short because the soluble content capable of being extracted into the brew decreases as fermentation progresses (Eden, 1976b). Three-quarters of the polyphenols in the tea leaf belong to a group known as flavanols. These are catechins and can readily turn brown. During

the fermentation process the catechins are oxidised to O-quinones by the polyphenol oxidase in the presence of oxygen. A series of condensation reactions follow and theaflavins (yellow bodies) and thearubigins (red and brown bodies) are formed. The theaflavins and thearubigins are the tannins in tea (Eden, 1976b).

(e) Firing

The general principle adopted in firing is that of subjecting the fermented tea to a forced blast of hot air in such a manner that the hottest air comes first into contact with the driest tea. The tea is fed into the top section, and moves in conveyor belt fashion till it discharges onto the tray immediately below, which is moving in the opposite direction and so on till the driest tea is discharged at the bottom. In the process moisture content is rapidly reduced till the leaf becomes a hygroscopic body and then heats up. During this process the enzyme responsible for fermentation is inactivated. The teas sold in the market might be blends of many different types of tea. Blending is decided upon in relation to the district of origin, flavour, colour, price and at times the hardness of the water in the areas in which the tea is likely to be infused (Pearson, 1976a). Foreign leaves,used tea leaves and other samples that contain

excessive stalk or are musty constitute adulterants in tea. However this is said to be virtually a relic of the past (Williams, 1964).

(f) Grading and Sorting

Grading is carried out for the most part on mechanically oscillated sieves fitted with meshes of approriate size. The products of the various sifting operations constitute the different grades and are defined by the meshes of two sieves through the larger of which the particles pass, and on the smaller of which they are retained. The grades in general production are named as follows; Broken orange Pekoe; Broken Pekoe, Orange Pekoe; Souchong; Broken orange, Pekoe fannings; Fannings and dust (Eden, 1976d).

2.2.4 Components of Tea

The chemical composition of the tea leaf is of interest mainly because of the reactions that take place during its manufacture. Importance is attached to the compounds that contribute to the strength, colour, pungency, flavour and stimulating properties of the beverage.

(a) Inorganic Constitutents

The inorganic constituents are found mainly as salts in the cell sap. Those of particular note are

Aluminium, Manganese, Potassium, Calcium, Magnesium, Iron, Copper, Zinc and Phosphorus.

i) Calcium: This mineral constituent has a concentration round about 0.5 to 0.7 per cent (Triea, 1954).

ii) Magnesium: Its content for deficient leaves is below 0.2 per cent.

iii) Iron: The Iron content of tea is very variable and can be quite low in leaf that has a high manganese content. Child (1955a) reports values lower than 100 mg/g.

iv) Copper: This element is of special importance to tea because of the role it plays in the fermentation process.

v) Zinc: Symptoms of Zinc deficiencies are the crowding of leaves on the shoot, and sickle-shaped foliage (Tolhurst, 1973).

vi) Phosphorus: Highest concentrations are in the young leaves which show a good deal of variation in content. Manuring with phosphates increases the amount in the foliage till luxury consumption is observed.

vii) Potassium: In concentration this element ranks highest among the mineral constitutents; the young foliage being the richest. The content is increased by potash manuring. Average figures compiled over

long periods lie between the range 1.35 to 1.76 per cent (Eden, 1944; Portsmouth 1953a). DeHaan and Schoorel (1940) placed the absolute potassium deficiency levels below about 0.6 per cent on the dry matter.

viii) Manganese: Tea foliage accumulates manganese in appropriate quantitites. The green tint of ashed tea leaf is due to the presence of Manganese salts. Values have been reported as high as 9,000 mg/g (0.90 per cent) in mature leaves from Malawi (Chenery,1955).

ix) Nitrogen Compounds: The average quality leaf, plucked for manufacture, usually contians 4.5 to 5 per cent of nitrogen in terms of the dry weight. The remaining quarter is from the alkaloid caffeine of which there is about 2.5 to 4.5 per cent in the dry leaf. One-quarter of the amino-acid and protein nitrogen is soluble so that, adding this to the caffeine, nearly half the nitrogen in tea leaf is found in the brew when tea is made. The most abundant amino-acid derivative in tea is theanine which constitutes something like 1.5 to 2 per cent of the dry matter of tea, and roughly one-sixth of this percentage to the nitrogen content. It has been identified as N-ethyl-Y-glutamine (Cartwright and

Roberts 1959). Figures from a series of analysis have been found as follows: total nitrogen 4.5 per cent, soluble protein and amino-acid nitrogen 0.92 per cent; insoluble nitrogen 2.51 per cent, caffeine nitrogen 1.07 per cent (Caffeine percentage 3.71).

x) Carbohydrates and Associated Compounds: Sugars and starch are found in tea leaf only in small quantities: Sugars, 0.73-1.43 per cent; starch, 0.82-2.96 per cent(Lamb and Sreerangacher, 1940). Lipids occur in the protoplasm. Pectins are present in quite large but very variable amounts in tea flush. The quantity varies according to the component parts of which the flush is made up. It is highest in the stalk (7.6 per cent) and in the first leaf (6.1 per cent) and lower in the bud and older leaves. It breaks down in the courses of manufacture to form pectic acid and methyl alcohol.

xi) Polyphenols: The most important and characteristic components of tea leaf are the polyphenols in the cell sap which undergo a series of chemical changes when the leaf is disintegrated during manufacture. Those occuring in tea are derivatives of gallic acid and of catechin. The best known gallic acid derivatives are the tannins. The polyphenols, like

alcohols are a very large class and their properties and derivatives differ widely.

xii) Pigments: The chlorophyll of the leaf enters into the chemical reactions of tea manufacture and is decomposed in the process of fermentation. Tea leaf also contains red and yellow pigments derived from anthocyanins and flavones (Eden, 1976d).

xiii) Enzymes: The oxidation of tea polyphenols on exposure to air is exceedingly slow unless speeded up by an enzyme. The major reaction is accomplished by a specific oxidase, a protein of which the prosthetic element is copper.

xiv) Aromatic Compounds: In judging the quality of tea the taster takes into account the aroma of the dry tea and also of the vapours emanating from the liquors.

xv) Vitamins: Riboflavin (vitamin B_2) is present in tea leaf and persist during manufacture and storage. As a source of riboflavin tea has, weight for weight about half the value of yeast and 80 percent of it passes into the cup when tea is brewed (Tric 1947). Ascorbic acid (Vitamin C) is also a constituent of tea leaf but is oxidized during the fermentation process in the manufacture of black tea.

2.2.5 Quality of Tea Beverage

Quality covers a variety of characteristics. It may mean a quantitative measureable character associated with the taste of one or several specific compounds. It is likely a description applied to a tea possessing all-round good cup characters of which colour, brightness, briskness, strength and aroma are all components (Hainsworth, 1961). The quality in tea is not determined by polyphenolic oxidation products alone (Roberts *et al*, 1961). The flavour of tea is dependent on a number of volatile substances including terpenoid and sulphur containing compounds, fatty-acids, alcohols, esters and carbonyl compounds (Stahl, 1962). During manufacture, infusion and drying of tea, there appears to be significant loss in flavour and theaflavins (Anon, 1968). In good quality teas the ratio of caffeine to tannin is about 1:3 (Pearson, 1976a). The pyrolysis volatiles from proteins are of some importance and include a large number of compounds such as acids, alcohols, aldehydes and phenols (Pearson, 1976b).

CHAPTER 3

3.0 MATERIALS AND METHODS

3.1 Sample Collection and Description

The coffee and tea samples analysed were obtained from New life supermarket, Bamenda main market, Nkwen market and from "Union centrale des Co-operatives agricoles de l'ouest in Bafoussam respectively. Five tea samples and four coffee samples were bought. The coffee samples are:

i) "Café delice" (Moulu 100 per cent arabica coffee)

ii) "Café force I" (Moulu 80 per cent arabica coffee and 20 per cent robusta coffee)

iii) "Café force II" (Moulu 70 per cent arabica coffee and 30 per cent robusta coffee)

iv) Arabica ground coffee

Types (i), (ii) and (iii) are processed by "Union centrale des Co-operatives agricoles de l'ouest, U.C.C.A.O" while type (iv) is processed by North-West Co-operative Association Limited (N.W.C.A).

The tea samples are packed in plastic bags weighing 100g. The plastic bags either carry a blue label or a red label. The samples are both grown, processed, packed and distributed in the United Rebulic of Cameroon. Below is a description of each sample.

3.2 Sample Description

3.2.1 Coffee Samples

(a) "Café delice (C.D) is 100 per cent arabica coffee. It is processed and distributed by "Union centrale des Co-operative agricoles de l'ouest", U.C.C.A.O. The coffee particles are packed in semi-plastic bags. The bags are made up of both paper and plastic. The cost per 1000g, 500g and 250g at different locations are shown in Table 2.3.

(b) "Café force I" (C.FI)is 80 per cent arabica coffee and 20 per cent robusta coffee. It is processed, and distributed by "Union centrale des Co-operatives agricoles de l'ouest", U.C.C.A.O. The coffee particles are fine and are packed in semi-plastic bags. The bags are made up of both paper and plastic. The cost per 1000g, 500g and 250g at different locations are shown in Table 2.4.

(c) "Café force II" (C.FII) is 70 per cent robusta coffee. It is processed and distributed by "Union centrale des Co-operative agricoles de l'ouest", U.C.C.A.O. The coffee samples are fine and packed in semi-plastic bags. The bags are made up of both paper and plastic. The cost per 1000g, 500g and 250g at different locations are shown in Table 2.5.

(d) Arabica ground coffee (A.G.C) is processed and distributed by the North-West Co-operative Association

Limited (N.W.C.A). The coffee particles are fine and packed in plastic bags. The cost per 250g is 400 francs C.F.A.

(e) Robusta coffee (R.C) is the raw material that is blended with arabica coffee in C.FI and C.FII. It was collected from "Union centrale des Co-operative agricoles de l'ouest", U.C.C.A.O. It is the grade two type and is greyish in colour.

(f) Arabica coffee (A.C) is the raw material used in the manufacture of Arabica ground coffee and "Café delice". It was collected from the North-West Co-operative Association Limited (N.W.C.A). The coffee is greyish in colour and consists of equal amounts of the following:

i) Washed arabica coffee type "A" 1991/92 crop
   Union of origin: NSO
   LOT No. 4510192

ii) Washed arabica coffee type "B" 1991/92 crop
   Union of origin: Mbengwi
   Lot No. 4590192

iii) Washed arabica coffee type "C" 1991/92 crop
   Union of origin: NSO
   Lot No. 4510192

iv) Washed arabica coffee type "D" 1991/92 crop
   Union of origin: Bali
   LOT No. 4550192

v) Washed arabica coffee type "F" 1991/92 crop
Union of origin: Nkambe
LOT No. 4570192

3.2.2 Tea Samples

(a) Djuttitsa tea Blue Label (D.B.L) is grown, processed and distributed in the United Republic of Cameroon by the Cameroon Development Corporation (C.D.C). The tea leaves are brownish black in colour and of small particle sizes. The leaves are packed in plastic bags. The cost per 100g is 200 francs C.F.A.

(b) Djuttisa tea Red Label (D.R.L) is grown, processed and distributed in the United Republic of Cameroon by the Cameroon Development Corporation (C.D.C). The tea leaves are brownish black in colour and of fairly large particle sizes. They are packed in plastic bags. The cost per 100g is 150 francs C.F.A.

(c) Tole tea Blue Label (T.B.L) is grown, processed in the United Republic of Cameroon by the Cameroon Development Corporation (D.D.C). The tea leaves are brownish black in colour and are of fine particle sizes. They are packed in plastic bags and the cost per 100g is 200 francs C.F.A.

(d) Ndu tea Blue Label (N.B.L) is grown, processed and distributed in the United Republic of Cameroon by the Cameroon Development Corporation (C.D.C). The tea leaves

are brownish black in colour and are of small particle sizes. They are packed in plastic bags and the cost per 100g is 200 francs C.F.A.

(e) Ndu tea Red Label (N.R.L) is grown, processed and distributed in the United Republic of Cameroon by the Cameroon Development Corporation (C.D.C). The tea leaves are brownish black in colour and of fairly large particle sizes. They are pakced in plastic bags and the cost per 100g is 150 francs C.F.A.

(f) Unprocessed tea leaves were collected from Djuttitsa in the Western province. They are the raw material for the Djuttitsa tea both blue and red labels. They are green in colour when fresh and become light black in colour when dried. The light black dried leaves were analysed because it was difficult to obtain fresh green leaves.

3.3 Determination of Moisture Content

This involves the measurement of the weight loss due to evaporation of water from the sample.

About 4g of each tea and coffee sample was weighed into separate dried crucibles. The samples were heated to constant weight in an air oven at 100 ± 1^{oC} (Pearson, 1976a,b). The total loss in weight of each sample was taken as the amount of moisture present.

$$\text{Per cent moisture content} = \frac{\text{Total loss in weight}}{\text{Wt of original sample}} \times \frac{100}{1}$$

3.4 Determination of the Ash Content

The ash of a foodstuff is the inorganic matter remaining after the organic matter has been burnt off by ignition (Perason, 1976a).

About 4g of each sample was weighed into a porcelain crucible that has previously been ignited. The crucible with the samples was then placed in a muffle furnace and ignited at 500±10^{oC}. When homogeneous greyish to brownish ash residues were obtined. The residues were allowed to cool in a dessicator before weighing. The per cent of ash content was then given as:

$$\frac{\text{Weight of ash}}{\text{Weight of original dried sample}} \times \frac{100}{1}$$

3.5 Determination of Water Soluble Ash

Water-soluble ash is the part of the ash that is soluble in water (Pearson, 1976c).

The ash obtained from the determination of the ash content for each sample was boiled with 25cm^3 water. The resulting mixture was filtered through an ashless filter paper. The residue and filter paper were washed with hot water and were ignited in the original crucible at 500±10^{oC}

for two hours. The residue was allowed to cool in a dessicator before weighing the water-insoluble ash.

$$\text{Per cent water-insoluble ash} = \frac{\text{Wt of water-insoluble ash}}{\text{Wt of original dried sample}} \times \frac{100}{1}$$

and per cent water-soluble ash = (per cent total ash - per cent water-insoluble ash).

3.6 Determination of Alkalinity of Soluble-Ash (Pearson, 1976c)

The filtrate obtained from the determination of the water soluble ash for each sample was allowed to cool and was titrated with 0.05M sulphuric acid using methyl orange as indicator. This gave the alkalinity of the soluble ash which was calculated as K_2O for tea and K_2CO_3 for coffee (Pearson, 1976a and b).

The reactions are as shown below:

(i) For the coffee samples by

$$K_2CO_3 + H_2SO_4 \longrightarrow K_2SO_4 + H_2O + CO_2$$

Weight of K_2CO_3 in ash = 0.05 x 0.138 x volume of acid

$$\%K_2CO_3 \text{ (alkalinity of ash} = \frac{0.05 \times 0.138 \times \text{vol. of acid}}{\text{Weight of dry sample}} \times \frac{100}{1}$$

(ii) For the tea samples by

$K_2O + H_2O \longrightarrow 2KOH$

$2KOH + H_2SO_4 \longrightarrow K_2SO_4 + 2H_2O$

Weight of K_2O in ash = 0.05 x 0.094 x volume of acid

$\%K_2O$ (alkalinity of ash = $\frac{0.05 \times 0.094 \times \text{vol. of acid}}{\text{Weight of dry sample}} \times \frac{100}{1}$

3.7 Organic Matter Determination

The total organic matter in the coffee and tea samples was determined by difference. The ash content of the dry sample was subtracted from the dry weight to give the organic matter content

Per cent total organic matter = 100 - per cent ash content

3.8 Determination of Mineral Elements

3.8.1 The ash in coffee sample is reported to contain mostly potassium, phosphorus and magnesium (Winton and Winton 1939), while the tea ash contains mostly potassium and phosphorus (Pearson 1976a).

The analytical methods for the determination of these elements are based on atomic absorption spectrophotmetry, colorimetry and photometry.

Dry ashing and wet digestion methods employed for the preparation of sample solutions. Some elements like Mercury, Cadmium and Zinc are known to be volatilized at

temperatures geater than 450°C. There are also difficulties in bringing alkali and alkaline earth metals in the ash obtained into solution completely as reported by Thiers (1957) and Gorsuch (1962). The non volatilization of metallic elements or phosphorus complete dissolution of the sample matrix has made the choice of wet digestion sutiable.

3.8.2 Method

About 0.5g of each sample was weighed into a 50 cm^3 Kjedahl flasks. 1.0cm^3 of perchloric acid (60 per cent), 5.0 cm^3 of Nitric acid (69.71 per cent) and 0.5 cm^3 of Sulphuric acid (98 per cent) were added. Digestion was carried out at low heat with gentle swirling of the flask. Heating was increased after the initial vigorous fuming. Digestion was continued for 10 minutes after the evolution of brown-fumes of nitrogen dioxide had ceased. The colourless digest was set aside to cool and was transfered into a 100 cm^3 volumetric flask and was made up to the mark with water. A blank digest carried out without the tea or coffee samples served as a control. The digested samples were examined for calcium, magnesium, zinc, manganese, iron, copper, potassium and sodium using the Perkin Elmer 290B Atomic Absorption Spectrophotometry. Phosphorus was determined by the yellow method. 50g of ammonium molybdate was added to 500 cm^3 of distilled water. 2.5g ammonium vanadate

was also added to 500 cm^3 of water and heated. 700 cm^3 of concentrated Perchloric acid was then added to the resulting mixture and made upto 2 litres by addition of water. 2 cm^3 of the prepared solution was added to 1 cm^3 of the digested sample and a yellow colour appeared. The amount of phosphorus present in the sample was determined using spectronic 20.

3.9 Total Nitrogen Determination

Tea leaves and coffee beans contain nitrogeneous matter which includes protein, caffeine and other nitrogen containing compounds (Pearson, 1976a and b; Winton and Winton, 1939). The total nitrogen content was determined by the micro-Kjeldahl method. The method involves the conversion of the nitrogen in the sample to ammonium salt by digestion involving acid hydrolysis.

3.9.1 Method

About 0.4g of each sample was weighed into a dried Kjeldahl flask. 1.9g potassium sulphate, 0.4g mercuric chloride and 20 cm^3 sulphuric acid were added to the flask. The mixture was heated in a fume cupboard using heating mantle until a clear clourless solution was obtained. The solution was quantitatively transferred to a 100 cm^3 volumetric flask, and was made upto mark with distilled

water and mixed. 10 cm^3 of this solution was transferred to a micro Kjehahl apparatus. 10 cm^3 of 50 per cent aqueous sodium hydroxide solution was added and the liberated ammonia was collected in 10 cm^3 of bromocresol green indicator in boric acid. The ammonia was then titrated with 0.1M hydrochloric acid. Each 1 cm^3 of 0.1M acid neutralised by the ammonical mixture corresponds to 0.0014g of nitrogen (Pearson, 1976c).

Total nitrogen = Volume of 0.1 acid neutralised by 10 cm^3 of ammoniacal mixture x 10 x 0.0014g.

$$\text{Per cent total nitrogen} = \frac{\text{Total nitrogen}}{\text{Weight of sample}} \times \frac{100}{1}$$

3.10 Determination of Tannin Content

3.10.1 Preparation of Reagents

(i) 8% (v/v) HCl in Methanol: This was prepared by measuring 8 cm^3 Concentrated HCl into a 100cm^3 Volumetric flask and diluting to volume with absolute methanol.

(ii) 1% (w/v) Vanillin in Methanol: This was prepared by weighing 1g of Vanillin and dissolving it in absolute methanol and the mixture diluted to volume with absolute methanol.

(iii) Vanillin - HCl Reagent: This was prepared just before use by mixing equal volumes of solutions (i) and (ii) above.

(iv) 4% (v/v) HCl in Methanol: This was prepared by measuring 4 cm^3 of concentrated HCl into a 100 cm^3 Volumetric flask and diluting to volume with methanol.

(v) 1% (v/v) HCl in Methanol: This was prepared by measuring 1 cm^3 of concentrated HCl into a 100 cm^3 Volumetric flask and diluting to volume with absolute Methanol.

(vi) Standard Solutions: A 1mg/50 cm^3 stock standard was prepared by dissolving 1 mg of Catechin standard in 50 cm^3 of absolute methanol. (This stock stored for several months in stoppered flasks under refrigeration). To prepare the working standards 0.2, 0.4, 0.6, 0.8 and 1.0cm^3 each of the stock standard was pipetted out and made up to 1.0 cm^3 with Methanol.

3.10.2 Tannin Extraction

About 2.5g of sample was transferred into a centrifuge tube. 12.5 cm^3 of 1% (v/v) HCl in Methanol was added to the tube and shaken on a mechanical shaker for 20 minutes. It was then centrifuged for 10 minutes and the aliquot

transferred to a 25 cm^3 Volumetric flask. 5 cm^3 of 1% (v/v) HCl in methanol was addedd to the centrifuge tube and shaken again for another 20 minutes. This was followed by centrifugation for 10 minutes after which the aliquot was transferred to the first extraction. The 25 cm^3 volumetric falsk was then made upto 25 cm^3 with 1% (v/v) HCl in methanol and mixed.

3.10.3 Method

The Vanillin - HCl method of tannin estimation is based on the formation a colour complex which absorbs at 500nm. The reaction is specific for Leucoanthocyanidins and catechins. Anthocyanidins and dihydrochalcones may interfer to some extent (Begovic 1969).

1 cm^3 of the extract was pipetted into a test tube. 5 cm^3 of Vanillin - HCl reagent (freshly prepared) was added slowly to the extract and catechin standards at different concentrations. Individual sample blanks were prepared by adding 5 cm^3 of 4% (v/v) HCl in methanol to 1 cm^3 aliquot. The absorbance were read at 500nm against reagent blank.

3.10.4 Calculations

A standard curve (Appendix F) was prepare by plotting the average absorbance readings of triplicate readings of Catechin concentration. The blank was subtracted from the

sample absorbance and the absorbance reading converted into concentration of Catechin per 50 cm^3. The Catechin equivalent (C.E) in parts per million was calculated as follows:

C.E. (ppm) = Mg Catechin per 50 cm^3 x 200

3.11 Determination of Caffeine Content of Coffee

The water extract of coffee was treated with Zinc ferrocyanide to clarify the solution. The Caffeine was then extracted into Chloroform and its content got by determining the nitrogen content using the micro-Kjeldahl method.

3.11.1 Reagents

(i) 0.88 Ammonia

(ii) Sulphuric acid about 98 per cent

(iii) Mercuric Chloride

(iv) Potassium Sulphate

(v) Chloroform analar grade

(vi) 2 per cent boric acid with 0.1 per cent bromocresol green indicator - Prepared by dissolving 2g of boric acid plus 0.1g of bromocresol green indicator in distilled water and making solution upto 100 cm^3.

(vii) Zinc acetate solution - Prepared by dissoving 21.9g crystallised zinc acetate in 3 cm^3 of glacial acetic acid in distilled water and diluting to 100 cm^3.

(viii) 1M Sodium hydroxide - Prepared by dissolving 4g Sodium hydroxide pellets in distilled water and making it upto 100 cm^3.

(ix) Potassium ferrocyanide solution - Prepared by dissolving 10.6g potassium ferrocyanide in distilled water. This solution and zinc acetate solution in equal volumes make the zinc ferrocyanide clearing agents.

3.11.2 Method

About 10g of each coffee sample was extracted with 400 cm^3 boiling water for 5 hours under reflux. The extract was concentrated by evaporation to about 85 cm^3 and was transferred to a 100 cm^3 standard flask. 5cm^3 each of the Zinc ferrocyanide were added. The solution was made upto the mark, mixed and filtered through a filter paper. The volume of the filtrate was measured. It was then transferred into a separator. 10 cm^3 0.88 Ammonia was added and the mixture shaken with five 25 cm^3 portions of Chloroform. The bulk extract was first shaken with 10 cm^3 1M Sodium hydroxide solution and the water extracts were shaken with a little Chloroform and added to the bulk Chloroform extract. The Chloroform extract was filtered into a pre-weighed round-bottom flask and the Chloroform evaporated on a water bath. The residue was dried at 100°C and weighed as crude caffeine. It was then transferred completely into a

Kjeldahl flask by small portions of concentrated Sulphuric acid. 1.9g of Potassium sulphate and 0.04g of Mercuric chloride were added to the Kjeldahl flask. The mixture was heated strongly until a clear colourless solution was obtained. The solution was then quantitatively transfered to a 100cm^3 Volumetric falsk, made upto the mark and mixed. 10 cm^3 of this solution was transferred to a micro Kjeldahl apparatus. 10 cm^3 of 50 per cent acqueous Sodium hydroxide solution was added and the liberated ammonia was collected in 10 cm^3 of bromocresol green indicator in boric acid. The ammonia was then titrated with 0.01M hydrochloric acid. According to Pearson (1976b):

1 cm^3 0.1M HCl = 4.855mg anhydrous caffeine

So that 1 cm^3 0.01M HCl = 0.4855 mg anhydrous caffeine

$$\text{Per cent Caffeine} = \frac{\text{Weight of Caffeine}}{\text{Weight of sample in filtrate}} \times \frac{100}{1}$$

3.12 Determination of Caffeine Content of Tea

Caffeine was extracted from its combination in the tea leaves by the using heavy Magnesium oxide solution. It was then extracted with Chloroform. The chloroform was evaporated off and the Caffeine content got by determining its nitrogen content by the micro-Kjeldahl method.

3.12.1 Reagents

(i) 50% aqueous NaOH solution - 50g NaOH dissolved and made upto 100 cm^3 with distilled water.

(ii) 1% Potassium hydroxide - Prepared by dissoving 1g Potassium hydroxide pellets in distilled water and making upto 100 cm^3 with the same solvent.

(iii) 0.01M Hydrochloric acid - Prepared by diluting 5.1cm^3 to 5.1 cm^3 of 0.5M standard hydrochloric acid to 500 cm^3 with distilled water.

(iv) 1% Sulphuric acid - Prepared by making up 5 cm^3 concentrated Sulphuric acid to 500cm^3 with distilled water.

(v) 10% Sulphuric acid - Prepared by making up 50 cm^3 concentrated Sulphuric acid to 500cm^3 with distilled water.

(vi) Sulphuric acid (about 98%).

(vii) Mercuric chloride

(viii) Potassium sulphate

(ix) Heavy magnesium oxide

(x) Chloroform

3.12.2 Method

About 5g of each tea sample was extracted with 200 cm^3 of water boing under reflux for 2 hours in the presence of 10g heavy Magnesium oxide. The extract was cooled, trans-

ferred to a 500 cm^3 Volumetric flasks, made upto the mark, mixed and filtered.

300 cm^3 of the filtrate was evaporated to about 100 cm^3 in the presence of 15 cm^3 of 10 per cent Sulphuric acid. The solution was filtered into a separator. Both the flask and the filter paper were rinsed with 1 per cent Sulphuric acid.The caffeine was extracted with six successive portions of Chloroform (25, 20, 15, 10, 10, and 10 cm^3 portions). The combined Chloroform extracts were treated with 5 cm^3 of 1 per cent Potassium hydroxide.

The Chloroform was evaporated on a water bath in a pre-weighed flask and the residue dried at 100°C. This was weighed as crude Caffeine and transferred to a Kjeldahl digestion flask using small portions of concentrated Sulphuric acid. The amount of Caffeine was determined as previously described in Section 3.11.2.

$$\text{Per cent Caffeine} = \frac{\text{Weight of Caffeine}}{\text{Weight of sample in 300 } cm^3 \text{ filtrate}} \times \frac{100}{1}$$

3.13 Physico-Chemical Studies

3.13.1 Kinetic Studies

Kinetic studies were carried out by the determination of water extractives (Pearson 1976a). The water extractives of the tea and coffee samples were carried out at different

time intervals. The kinetics of the extraction was studied from graphs of water soluble extractions against time. The initial slopes of the graphs gave the rate of infusion of the various tea and coffee samples. The water-soluble extraction of tea and coffee samples were carried out as follows:

A known weight of dried tea and coffee sample, about 2g, was boiled with 100 cm^3 of water under reflux for 1, 2.5, 5, 10, 20, 30, 40, 50 and 60 minutes respectively. This was filtered into a 250 cm^3 Volumetric flask. The filter paper with the residue was reboiled with another 100 cm^3 water and filtered into the Volumetric flask. The filtrate was cooled, made upto the mark with water. 50 cm^3 of it was pipetted into a weighed crucible and evaporated on a water bath. The crucible was dried to constant weight in the oven at 100±1°C.

Total extractives = weight of extractives in crucible x 5

$$\text{Per cent extractives} = \frac{\text{Total extractives}}{\text{Weight of dry sample taken}} \times \frac{100}{1}$$

Graphs of per cent extractives were then plotted against time (Figures 4.1 to 4.4).

3.13.2 Particle Size Determination

Endecotts tests sieves were arranged in decreasing order of mesh size. About 100 grams of tea or coffee sample

was placed at the top-most test. The test sieves were then placed on a shaker machine for one hour. The sieves were removed from the machine and the amount of samples on each test sieve was determined.

$$\text{Per cent particle size} = \frac{\text{Wt of sample on each test sieve}}{\text{Original wt. of sample on top-most sieve}} \times \frac{100}{1}$$

Graphs of per cent particle size against mesh size were drawn (Figures 4.5 to 4.10).

3.13.3 Determination of Particle Size with Highest Extraction

About 2g of each sample was collected from the different particle sizes determined in Section 3.13.2. The water-soluble extractives of tea and coffee samples of the different particle sizes was then determined as in Section 3.13.1 for 5 minutes. The particle sizes with highest extraction were determined by plotting graphs of per cent water extractives against the different particle sizes.

3.13.4 Determination of The Infusion Rate for Teas and Coffees of Particle Size With Highest Extraction Using Infusion Bags (SACHETS)

This was a comparative study between the rate of infusion using sachets and the rate of infusion

without sachets. Lipton tea sachets were bought from Leventis Supermarket in Zaria and the tea removed. The emptied infusion bags were used for the comparative studies as follows:

2g of the sample collected from the particle size with highest extraction determined in Section 3.13.3. The dried tea and coffee sample was placed in an infusion sachet and carefully sewn. Each sachet was boiled with 100 cm^3 of water under reflux for 5 minutes. The filtrate was placed in a 100 cm^3 volumetric flask. The filtrate on cooling was made upto mark with water in a 100 cm^3 volumetric flask. 50 cm^3 of it was pipetted into a dried, weighed crucible and the water evaporated on a water bath. The crucible was dried to constant weight in the oven at 100±1°C.

Total extractives = weight of extractives in crucible x 2

$$\text{Per cent extractives} = \frac{\text{Total extractives}}{\text{Weight of dried sample in each Sachet}} \times \frac{100}{1}$$

CHAPTER 4

RESULTS

The results of the analysis of the tea and coffee samples are shown in Tables 4.1 to 4.10. They are also shown in Figures 4.1 to 4.14. The results of the analysis of the tea samples are shown in Tables 4.1, 4.2, 4.3, 4.7, and 4.8. Table 4.1 shows the moisture content, ash content, water-soluble ash, alkalinity, total organic matter and total nitrogen. Table 4.2 shows water extractive for particle size with highest extraction using sachets, water extractive for particle size with highest extraction without using sachets, initial slope of infusion against time curve, tannin content for whole samples, peak particle sizes and particle sizes with highest extraction. Table 4.3 shows tannin content for peak particle sizes, tannin content for particle sizes with highest extraction, caffeine content for whole samples, caffeine content for peak particle sizes and caffeine content for particle sizes with highest extraction. Tables 4.7 and 4.8 give summary of the results in concentration () of the mineral elements. Table 4.7 gives the concentration (mg/g) of calcium, magnesium, Zinc, manganese and iron while Table 4.8 shows the concentration (mg/g) of copper, potassium, sodium and phosphorus.

The results of the analysis of the coffee samples are shown in Tables 4.4, 4.5, 4.6, 4.9 and 4.10. Table 4.4 shows moisture content, ash content, water-soluble ash, alkalinity, total organic matter and total nitrogen. Table 4.5 shows water extractive for particle sizes with highest extraction using sachets, water extractives for particle sizes with highest extraction without using sachet, initial slope of the plot of infusion against time curve, tannin content for whole samples, peak particle sizes and particle sizes with highest extraction. Table 4.6 shows tannin content for peak particle sizes, tannin content for particle sizes with highest extraction, caffeine content for whole samples, caffeine content for particle sizes with highest extraction and caffeine content for peak particle sizes. Tables 4.9 and 4.10 show summary of the results in concentration (mg/g) of the mineral elements. Table 4.9 shows the the concentration (mg/g) of calcium, magnesium, zinc, manganese and iron while Table 4.10 shows the concentration (mg/g) of copper, potassium, sodium and phosphorus.

Figures 4.1 and 4.2 are graphs of per cent water extractives against time for the tea samples while Figures 4.3 and 4.4 are graphs of per cent water extractives against time for the coffee samples. Figures 4.5 to 4.9 present graphical results of particle size distribution of the tea

and coffee whole samples. Figures 4.10 - 4.14 are graphs of per cent water extractives against various particle sizes of the tea and coffee samples.

These results are discussed on the next chapter where deductions are also made.

Table 4.1: Summary of Results of Analysis of the Tea Samples

Sample	Moisture content (%)	Ash content (dry weight) (%)	Water soluble (dry wt) (%)	Alkalinity (as K_2O) (%)	Total organic matter (dry weight) (%)	Total nitrogen (dry weight) (%)
D.R.L	6.21 ± 0.18	5.95 ± 0.09	2.62	0.11 ± 0.02	94.05 ± 0.09	4.92 ± 0.02
D.B.L	4.94 ± 0.11	5.48 ± 0.16	2.86	0.12 ± 0.10	94.52 ± 0.16	3.60 ± 0.30
N.R.L	7.91 ± 0.13	5.55 ± 0.05	2.22	0.09 ± 0.06	94.45 ± 0.05	5.58 ± 0.04
N.B.L	5.39 ± 0.08	5.59 ± 0.11	2.43	0.13 ± 0.07	94.41 ± 0.11	4.54 ± 0.11
T.B.L	5.34 ± 0.15	6.24 ± 0.10	2.64	0.11 ± 0.03	93.58 ± 0.10	4.79 ± 0.14
Unprocessed Tea leaves	6.24 ± 0.29	7.87 ± 1.83	4.56	0.29 ± 0.05	92.13 ± 1.83	9.09 ± 0.08

Table 4.2: Summary of Results of Analysis of the Tea Samples

Sample	Water extractive for particle size with highest extraction using sachets (%)	Water extractive for particle size with highest extraction without using sachets (%)	Initial slope of infusion against time curve (% min^{-1})	Tannin content whole samples (dry weight) (ppm)	Peak particle sizes (mm)	Particle sizes with highest extraction (mm)
D.R.L	34.77 ± 0.18	35.97 ± 0.25	30.63	56.01 ± 0.03	0.71	0.50
D.B.L	33.20 ± 0.14	33.35 ± 0.16	31.25	47.10 ± 0.10	0.71	0.43
N.R.L	32.19 ± 0.29	32.40 ± 0.30	25.83	72.03 ± 1.00	0.71	0.50
N.B.L	31.90 ± 0.24	34.68 ± 0.24	32.50	60.05 ± 0.98	0.71	0.50
T.B.L	30.75 ± 0.19	31.00 ± 0.28	31.03	45.07 ± 0.92	0.50	0.50
Unprocessed Tea leaves	-	-	-	68.13 ± 0.01	-	-

Table 4.3: Summary of Results of Analysis of the Tea Samples

Sample	Tannin content (dry wt) peak particle sizes (mg/g)	Tannin content (dry wt) particle sizes with highest extraction (mg/g)	Caffeine content (dry wt) whole samples (%)	Caffeine content (dry wt) peak particle sizes (%)	Caffeine content (dry wt) particle sizes with highest extraction (%)
D.R.L	44.40 ± 0.09	64.17 ± 0.29	3.88 ± 0.06	3.69 ± 0.06	4.70 ± 0.03
D.B.L	46.20 ± 0.92	49.60 ± 0.03	2.52 ± 0.10	2.66 ± 0.08	3.14 ± 0.10
N.R.L	62.60 ± 0.04	73.33 ±1. 00	4.60 ± 0.08	5.76 ± 0.07	5.79 ± 0.15
N.B.L	47.67 ± 0.58	66.40 ± 0.37	3.43 ± 0.11	3.01 ± 0.04	4.51 ± 0.06
T.B.L	43.40 ± 0.11	44.20 ± 1.06	3.88 ± 0.04	3.27 ± 0.05	3.91 ± 0.07
Unprocessed Tea leaves	-	-	8.12 ± 0.13	-	-

Table 4.4: Summary of Results of Analysis of the Coffee Samples

Sample	Moisture content (%)	Ash content (dry weight) (%)	Water soluble (dry wt) (%)	Alkalinity (as K_2O) (%)	Total organic matter (dry weight) (%)	Total nitrogen (dry weight) (%)
C.D	0.57 ± 0.02	5.49 ± 0.09	4.16	0.59 ± 0.07	94.51 ± 0.09	4.41 ± 0.05
C.FI	0.55 ± 0.55	4.68 ± 0.04	4.09	0.79 ± 0.05	95.32 ± 0.04	4.62 ± 0.14
C.FII	0.65 ± 0.07	4.14 ± 0.46	3.70	0.83 ± 0.12	95.86 ± 0.46	4.51 ± 0.07
A.G.C	2.32 ± 0.24	6.73 ± 0.06	5.40	0.72 ± 0.06	93.27 ± 0.06	4.09 ± 0.09
Robusta coffee	7.48 ± 1.21	5.42 ± 0.12	4.42	0.60 ± 0.04	94.58 ± 0.10	5.58 ± 0.11
Arabica coffee	7.46 ± 0.67	4.14 ± 0.25	3.10	0.89 ± 0.09	95.86 ± 0.25	4.22 ± 0.13

Table 4.5: Summary of Results of Analysis of the Coffee Samples

Sample	Water extractive for particle size with highest extraction using sachets (%)	Water extractive for particle size with highest extraction without using sachets (%)	Initial slope of infusion against time curve (% min^{-1})	Tannin content whole samples (dry weight) (mg/g)	Peak particle sizes (mm)	Particle sizes with highest extraction (mm)
C.D	28.96 ± 0.26	23.94 ± 0.41	22.25	75.33 ± 0.58	1.18	1.40
C.FI	24.58 ± 0.32	23.86 ± 0.26	21.43	70.31 ± 0.47	0.71	0.50
C.FII	27.67 ± 0.06	24.83 ± 0.23	20.63	45.73 ± 0.07	0.71	1.18
A.G.C	25.03 ± 0.22	22.26 ± 0.25	24.69	79.04 ± 1.12	0.71	0.50
Robusta coffee	-	-	-	57.13 ± 0.46	-	-
Arabica coffee	-	-	-	63.21 ± 0.37	-	-

Table 4.6: Summary of Results of Analysis of the Coffee Samples

Sample	Tannin content (dry wt) peak particle sizes (mg/g)	Tannin content (dry wt) particle sizes with highest extraction (mg/g)	Caffeine content (dry wt) whole samples (%)	Caffeine content (dry wt) peak particle sizes (%)	Caffeine content (dry wt) particle sizes with highest extraction (%)
C.D	43.73 ± 0.46	44.20 ± 0.69	3.30 ± 0.21	3.62 ± 0.05	3.18 ± 0.07
C.FI	42.81 ± 0.31	42.60 ± 0.71	3.53 ± 0.06	4.30 ± 0.11	3.70 ± 0.06
C.FII	35.87 ± 0.71	40.05 ± 0.07	3.94 ± 0.11	4.27 ± 0.61	3.98 ± 0.10
A.G.C	43.11 ± 0.35	45.07± 0.91	3.46 ± 0.07	4.62 ± 0.07	3.73 ± 0.04
Robusta coffee	-	-	4.47±0.09	-	-
Arabica coffee	-	-	3.15 ± 0.03	-	-

Table 4.7: Summary of the Results in Concentration (mg/g) of Mineral Elements in the Tea Samples

Sample	Ca (10^{-3})	Mg (10^{-4})	Zn (10^{-2})	Mn (10^{-3})	Fe (10^{-4})
D.R.L	3.06	2.12	6.01	2.30	3.50
D.B.L	1.00	1.58	5.20	1.92	2.70
N.R.L	3.50	1.36	5.71	6.10	3.30
N.B.L	2.16	1.35	3.90	5.00	1.00
T.B.L	2.16	1.67	6.51	7.30	2.10
Unprocessed tea leaves	2.92	2.36	6.51	1.76	3.90

Table 4.8: Summary of the Results in Concentration (mg/g) of Mineral Elements in the Tea Samples

Sample	Cu (10^{-2})	K (10^{-3})	Na (10^{-2})	P (10^{-3})
D.R.L	1.51	6.40	8.01	2.07
D.B.L	3.00	7.24	5.60	2.78
N.R.L	1.09	5.80	5.60	2.49
N.B.L	1.19	6.32	12.00	2.56
T.B.L	1.15	7.20	10.20	3.00
Unprocessed tea leaves	1.10	8.40	19.00	2.71

Table 4.9: Summary of the Results in Concentration (mg/g) of Mineral Elements in the Coffee Samples

Sample	Ca (10^{-4})	Mg (10^{-3})	Zn (10^{-4})	Mn (10^{-3})	Fe (10^{-3})
C.D	7.40	1.74	3.41	3.01	1.00
C.FI	7.00	1.58	3.70	2.81	6.00
C.FII	8.00	1.74	3.50	3.01	1.10
A.G.C	3.50	1.62	4.50	3.10	1.00
Robusta coffee	9.80	1.44	3.41	2.81	4.00
Arabica coffee	9.60	1.50	4.90	3.21	7.01

Table 4.10: Summary of the Results in Concentration (mg/g) of Mineral Elements in the Coffee Samples

Sample	Cu	K (10^{-3})	Na (10^{-2})	P (10^{-3})
C.D	95.00	7.60	7.01	1.60
C.FI	99.00	7.20	7.01	1.60
C.FII	91.00	7.28	1.04	1.70
A.G.C	30.00	7.76	9.01	1.73
Robusta coffee	165.00	6.64	6.60	1.73
Arabica coffee	95.00	6.52	7.41	1.64

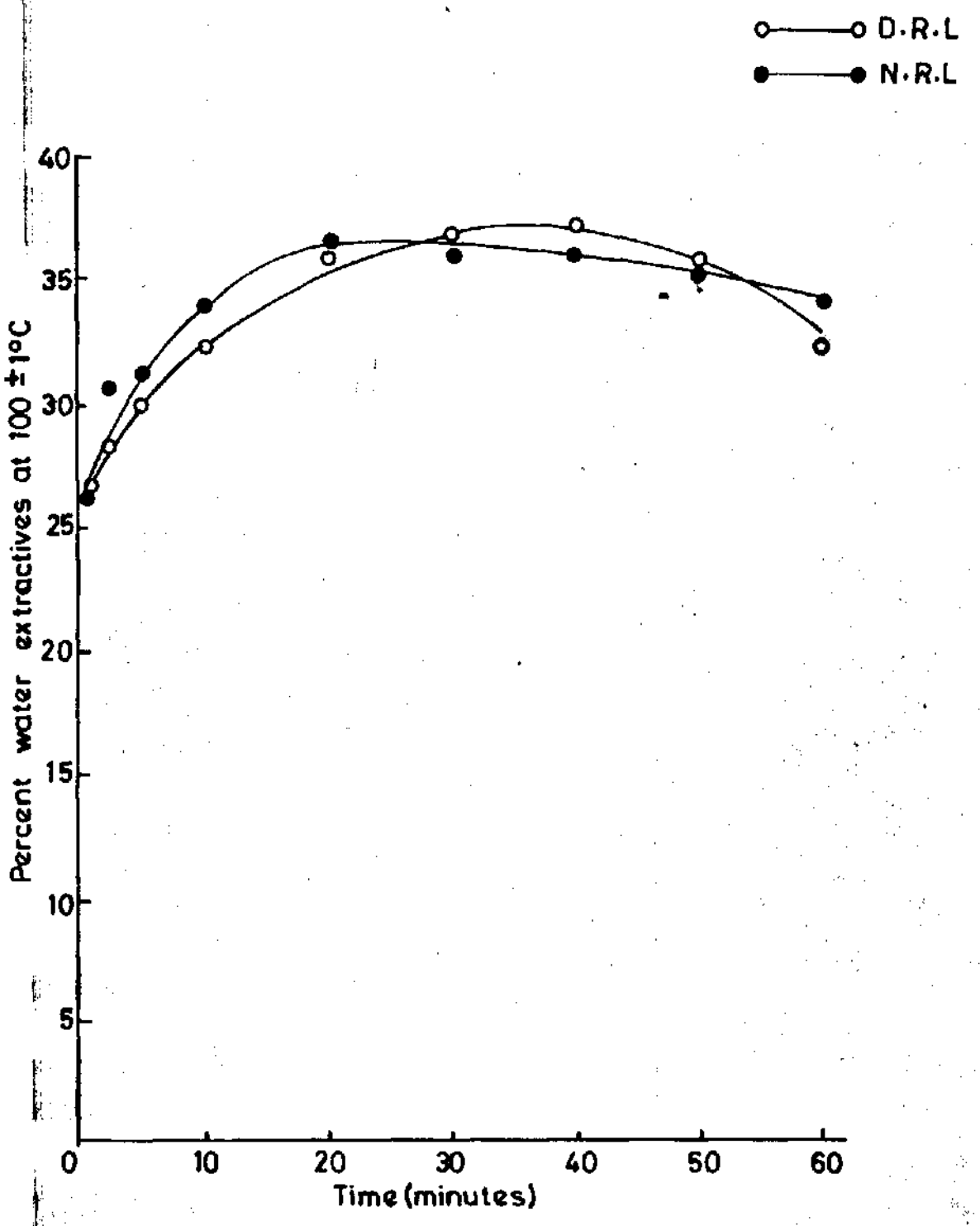
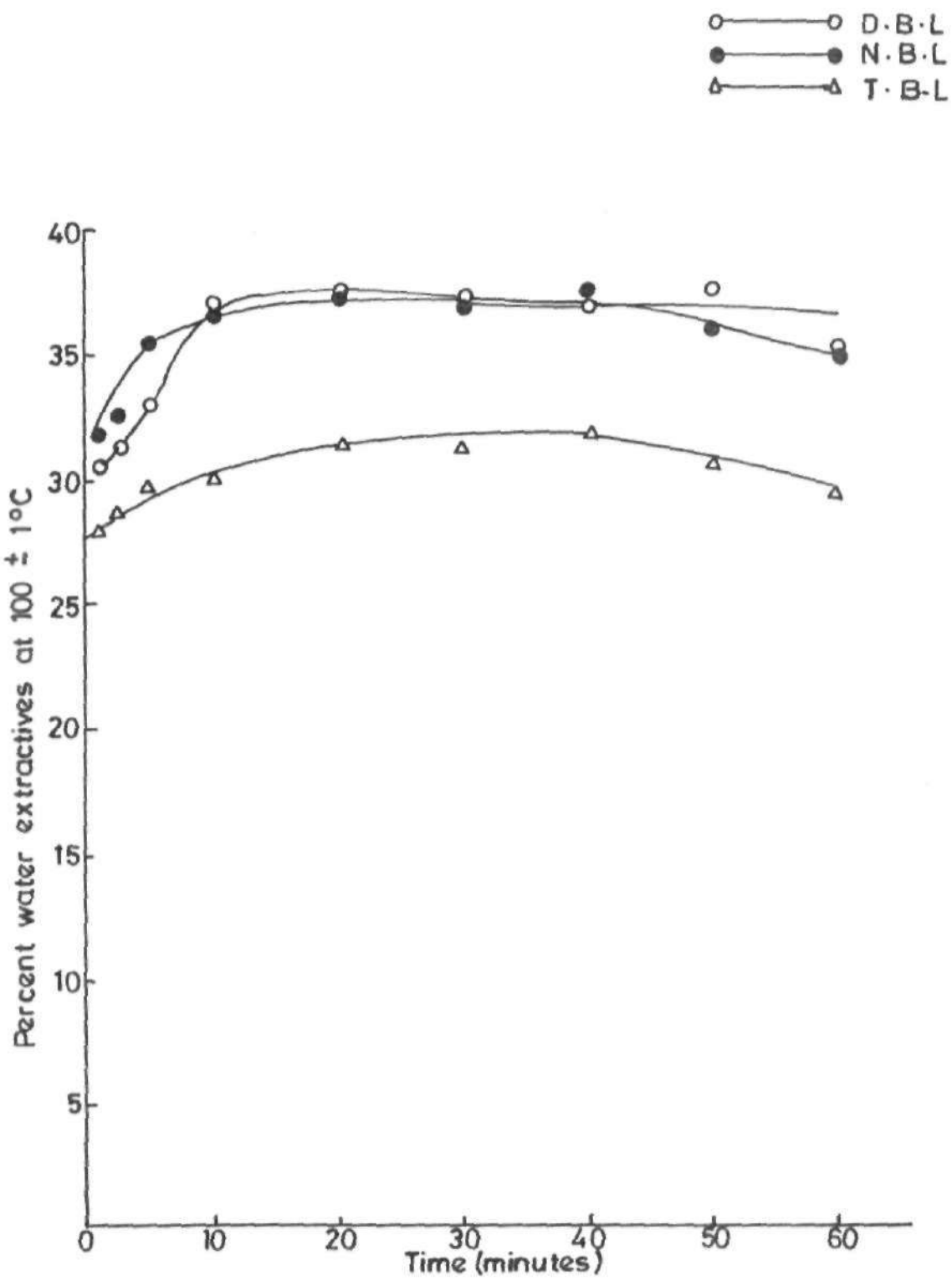


Fig.41:Graph of percent water extractives against time for D·R·L and N·R·L whole samples (i.e Unfractionated)



Fig·4·2:Graph of percent water extractives against time for D·B·L N·B·L and T·B·L whole samples (i.e Unfractionated)

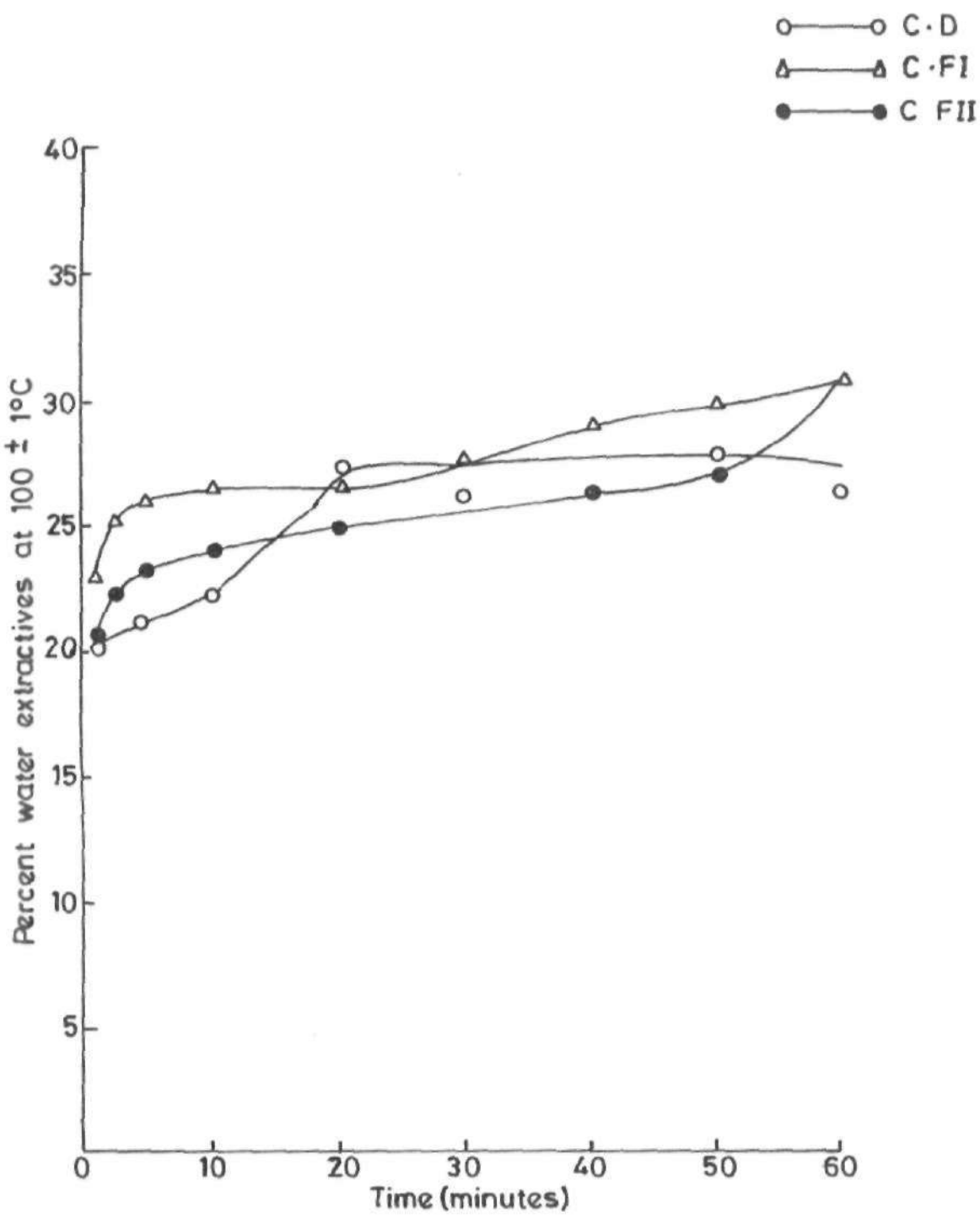


Fig-4.3:Graph of percent water extractives against time for C·D, C·FI and C·FII whole samples(i.e Unfractionated)

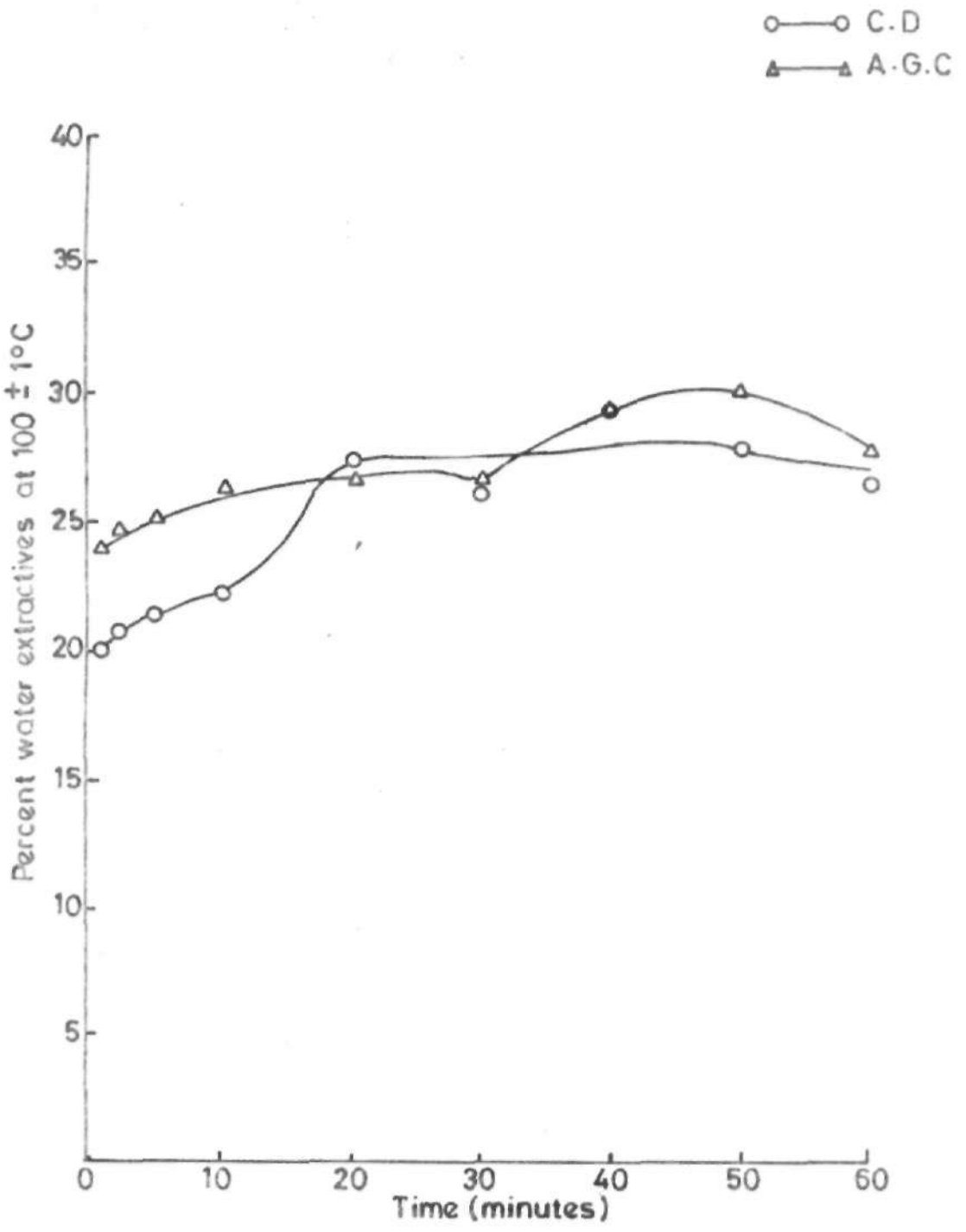


Fig.4.4: Graph of percent water extractives against time for C.D and A.G.C whole samples (i.e Unfractionted)

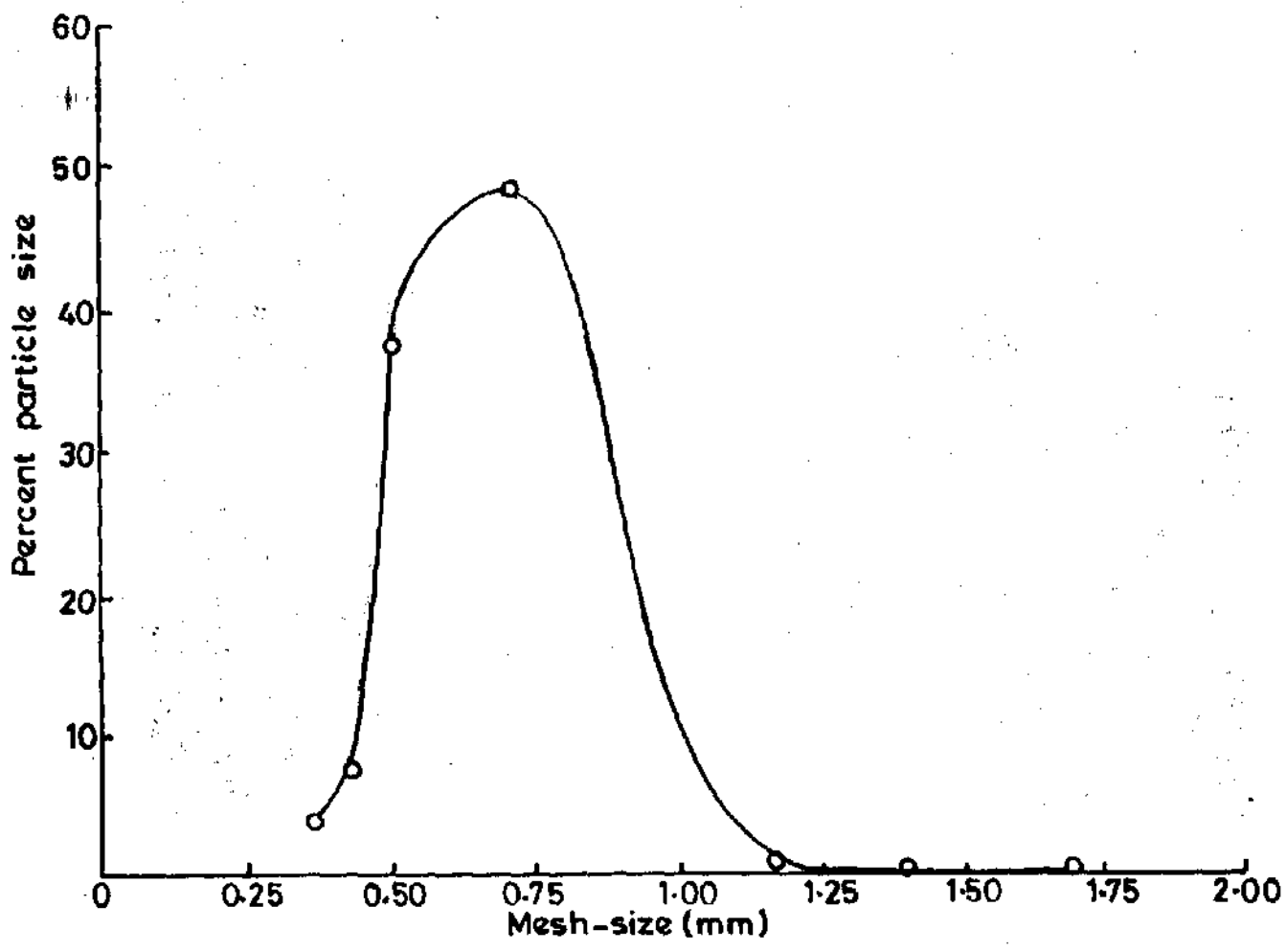


Fig.4.5:Graph of particle size distribution of lipton tea whole sample (ie Untracfionated)

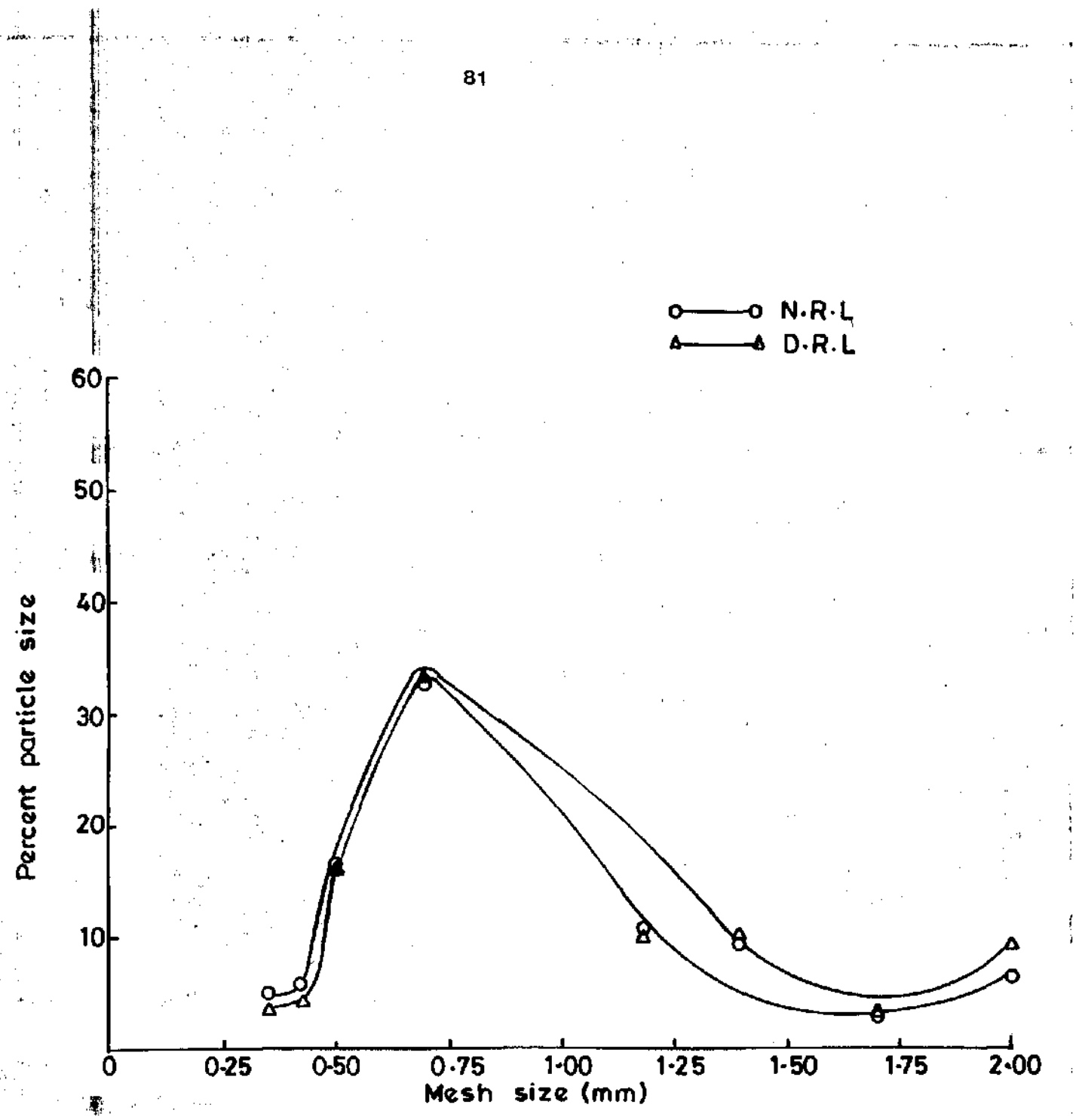


Fig.4·6. Graph of particle size distribution of D·R·L and N·R·L whole samples (i.e Unfractionated)

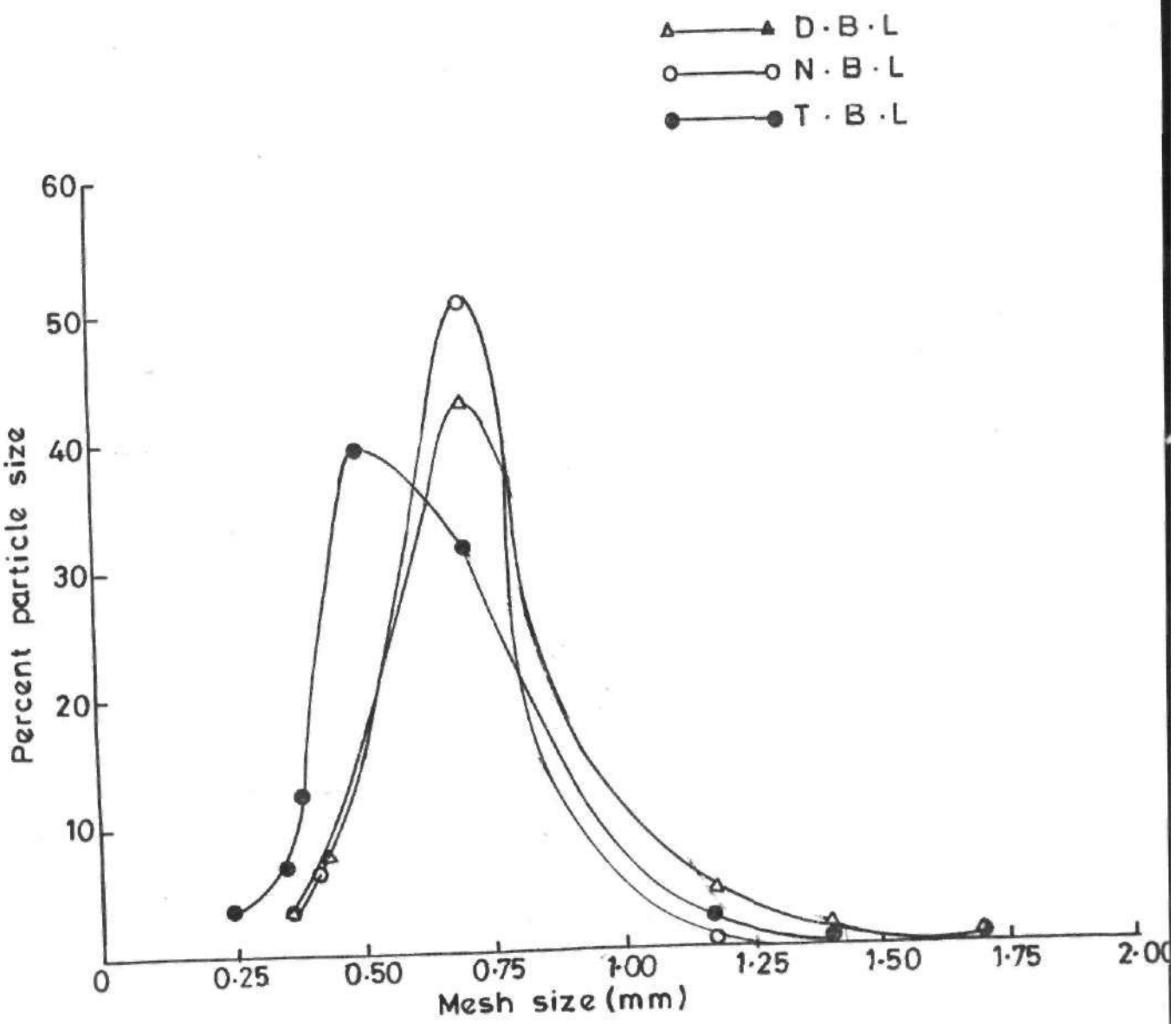


Fig 4.7: Graph of particle size distribution of D·B·L, N·B·L and T·B·L whole samples (i·e Unfractionated)

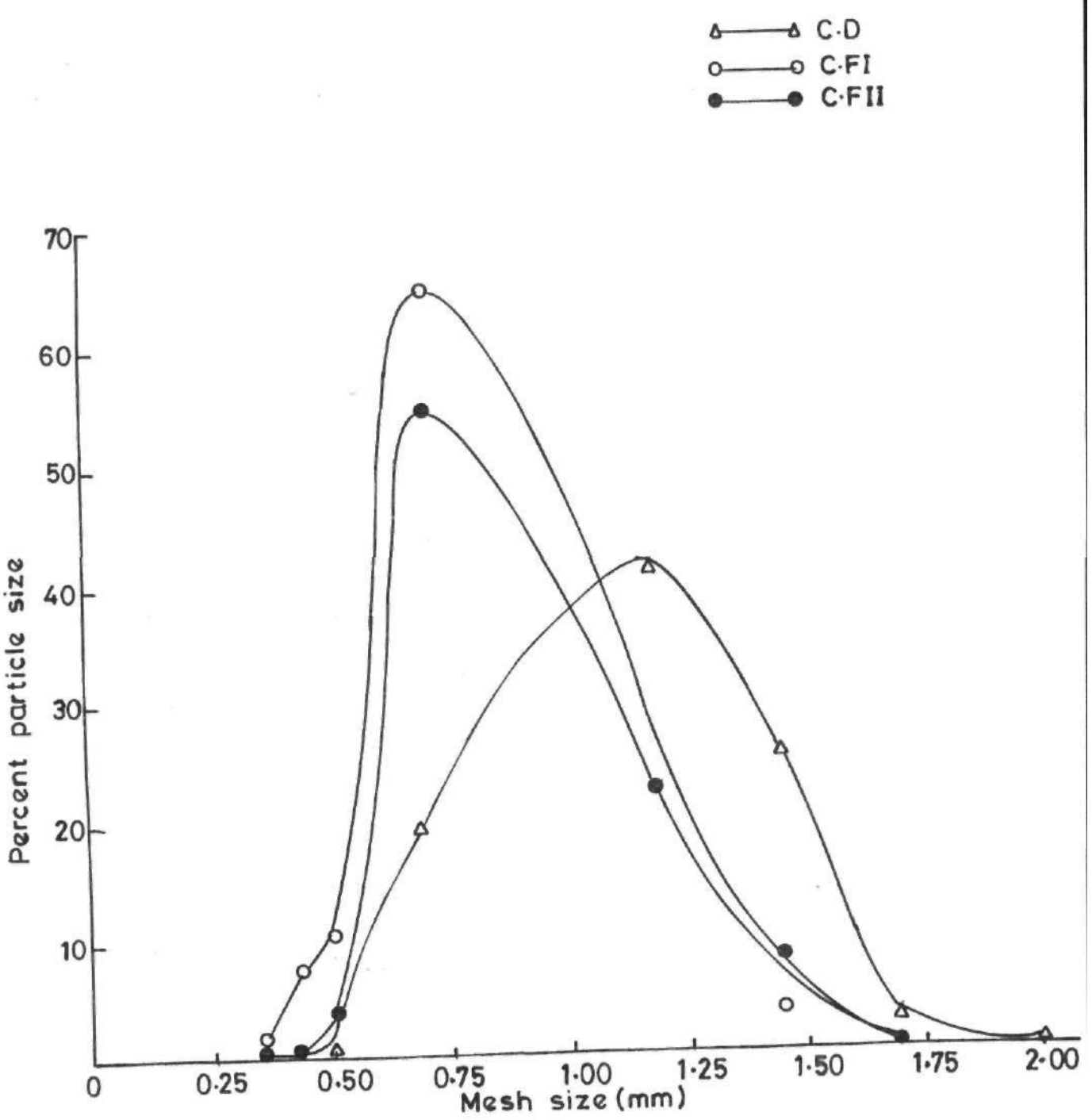


Fig 8: Graph of particle size distribution of C·D, C·FI and C·FII whole samples (i·e Unfractionated)

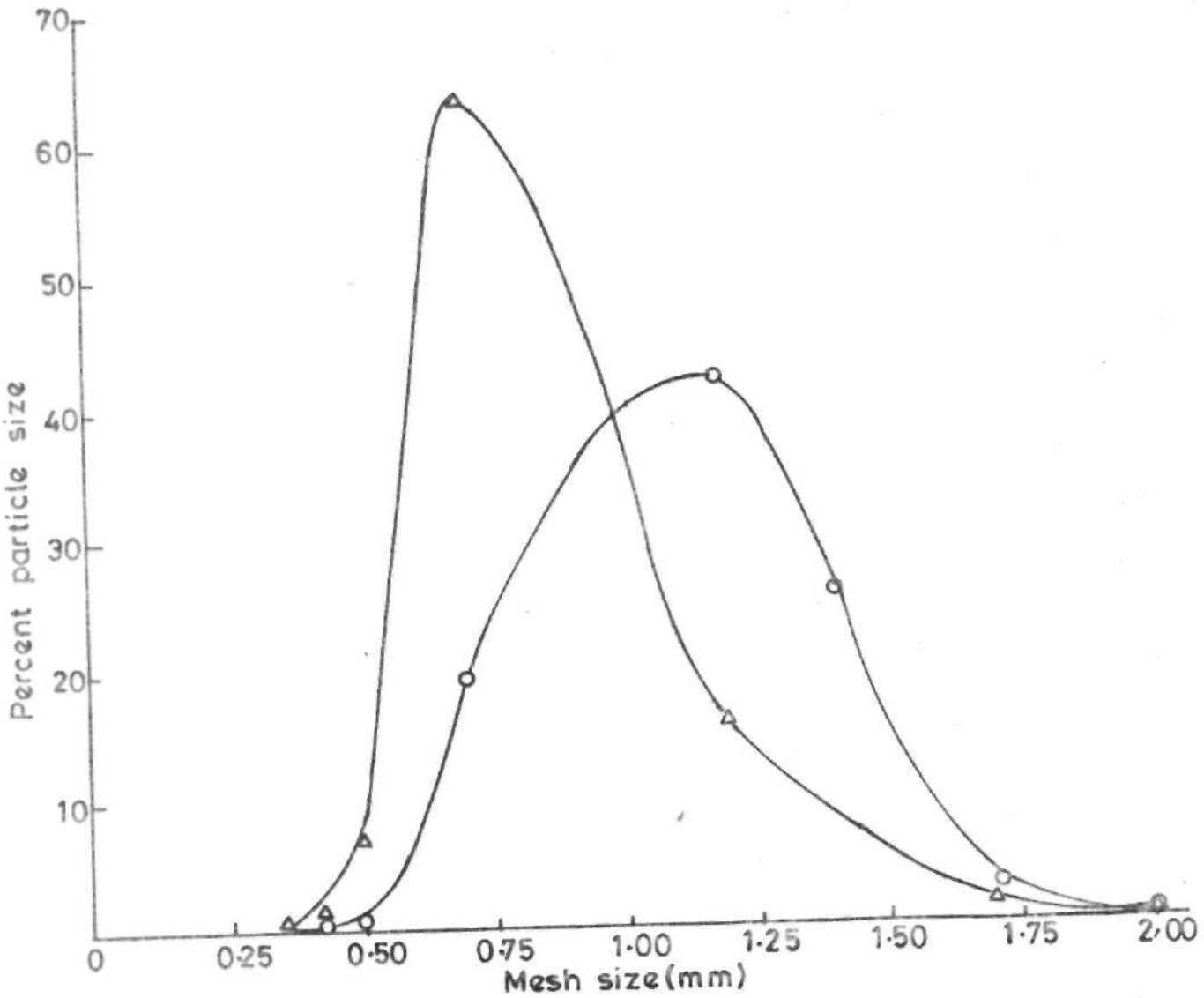


Fig-49: Graph of particle size distribution of C·D and A·G·C whole sample (i·e Unfractionated)

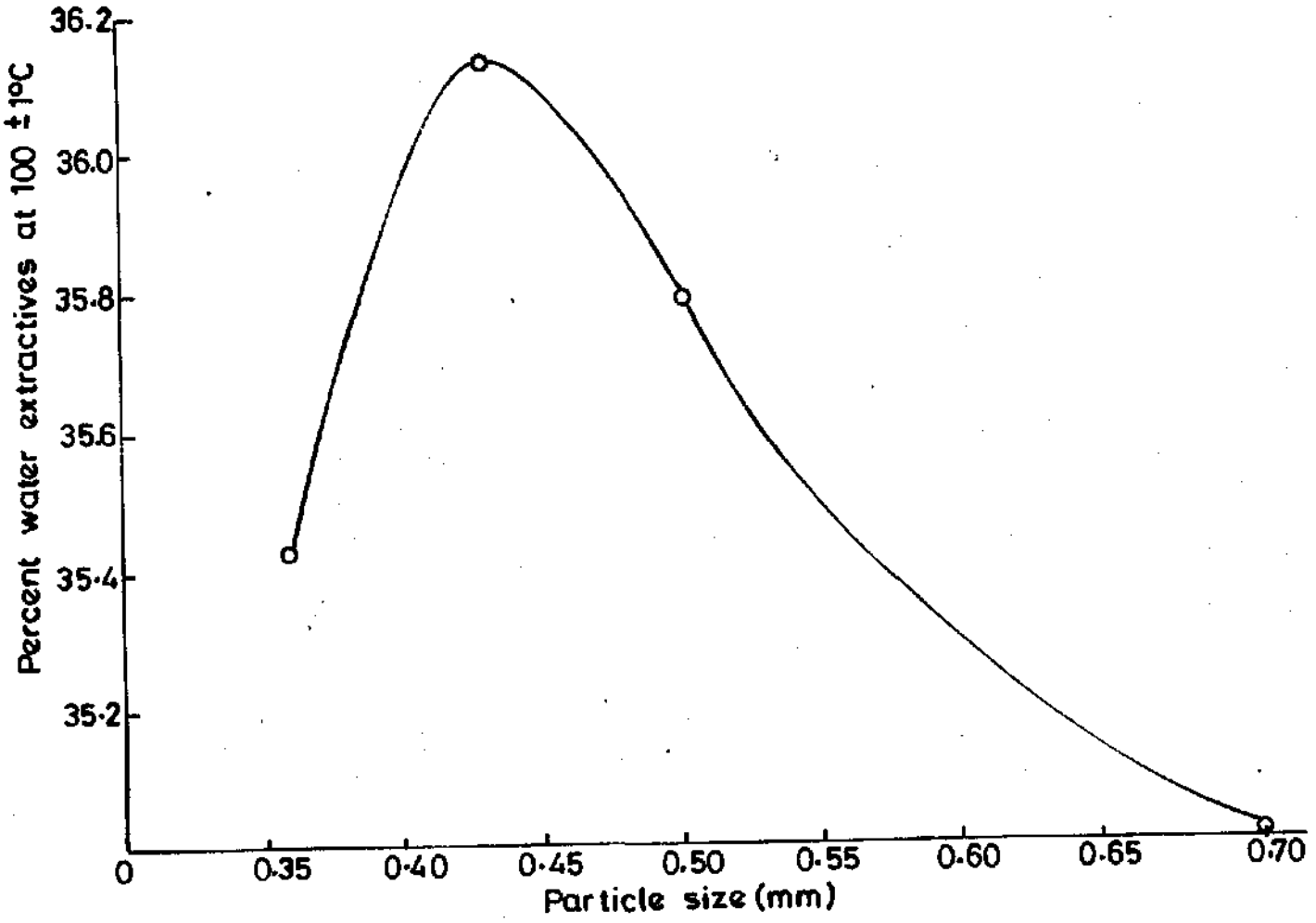


Fig.4-10:Graph of percent water extractives against various particle sizes of lipton tea

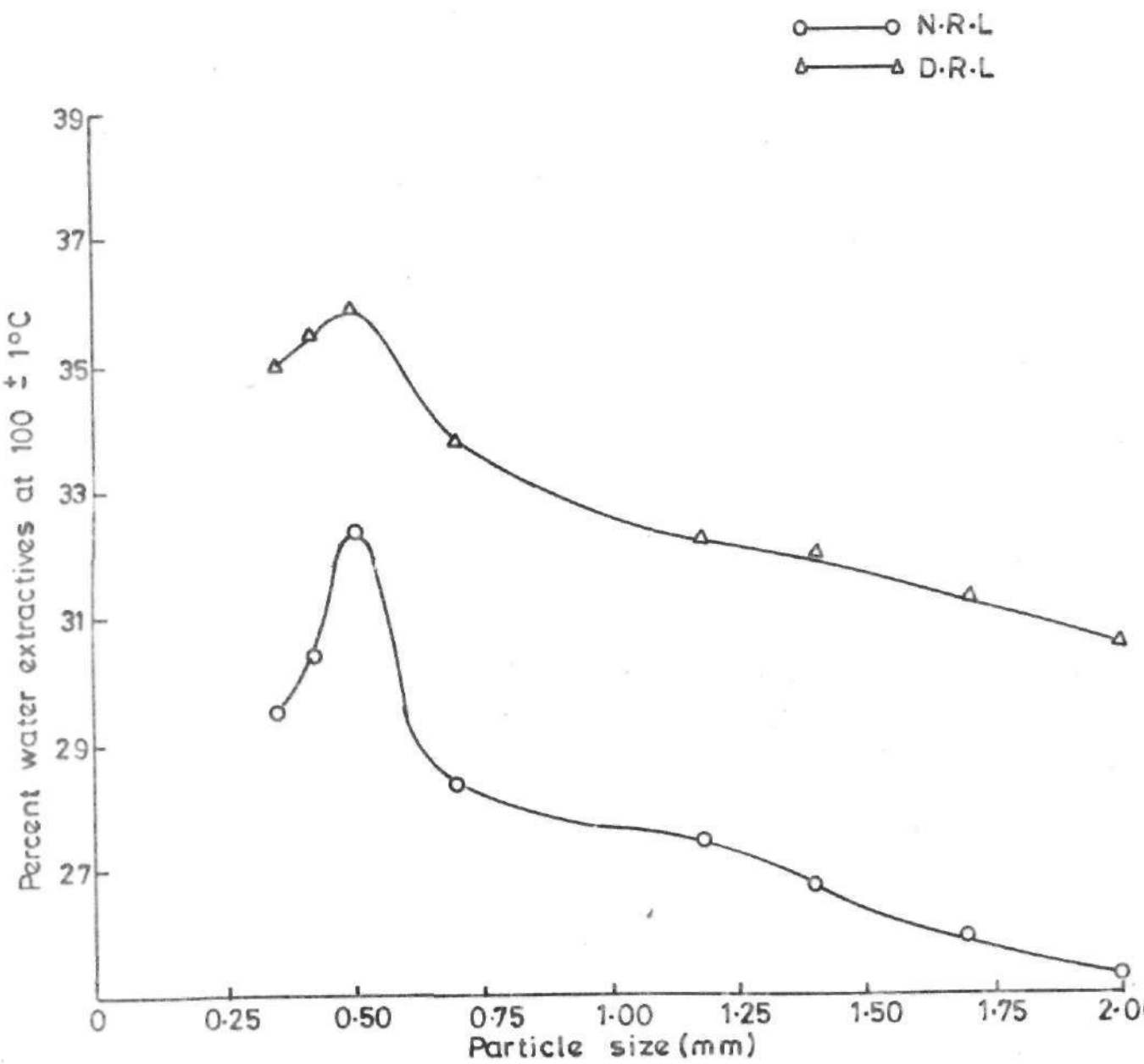


Fig.4.11:Graph of percent water extractives against various particle siz
of N·R·L and D·R·L

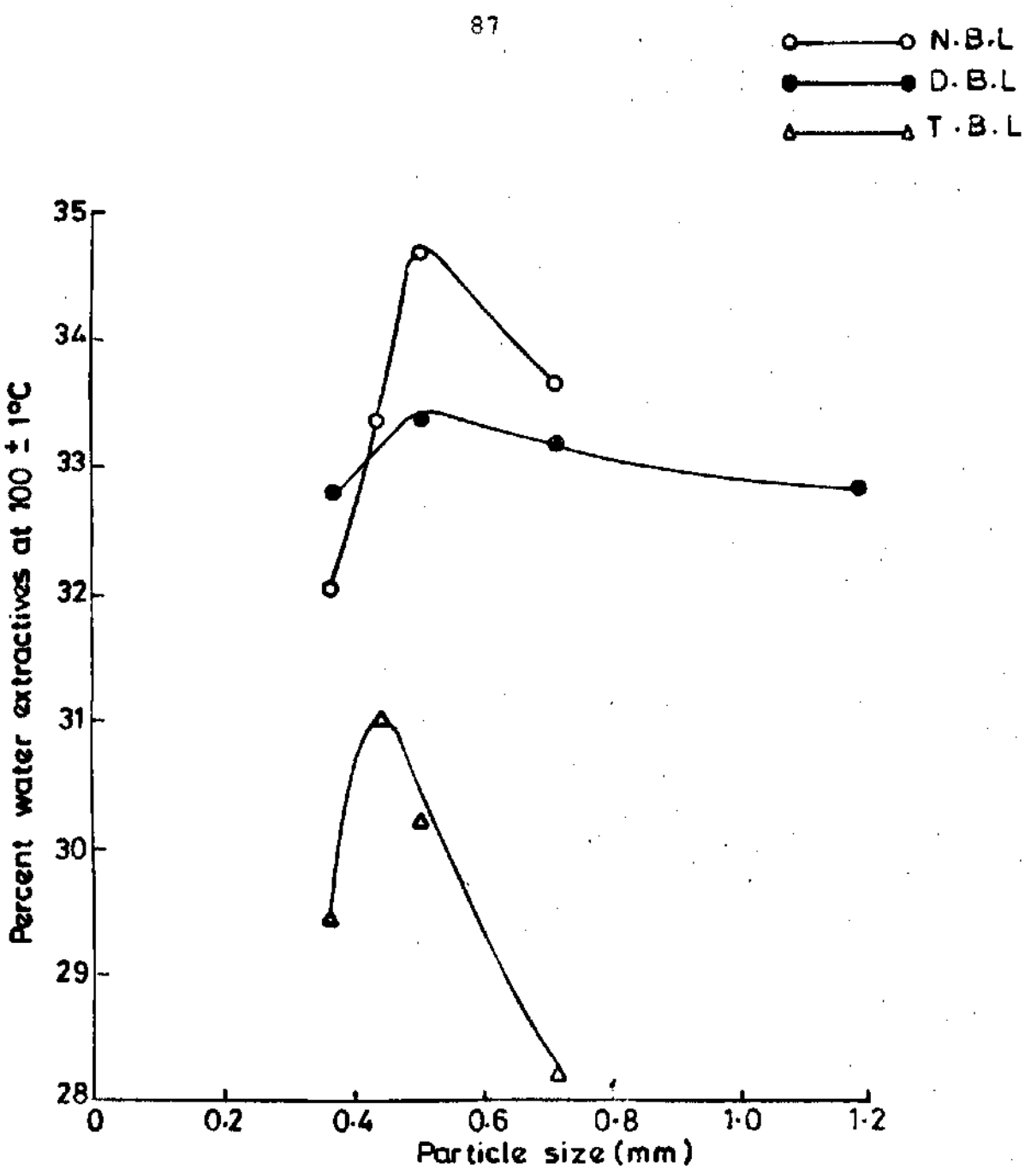


Fig.4·12:Graph of percent water extractives against various particle sizes of D·B·L, N·B·L and T·B·L

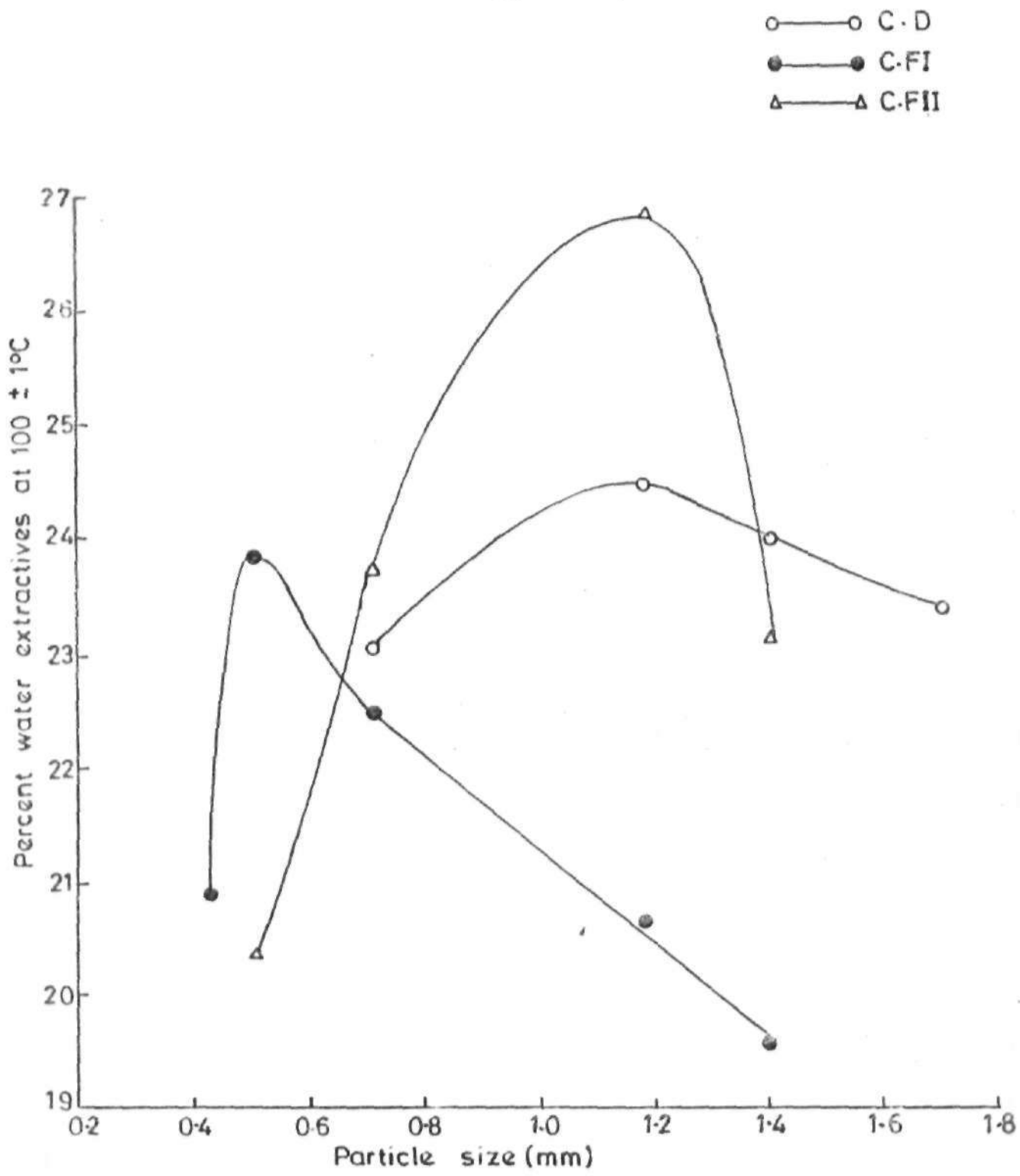


Fig.4·13 Graph of percent water extractives against various particle sizes of C·D, C·FI and C·FII

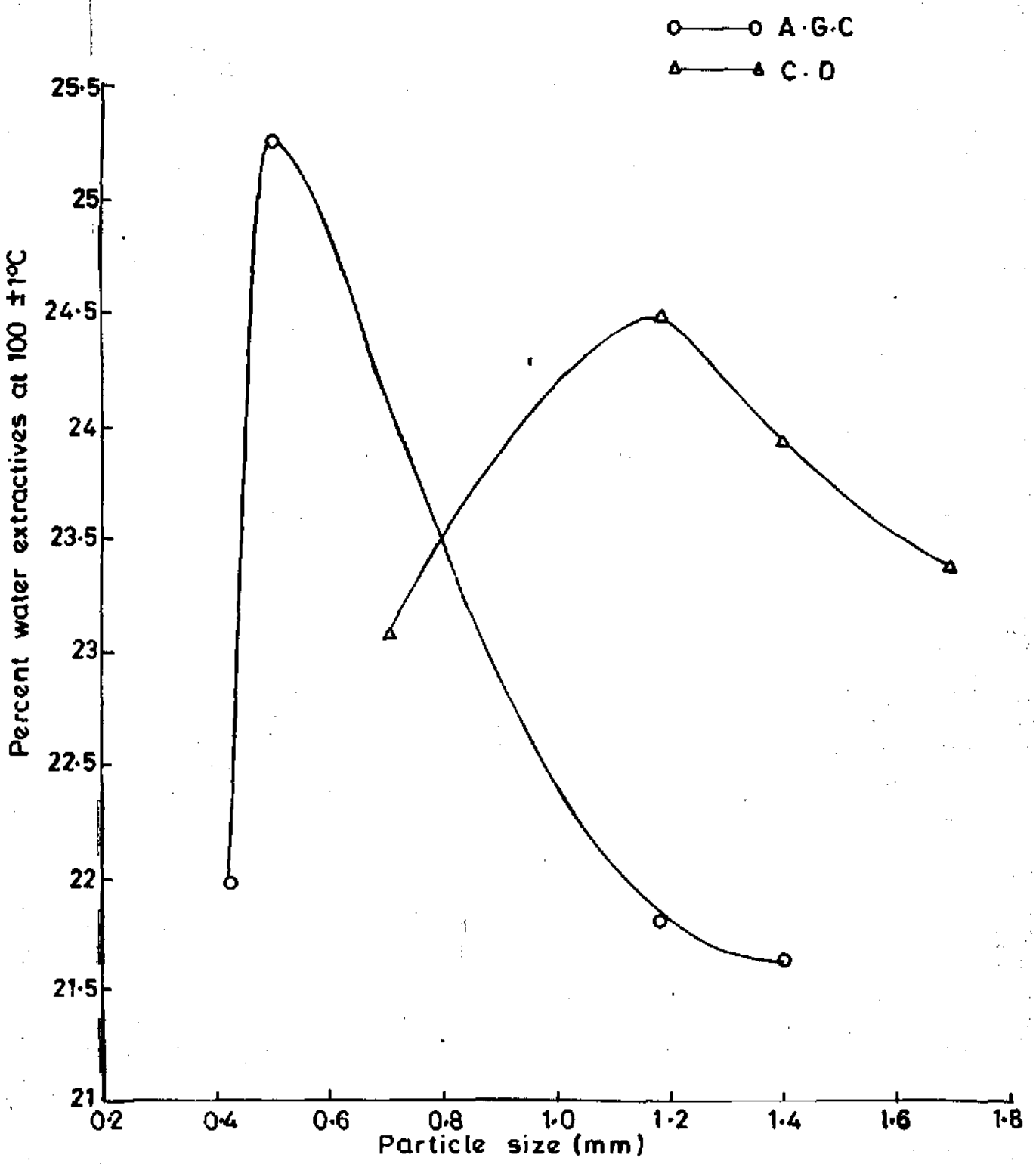


Fig.4.14:Graph of percent water extractives against various particle size of C·D and A·G·C

CHAPTER 5

5.0 DISCUSSION AND CONCLUSIONS

5.1 Moisture Content

The results of the moisture content determination of the samples are given in Tables 4.1 and 4.4. The moisture content of the tea samples ranges from 4.94 to 7.91 per cent. The 6.24 per cent moisture content of the unprocessed tea leaves is an approximate value because the leaves arrived Zaria after being dried to preserve it for long.

For the coffee samples the moisture content is between 0.55 to 7.48 per cent. The Arabica ground coffee produced by North West Co-operative Association has a moisture content of 2.32 per cent which is higher than the "Union Centrale des Co-operatives agricoles de l'ouest", samples. Robusta and Arabica Coffees have a moisture content of 7.46 and 7.48 per cent. This is only an approximate because the Coffee beans were dried before being brought to Zaria for analysis so as to preserve it for long. The moisture content is frequently an index of stability and quality. It is also a measure of yield and quantity of food solids. Decreasing available water content of foods and food products by drying and dehydration increases storage stability. It is therefore necessary that moisture content is controlled during preparation and storage. A good

quality tea seldom has a moisture content in excess of 7 per cent and that of coffee samples 5 per cent (Pearson 1976a, b).

The moisture contents of the Coffee samples are lower than that of the tea samples. Coffee samples after grinding may have been packed in such a way as to reduce moisture content hence reducing deterioration. On performing t-test analysis on the results it was observed that the moisture content of most of the tea samples analysed are not different ($P > 0.05$) from the value recommended by Pearson (1976a). Only N.R.L. has a moisture content of 7.91 per cent which is in excess of the value recommended by Pearson (1976a) ($P < 0.05$). This indicates that N.R.L. would have a shorter shelve life. When the same test was applied to the Coffee samples C.D., C.FI, C.FII and A.G.C. were within the literature value ($P > 0.05$). This implies that the coffee samples may not go stale within a short period. Pure unprocessed Robusta and Arabica Coffees have moisture content significantly in excess of the recommended value of 5 per cent ($P < 0.05$). This may imply that some processes are taken by the Company to reduce the moisture content during production so as to make the finished product durable.

5.2 Ash Content

The results of the ash content determination are shown in Tables 4.1 and 4.4. The total ash content of the different tea samples range between 5.48 and 7.87 per cent. Total ash content of tea should not exceed 7 per cent (Pearson 1976a). The unprocessed tea leaves have ash content of 7.87 per cent which is greater than the 7 per cent (Pearson 1976a). This suggests that in the manufacture process care has been taken to bring the ash content within the acceptable range.

The total ash contents of the different coffee samples range between 4.14 and 6.73 per cent. The A.G.C. sample which is processed by the North West Co-operative Association has the highest ash content of 6.73 per cent. The Coffee samples from "Union Centrale des Co-operatives agricoles de l'ouest", have their total ash between 4.14 and 5.49 per cent. The total ash of ground roasted coffee lies between 3.40 to 4.90 per cent (Clifford 1975, Joslyn 1963, Winton and Winton 1939). The difference between these values and those obtained from the analysis could be as a result of specie difference. The ash contained is not necessarily of exactly the same composition as the mineral matter present in the original food. This is due to losses as a result of volatilisation or some interaction between constituents. Ash content is helpful in determining the ash

soluble and insoluble in water and the alkalinity of the soluble ash. Ashing is also necessary in the preparation of food products for analysis of naturally occuring minerals or metalic salts present as contaminants. As a measure of quality it has been found that in many tea and coffee samples the ash is between 5 and 6 per cent and in spent or exhausted tea and coffee samples the ash drops below 3 per cent (Jacobs 1962). The total ash content of tea leaf plucked for manufacture varies from 4.5 to 5 per cent (Eden 1976a).

5.3 Water-Soluble Ash

The Water-soluble ash content of the samples analysed are given in Tables 4.1 and 4.4. In genuine tea about 50 per cent of the ash is water-soluble (3 to 3.5 per cent of dry tea samples). In exhausted teas, it drops to about 0.5 per cent (Jacobs, 1962). This is because a low water-soluble ash shows previously abstraction of constituents with lowering of quality. The tea samples have water-soluble ash ranging from 2.22 to 2.86 per cent of the samples. This is lower than the range of 3 to 3.5 per cent given by Jacobs (1962). The water-soluble ash of coffee samples should be 3.0 to 3.6 per cent (Clifford 1975). The Coffee samples analysed have water-soluble ash between 3.10 to 5.40 per cent. These values are higher than those given

in the literature with the exception of the 3.10 per cent value of Arabica coffee which is within the range given by Clifford. The reason for this departure may be due to adulterations.

5.4 Alkalinity of Soluble Ash

The alkalinity of soluble ash is given in Tables 4.1 and 4.4. The alkalinity is useful for the detection of exhausted tea leaves or coffee beans (Jacobs 1962). It is expressed K_2O for tea samples and K_2CO_3 for the coffee samples (Pearson 1976c). A low alkalinity of the ash indicates previous abstraction of important constituents with consequent lowering of quality (Clifford 1975). Pearson (1976a, b) recorded the following range of values: 1.20 to 2.00 per cent as K_2O for the tea samples and 1.90 and 3.20 as K_2CO_3 for the ground coffee samples. For the tea samples analysed the alkalinity ranges from 0.11 to 0.29 per cent as K_2O. These fall below the range given by Pearson (1976a). This may be due to specie difference or/and adulterations.

The coffee samples analysed have alkalinity ranging from 0.59 to 0.89 per cent as K_2CO_3. These are also lower than the range given in the literature by Pearson (1976b). These low alkalinity values may be due to the type of

treatment (dry method of curing) they underwent during processing (Clifford 1975).

5.5 Total Organic Matter Content

The results of the organic matter content are shown in Tables 4.1 and 4.4. The tea values have a close range of total organic matter. It ranges from 92.13 to 94.52 per cent. Total organic matter content of the tea should not exceed 93 per cent (Pearson 1976a). The difference may be as a result of specie difference. Total organic matter for the coffee samples is shown in Table 4.4. It ranges from 93.27 to 95.86 per cent. The total organic matter of ground roasted coffee lies between 95.1 to 96.6 per cent (Clifford 1975, Joslyn 1963, Winton and Winton 1939). The difference may be due to either specie difference or/and adulterations.

5.6 Mineral Content

The major constituents of ash of roasted coffee are potassium, phosphorus and magnesium while that of tea are potassium and phosphorus (Winton and Winton 1939). This is consistent with the results obtained from the analysis of tea and coffee samples shown in Tables 4.7 to 4.8 and 4.9 to 4.10. Other major constituents of tea ash are magnesium, calcium and iron. As such claims have been made that the beverage may alleviate acidosis in the system and reduce the

tendency to gout (Harler, 1963b). The elements determined in this study are calcium, magnesium, zinc, manganese, iron, copper, potassium, sodium and phosphorus.

5.6.1 Calcium

Table 4.7 shows calcium content of the tea samples. The values range between 1.00 x 10^3 and 3.50 x 10^3 per cent. N.R.L has the highest value of 3.50 x 10^3 mg/g while D.B.L has the lowest value of 1.00 x 10^3 mg/g. The calcium content of the red labels are higher than those of the blue lablels. The concentration of calcium in tea is about 5.00 x 10^3 to 7.00 x 10^3 mg/g (Triea 1954). The values obtained for both the blue and red label teas are slightly lower than the range given by Triea.

Table 4.9 show the values for the coffee samples. Robusta coffee has the highest value of 9.80 x 10^4 mg/g while A.G.C. has the lowest value of 3.50 x 10^4 mg/g. These are within the range of 3.8 x 10^4 mg/g given by Haarer (1962a). It could generally be seen that the coffee samples have higher calcium content than the tea samples.

5.6.2 Magnesium

The magnesium contents of the tea samples are shown in Table 4.7. All the samples have about the same values of 1.35 x 10^4 to 1.67 x 10^4 mg/g except D.R.L and unprocessed

tea leaves which have slightly higher values of 2.12×10^4 and 2.36×10^4 mg/g respectively. These values are lower than the 2.2×10^5 mg/g given by Eden (1976b).

Table 4.9 gives the magnesium content of the coffee samples. The coffee samples have comparable values which range from 1.44 to 1.74×10^3 mg/g while C.D and C.FII have the highest values of 1.74×10^3 mg/g. C.FI, A.G.C and Arabica coffee have values of 1.58×10^3, 1.62×10^3 and 1.50×10^3 mg/g respectively. These are lower than the 7.60×10^4 mg/g given by Haarer (1962a).

5.6.3 Zinc

Table 4.7 shows zinc content of the tea samples. The zinc content ranges between 3.90×10^2 and 6.51×10^2 mg/g. T.B.L and unprocessed tea leaves have the highest values of 6.51×10^2 mg/g while N.B.L has the lowest value of 3.90×10^2 mg/g. D.R.L., D.B.L and N.R.L have values of 6.01×10^2, 5.20×10^2 and 5.71×10^2 mg/g respectively. These are slightly lower than the 3.00×10^3 mg/g given by Eden (1976a).

Table 4.9 shows the values for the coffee samples. Arabica coffee has the highest value of 4.90×10^4 mg/g while C.D and Robusta coffee have the least values of 3.41×10^4 mg/g The values of C.FI, C.FII and A.G.C are 3.70×10^4, 3.50×10^4 and 4.50×10^4 mg/g respectively. These

values are lower than the 8.2 x 10^4 mg/g given by Haarer (1962a).

5.6.4 Manganese

Table 4.7 shows manganese of the tea samples. The manganese content range between 1.76 x 10^3 and 76.30 x 10^3 mg/g. Unprocessed tea leaves have the least value of 1.76 x 10^3 mg/g while T.B.L. has the hightest value of 7.30 x 10^3 mg/g. D.B.L. have values of 2.30 x 10^3 mg/g and 1.92 x 10^3 mg/g while N.R.L and N.B.L have 6.10 x 10^3 and 5.00 x 10^3 mg/g respectively. Chenery (1955) reports values as high as 9.00 x 10^3 mg/g in mature tea leaves from Malawi. Ordinary flush plucked in the field contains upto 1.9 x 10^3 mg/g in Kenya samples (Eden, 1976b). The values obtained from the analysis are within the range of values given by Chenery (1955) and Eden (1976b). Table 4.9 shows the values for coffee samples. Arabica coffee has the highest value of 3.21 x 10^3 mg/g while Robusta coffee and C.FI have values of 2.81 x 10^3 mg/g. C.D., C.FII and A.G.C. have values of 3.01 x 10^3, 3.01 x 10^3 and 3.10 x 10^3 mg/g respectively. These values are slightly above the 2.1 x 10^3 mg/g given by Hearer (1962a).

5.6.5 Iron

Table 4.7 shows the iron content of the tea samples. The values range between 1.00 x 10^4 and 3.90 x 10^4 mg/g. Unprocessed tea leaves have the highest value of 3.90 x 10^4 mg/g while N.B.L has the least value of 1.00 x 10^4 mg/g. The red lables (D.R.L) have similar values of 3.50 x 10^4 and 3.30 x 10^4 mg/g while the blue lables (D.B.L and T.B.L) have values of 2.70 x 10^4 and 1.00 x 10^4 mg/g respectively. These values are lower than the 1.5 x 10^5 mg/g given by Eden (1976b).

Table 4.9 shows the values for the coffee samples. Arabica coffee has the highest value of 7.01 x 10^3 mg/g while C.D and A.G.C have the lowest values of 1.00 x 10^3 mg/g C.FI, C.FII and Robusta coffee have 6.00 x 10^3, 1.00 x 10^3 and 4.00 x 10^3 mg/g respectively. These are within the range of 2.12 x 10^3 mg/g given by Hearer (1962a). The total amount of iron in the body is 1000 to 1500 mg and it is mostly stored in the form of Forritin and Haemoriderin. The highest iron content in the tea and coffee samples are contained by D.R.L and C.FI and hence could be taken by pregnant women and infants to replenish the iron lost during menstruation and the periods of growth especially in infants.

5.6.6. Copper

Tables 4.7 and 4.10 show the copper contents of the tea and coffee samples. These values are much smaller for the coffee samples than the tea sample. In the tea samples the copper content range between 1.09 x 10^2 mg/g and 3.00 x 10^2 mg/g. N.R.L has the lowest value of 1.09 x 10^2 mg/g while D.B.L has the highest value of 3.00 x 10^2 mg/g. The copper content of D.R.L., N.B.L, T.B.L and unprocessed tea leaves are 1.51 x 10^2, 1,19 x 10^2, 1.15 x 10^2 and 1.10 x 10^2 mg/g respectively. These are within the range of the 2.0 x 10^2 mg/g given by Eden (1976b).

In the coffee samples copper content ranges between 30.0 and 165.0 mg/g. A.G.C has the lowest value of 30 mg/g while Robusta coffee has the highest value of 165.00 mg/g. The copper content of C.D, C.FI C.FII and Arabica coffee are 95, 99, 91 and 95 mg/g respectively. Copper is of special importance to tea because it plays a vital role in the fermentation process (Eden 1976a). This may explain why the copper content is much higher in the tea samples than the coffee samples.

5.6.7 Potassium

Potassium content of the tea and coffee samples are shown in Tables 4.8 and 4.10. The potassium content of the tea samples ranges from 5.80 x 10^3 to 8.40 x 10^3 mg/g.

Unprocessed tea leaves have the highest value of 8.40 x 10^3 mg/g while N.R.L has the lowest value of 5.80 x 10^3 mg/g. D.R.L, D.B.L, N.B.L and T.B.L have values of 6.40 x 10^3, 7.24 x 10^3, 6.32 x 10^3 and 7.20 x 10^3 mg/g respectively. Average figures compiled for a wide range of teas lie within the range 1.35 x 10^4 and 1.76 x 10^4 mg/g (Eden 1944, Portsmouth 1953). The values obtained for the tea samples are lower than the literature values given by Eden and Portsmouth.

The coffee samples have potassium content ranging from 6.52 x 10^3 mg/g to 7.76 x 10^3 mg/g. A.G.C and C.D have the highest values of 7.76 X 10^3 and 7.60 x 10^3 mg/g while Robusta coffee and Arabica coffee have the lowest values of 6.64 x 10^3 and 6.52 x 10^3 mg/g. C.FI and C.FII have values of 7.20 x 10^3 and 7.28 x 10^3 mg/g respectively. These are comparable to the 5.30 x 10^3 mg/g given by Haarer (1962a).

5.6.8 Sodium

The Sodium content of the tea sample is shown in table 4.8. It ranges between 5.60 x 10^2 and 1.90 x 10^3 mg/g. Unprocessed tea leaves have the highest value of 1.90 x 10^3 mg/g while N.R.L has the lowest value of 5.60 x 10^2 mg/g. D.R.L, D.B.L, N.B.L and T.B.1 have values of 8.01 x 10^2, 5.60 x 10^2, 1.20 x 10^2 and 1.02 x 10^3 respectively. These values are lower than the 3.0 x 10^3 mg/g given by Eden

(1976b). The values for the coffee samples are shown in Table 4.10 Arabica coffee has the highest value of 7.40 x 10^2 mg/g while C.FII has the least value of 1.04 x 10^2 mg/g. The values of C.D, C.FI, A.G.C and Robusta are 7.01 x 10^2, 7.01 x 10^2, 9.01 x 10^2 and 6.60 x 10^2 mg/g respectively. These are slightly lower than the 2.12 x 10^3 mg/g given by Haarer (1962a).

5.6.9. Phosphorus

The phosphorus contents of the tea samples are given in Table 4.8. It ranges between 2.07 x 10^3 and 3.00 x 10^3 mg/g. T.B.L has the highest value of 3.00 x 10^3 mg/g while D.R.L has the lowest value of 2.07 x 10^3 mg/g. D.B.L, N.R.L, N.B.L and unprocessed tea leaves have the values 2.78 x 10^3, 2.49 x 10^3, 2.56 x 10^3 and 2.71 x 10^3 mg/g respectively. They are higher than the range 1.40 x 10^3 - 1.80 x 10^3 mg/g given by Pearson (1976a).

The phosphorus content of the coffee samples are shown in Table 4.10. It ranges from 1.60 x 10^3 to 1.73 x 10^3 mg/g. A.G.C and Robusta coffee have the highest values of 1.73 x 10^3 mg/g while C.D and C.FI have the lowest values of 1.60 x 10^3 mg/g. C.FII and Arabica coffee have values of 1.70 x 10^3 and 1.64 x 10^3 mg/g respectively. They are within the range of the literature values given by Haarer (1962a) which is 1.20 x 10^3 to 1.80 x 10^3 mg/g.

5.7 Total Nitrogen Content Determination

The result of the total nitrogen determination of the tea and coffee samples is shown in Tables 4.1 and 4.2. Total nitrogen includes the nitrogen due to protein, caffeine, nucleic acids and other N-containing compounds. The nitrogen content of the dry tea samples is shown in Table 4.1. The values range between 3.60 and 9.09 per cent. Unprocessed tea leaves have the highest value of 9.09 per cent while D.B.L has the lowest vvalue of 3.60 per cent. D.R.L, N.R.L and T.B.L have values of 4.92, 5.58, 4.54 and 4.79 per cent respectively. These values except for N.R.L are either below or above (in the case of unprocessed tea leaves) the range of values quoted by Pearson (1976a) which is between 5.00 and 6.20 per cent.

This probably indicate that tea samples analysed have lower nitrogen containing compounds than the samples analysed by Pearson (1976a) except for the case of N.R.L. . This difference may be due to the blending of the tea samples with spent tea leaves. The results for the coffee samples are shown in Table 4.4. Robusta coffee has the highest value of 5.58 per cent while A.G.C has the lowest value of 4.09 per cent. C.D, C.FI, C.FII and Arabica coffee have values of 4.41, 4.62, 4.51 and 4.22 per cent respectively. These values are higher than those quoted by

Pearson (1976b) i.e between 2.10 and 3.30 per cent. The difference may due to specie differences.

5.8 Tannin Content Determination

The tennin content of the tea samples are given in Tables 4.2 and 4.3. These tables show the tennin content for whole samples, peak particle sizes and particle sizes with highest extraction. For the whole tea samples the values range between 45.07 and 72.03 mg/g. N.R.L has the highest value of 72.03 mg/g while T.B.1 has the lowest value of 45.07 mg/g. D.R.L, D.B.L., N.B.L and unprocessed tea leaves have values of 56.01, 47.10, 60.05 and 68.13 mg/g respectively. On a comparative note the blue labels have lower tannin content than their corresponding red labels. This reflects their qualities and differences in their prices which are often higher by about 35 per cent.

For the peak particle size the tannin content ranges from 43.40 and 62.60 mg/g. The highest value is that of 0.71 mm for N.R.L which is 62.60 mg/g while the lowest is that of 0.50mm for T.B.L which is 43.40 mg/g. The peak particle sizes of D.R.L., D.B.L., and N.B.L which are 0.71mm have values of 44.40, 46.20 and 47.62 mg/g respectively. For the particle sizes with highest extraction the tannin content ranges from 44.20 and 73.33 mg/g. The highest value

is that of 0.50 mm for N.R.L which 73.33 mg/g while the lowest is that of 0.43 mm for T.B.L which is 44.20 mg/g. D.R.L., D.B.L and N.B.L which are all 0.50 mm have values of 64.17, 49.60 and 66.40 respectively. The blue labels which have lower tannin contents are outstanding since they are less likely to suffer from the nutritional consequences of tannins (Begovie and Ozegovic, 1969; Flowler and Richards, 1965; Camp *et al*, 1967). The common nutritional problem caused by tannin is the net loss of protein in the animal.

The tannin content of the coffee samples are given in Tables 4.5 and 4.6. The tables show tannin content for the whole samples, peak particle sizes and particle sizes with highest extraction. For the whole coffee samples the values range between 45.73 and 79.04 mg/g. A.G.C has the highest value of 79.04 mg/g while C.FII has the lowest value of 45.73 mg/g. Robusta and Arabica coffees have 57.13 and 63.21 mg/g while C.D and C.FI have values of 75.33 and 70.31 mg/g respectively.

For the peak particle sizes the tannin content range from 35.87 and 43.73 mg/g. The highest value is the particle size of 1.18 mm for C.D which is 43.73 mg/g while the lowest is that of 0.71 mm for C.FII which is 35.87 mg/g. C.Fi and A.G.C which are all 0.71 mm have values 42.81 and 43.11 mg/g.

For the particle sizes with highest extraction the tannin content range between 40.05 and 45.07 mg/g. A.G.C which is 0.50 mm has the highest value of 45.07 mg/g. C.D and C.FI of 1.40 mm and 0.50 mm have values of 44.20 and 42.60 mg/g repectively. For tea samples the tannin content of the particle sizes with highest extraction are generally more than those for the whole samples with the exception of T.B.L. The least tannin content is shown by the peak particle sizes. For the coffee samples the tannin content for the whole samples are generally more than those of the particle sizes with highest extraction. The least tannin content is shown by the peak particle sizes.

5.9 Caffeine Content Determination

The caffeine content of the tea samples are given in Table 4.3. This table shows the caffeine content for whole samples, peak particle sizes and particle sizes with highest extraction.

For whole samples the values range between 2.52 and 8.12 per cent. Unprocessed tea leaves have the highest value of 8.12 per cent while D.B.L has the lowest value of 2.52 per cent. D.R.L, N.R.L, N.B.L and T.B.L have values of 3.88, 4.60. 3.43 and 3.88 per cent respectively. On a comparative note the blue labels have lower caffeine

content than their corresponding red labels. D.B.L and N.B.L fall within the literature value given as between 1.9 and 3.6 per cent by Pearson (1976a). T.B.L and D.R.L fall within the literature value given as between 2.7 and 4.1 per cent by Kaplan et al (1974). D.R.L, N.R.L and T.B.L have higher caffeine content and may make more stimulating infusions.

For the peak particle sizes the caffeine content range from 2.66 to 5.76 per cent. The highest value is that of 0.71 mm for N.R.L which is 5.76 per cent while the lowest is that of 0.71 mm for D.B.L which is 2.66 per cent. The peak particle sizes of D.B.L and T.B.L which are 0.71 mm, 0.71 mm and 0.50 mm are 3.69, 3.01 and 3.27 per cent respectively.

For the particle sizes with highest extraction the caffeine content range from 3.14 to 5.79 per cent. The lowest value is that of 0.50 mm for D.B.L which is 3.14 per cent while the highest value is that of 0.50 mm for N.R.L which is 5.79 per cent. The particle sizes with highest extraction of D.R.L, N.B.L and T.B.L which are 0.50 mm, 0.50 mm and 0.43 mm are 4.70, 4.51 and 3.91 per cent respectively.

The caffeine content of the coffee samples are given in Table 4.6. The table shows the caffeine content for whole samples, peak paricle sizes and paricle sizes with highest extraction.

For whole coffee samples the values range between 3.15 and 4.47 per cent. Robusta coffee has the highest value of 4.47 per cent while Arabica coffee has the lowest value of 3.15 per cent. C.D, C.FI and C.FII have values of 3.30, 3.53 and 3.94 per cent respectively,while A.G.C. has a value of 3.46 per cent. The literature value is given as between 2.00 and 8.00 per cent (Pearson, 1976b). All the coffee samples fall within the literature value. The caffeine content of freshly ground roasted coffee range between 0.80 and 1.80 per cent (Kaplan et al 1974). Clifford reported the caffeine content of 0.90 and 1.80 per cent (Clifford, 1975).

For the peak particle sizes the caffeine content range from 3.18 and 3.98 per cent. The highest value is that of 0.71 mm for C.FII which is 3.98 per cent while the lowest is that of 1.18 mm for C.D which is 3.18 per cent. C.FI and A.G.C which are both 0.71mm have caffeine content of 3.70 and 3.73 per cent respectively.

For the particle sizes with highest extraction the caffeine content range from 3.62 and 4.62 per cent. The highest value is that of 0.05 mm forA.G.C which is 4.62 per cent while the lowest value is that of 1.40 mm for C.D which is 3.62 per cent . C.FI and C.FII of both 0.50 mm and 1.18

mm have caffeine content of 4.30 and 4.27 per cent respectively.

For the tea samples caffeine content of the particle sizes with highest extraction are generally more than those with whole samples. The least caffeine content is shown by the peak particle sizes with the exceptions of D.B.L and N.R.L whose values of 2.66 and 5.76 per cent are higher than 2.52 and 4.60 per cent for the whole samples.

For the coffee samples caffeine content of the particle sizes with highest extraction are generally more than those with peak particle sizes. The least caffeine content is shown by the whole samples with the exception of C.D which has a value of 3.30 per cent higher than 3.18 per cent for the peak particle size.

5.10 Water Extractives Determination (Kinetic Studies)

The results of the determination of water extractive at different selected times were used for the Kinetic studies. The results of the determinations of water extractives of the tea and coffee samples are given in Figures 4.1 to 4.4. It could be seen from Figures 4.1 and 4.2 that the per cent water extractive for the five tea samples range as in Table 5.1.

The range of values of per cent water extractives given in literature is 35.50 - 46.40 per cent (Pearson 1976a).

Table 5.1: Per cent Water Extractive for the Tea Samples

Range of Extracts for the five tea samples (%)	Time of Extraction (minutes)
26.19 - 31.76	1.0
28.35 - 32.59	2.5
29.90 - 35.50	5.0
30.11 - 37.04	10.0
31.46 - 37.62	20.0
31.28 - 37.24	30.0
31.95 - 37.53	40.0
30.46 - 37.73	50.0
29.41 - 35.33	60.0

The per cent water extractive however depend on the source and specie of the tea. Manley (1965) stated that most Indian teas give 35.50 - 46.40 per cent extractives while China teas give lower figures ranging from 29.60 to 41.40 per cent.

The results of the determinations of water extractive of the four coffee samples are given in Figures 4.3 and 4.4. It could be seen from these figures that the per cent water extractive for the four coffee samples range as in Table 5.2

The water soluble solids are determined and used as criteria of good quality tea and coffee. Very low water extractives is an indication of previous abstraction since these solids represent the palatable part of the tea and coffee beverages.

For the tea beverages the initial slope of the plot of infusion against time is given in Table 4.2. The initial rate of infusion for the blue labels are 31.25% min^{-1} for D.B.L, 32.50% min^{-1} for N.B.L and 31.03% min^{-1} for T.B.L while for the red labels the intial rate of infusion is faster for the blue labels than the red labels. The initial slope of the plot of infusion against time for the coffee samples is given in Table 4.5. The intial rate of infusion for the unblended coffee are 24.69 min^{-1} for A.G.C, 22.25 min^{-1} for C.D. For the blended coffees the intial rate of

Table 5.2: Per cent Water Extractive for the Coffee Samples

Range of Extracts for the five tea samples (%)	Time of Extraction (minutes)
20.05 - 24.03	1.0
20.74 - 25.16	2.5
21.34 - 26.04	5.0
22.28 - 26.24	10.0
24.68 - 27.30	20.0
26.10 - 27.69	30.0
26.12 - 31.78	40.0
27.00 - 30.14	50.0
26.45 - 31.17	60.0

infusion are 21.43 min^{-1} for C.FI and 20.63 min^{-1} for C.FII. The results show that A.G.C. has the fastest intial rate of infusion. The initial rate of infusion of C.D is higher than that of C.FI which in turn is higher than that of C.FII. This difference in initial infusion rates may be due to the different ratios of robusta coffee used in the blends. It can therefore be proposed that the infusion for the blue and the unblended coffee take place instantaneously, while infusion for the red labels and the blended coffees take place at a much slower rate. The Kinetic studies was done at different time intervals from 1 minute to 60 minutes. The producers recommeded that the infusion should be carried out for 5 minutes in boiling water. The percentage of maximum extraction that actually occured at 5 minutes recommended by the producers is shown in Table 5.3 and 5.4.

The 5 minutes recommended by the producers is justified since for both tea and coffee samples more than 70% of the maximum extraction is obtained. This is reasonable especially when one considers the high costs of electricity, firewood, gas and kerosine involved in the boiling of the tea and coffee. Comsumers will also find it difficult to wait for longer periods before being given a cup of tea or coffee.

Table 5.3: Percentage of Maximum Extraction of the Tea Samples that Occurred at 5 Minutes

Sample	Five Minutes Infusion Expressed as Percentage Maximum Infusion
D.R.L	81.08
D.B.L	87.42
N.R.L	84.36
N.B.L	94.36
T.B.L	95.20

Table 5.4: Percentage of Maximum Extraction of the Coffee Samples that Occurred at 5 Minutes

Sample	Five Minutes Infusion Expressed as Percentage Maximum Infusion
C.D	77.98
C.FI	83.87
C.FII	74.19
A.G.C	83.33

From Figures 4.1 to 4.4 there seems to be a tendency for a decrease in extract on longer period of extraction for the tea and coffee samples except C.FI and C.FII. This might be due to adsorption of extracts on the tea leaves and coffee beans.

5.11 Comparison of Infusion Rates

The per cent water extractives of the tea samples using sachets are shown in Table 4.2. The per cent water extractive ranges between 30.75 and 34.77 per cent. The highest extract is from D.R.L while the lowest is from T.B.L. Lipton, D.B.L, N.R.L and N.B.L have values of 32.47, 33.20, 32.19 and 31.90 per cent respectively. The per cent water extractives of the tea samples without using sachets is also shown in Table 4.2. The tea leaves are placed directly into boiling water and filtered through a filter paper. The per cent water extractive ranges between 31.00 and 36.13 per cent. Lipton tea has the highest per cent water extractive value of 36.13 per cent while the lowest is from T.B.L which is 31.00 per cent. D.R.L, D.B.L, N.R.L and N.B.L have per cent water extractives of 35.97, 33.35, 32.40 and 34.68 per cent respectively.

The per cent water extractives of the various tea samples without using sachets are higher than the extractives using sachets. The extractives of various teas are more when

placed directly into boiling water than when sachet bags were used. It is therefore advisable that the tea leaves should be placed directly into boiling water than being sewn in sachet bags. Sachet bags have the additional disadvantage of being expensive but have the advantage of eliminating fine size tea leaf particles. It is also possible that some extractives adhered to the sachet of tea.

The per cent extractives of the coffee samples using sachets are shown in Table 4.5. The per cent water extractives range between 24.58 and 28.96 per cent. C.D has the highest per cent water extractive value of 28.96 per cent while C.FI has the lowest value of 24.58 per cent. C.FII and A.G.C. are 27.63 and 25.03 per cent respectively. The per cent water extractives without using sachets is also shown in Table 4.5. The coffee samples were placed directly into boiling water and a filter paper was used to filter it. The per cent water extractives range from 22.26 and 24.83 per cent. C.FII has the highest per cent water extractive value of 24.83 per cent while A.G.C has the lowest value 22.26 per cent. C.D and C.FI have values of 23.94 and 23.86 per cent respectively. The per cent water extractives of the various coffee samples using infusion bags (sachets) are higher than the extractives without sachets. This could be probably due to the soft and permeable nature of the sachets compare to the hard nature of the filter paper used for the filtration. It is therefore advisable that despite cost

disadvantage the coffee should be sewn in infusion bags (sachets) rather than placing it directly in boiling water.

5.12 Comparison of Samples

The samples analysed are paired up as shown below and compared.

5.12.1 D.B.L, N.B.L. and T.B.L (Blue Labels)

The raw materials for the blue label teas are grown in the United Republic of Cameroon by the Cameroon Development Corporation (C.D.C.). The teas are processed and distributed by the same company. The cost per 100g of the tea is 200 france C.F.A. T.B.L has the highest ash content, total nitrogen, caffeine content, magnesium, zinc. manganese and phosphorus concentrations. The calcium concentration of T.B.L and N.B.L are the same. T.B.L however has lowest alkalinity, total organic matter and tannin content. N.B.L has the highest moisture content, alkalinity, tannin and sodium content. N.B.L however has the lowest water - soluble ash, magnesium, zinc and iron contents. D.B.L has the highest water soluble ash, and potassium contents. D.B.L however has the lowest moisure content, total nitrogen, caffeine content, calcium, manganese and sodium concentrations.

Generally, the blue labels have lower moisure content and higher initial slope of infusion than their corresponding red labels. They therefore have longer shelf life and can infuse faster than the red labels. This may however justify their higher prices.

5.12.2 D.R.L and N.R.L (Red Labels)

The raw materials for the red label teas are also grown, processed and distributed in the United Republic of Cameroon by the Cameroon Development Corporation (C.D.C). The cost per 100g of the tea is 150 francs C.F.A. It is cheaper than the blue labels by 25 per cent. D.R.L has higher ash content, water-soluble ash, alkalinity, magnesium and iron concentrations. D.R.L however has lower moisture content, total nitrogen, total organic matter, tannin content, caffeine content and phospohrus concentration.

Generally the red labels have a higher moisture content and lower initial slope of infusion than thei corresponding blue labels. They are therefore more likely to go mouldy faster with time than the blue labels. They also have slower intial infusion rates than blue labels. This could however have accounted for their lower prices.

5.12.3 C.D and A.G.C (Unblended)

Café delice (C.D) is made up mainly of 100 per cent arabica coffee. It is produced and distributed by Union Centrale des Co-operative agricoles de l ouest, U.C.C.A.O. The cost per 250g of the coffee is shown in Table 2.3. It varies depending on the location of the province from where the coffee is produced. The price in Western province where the coffee is produced is 485 francs C.F.A.

Arabica ground coffee (A.G.C) is made up mainly by the North-west Co-operative Association Limited (N.W.C.A). The cost per 250g is 400 frans C.F.A.

A.G.C has the highest moisture content, ash content, water-soluble ash, alkalinity, tannin content, caffeine content, zinc, manganese, potassium, sodium and phosphorus concentrations.. The iron concentration is the same in both C.D and A.G.C. It however has a lower total organic matter, calcium and copper concentrations. The initial infusion of A.G.C is faster than that of C.D. The moisture content of C.D is lower than that of A.G.C which means C.D has longer shelf-life than A.G.C. The differences in their prices could have been as a result of their packaging. C.D is packed in a more presentable and better container than A.G.C.

5.12.4 C.FI and C.FII (Blended)

Café force I (C.FI) is made up mainly of 80% Arabica coffee and 20% robusta coffee. The price per 250g of the coffee in the Western orvince where it is produced is 475 francs C.F.A. Café force II (C.FII) is made up mainly of 70% arabica coffee and 30% robusta coffee. The price per 250g of the coffee in the Western province where it is produced is 470 francs C.F.A. They are both processed and distributed by "Union Centrale des Co-operatives agricoles de l'ouest", U.C.C.A.O. C.FII is 1.05 per cent cheaper than C.FI.

C.FII has the highest moisture content, alkalinity, total organic matter, total nitrogen, caffeine content and calcium concentration. C.FII however has a lower ash content, water-soluble ash and tannin. C.FI infuses faster initially than C.FII. It also has a lower moisture content than C.FII. This might have accounted for the 1.05 per cent difference in price. C.FII is more stimulating than C.FI. This might be due to the high ratio of robusta in the blend.

Generally C.FII has the highest caffeine content, followed by C.FI and then the unblended coffees. The blending must therefore have been done to control the stimulating effects of the coffees. This is because as the ratio of robusta in the blend increases, the caffeine content and hence stimulating effect of the coffee

increases. It could also have been done to improve upon the aroma. The difference in prices of the blended and unblended coffees could have been as a result of high demand for the unblended coffee. This is because customers derive the same flavour from it but have the additional advantage that their sleep is not disturbed since it is low stimilating than the blended coffees.

5.13 Conclusion and Suggestions for Further Work

This research work shows that the tea and coffee samples analysed are of similar qualities with other tea and coffee samples analysed and reported in literature. It is advisable that the authority in charge of these beverages in Cameroon should lay down legal requirements for tea and coffee beverages manufactured in the country. The legal requirements should include levels of inorganic elements. Caffeine, nitrogen content, tannin content,total ash, water-soluble ash moisture content. It should also include the maximum amount of time that the product can stay without going bad (Shelf-life of the product).

It is suggested that analysis of more tea and coffee beverages be carried out to have more information about the different samples flooding the Cameroon markets.

In deciding which tea or coffee is best for consumption the tannin, caffeine, water-soluble ash, kinetic studies using water extractives for duration of time recommeded by the company and price should be considered. It is found in this work that the products with higher prices are better than those with lower prices which implies that the companies are aware of the expensive nature of quality products. Tannin is present in tea and coffee beverages hence it is necessary to have an official lethal dose to man especially as it is toxic and of therapeutic importance.

In this work some of the tea samples were found to have higher caffeine contents than the coffee samples. It is generally believed that nervousness is felt only when coffee is taken and it does not usually occur with intake of tea. It is therefore suggested that an examination of the difference between coffee and tea and between their organic constituents might produce useful information. This will help isolate other biological active substances in coffee.

The effects of caffeine is controversial and of much interest. Some people see nothing dangerous in few cups taken per day while others see it as health hazard. The relationship of caffeine intake to various diseases such as pathogenesis of peptic ulcer, hepatitis, development of cancer, heart diseases and cirrhosis of the liver (Graham,

1978) should further be investigated. It is accepted that the fatal dose of caffeine for human is 170mg per kilogram of body weight (Select committee on GRAS Substances, 1976 and Timson, 1978).

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APPENDICES

WATER EXTRACTIVES DETERMINATION (KINETIC STUDIES)

Percentage Water Extractives of the Tea Samples

Table 1a: D.B.L

Time (Minutes)	Per cent Water Extractives
1	26.65 ± 0.20
2.5	28.35 ± 0.21
5	30.12 ± 1.11
10	32.04 ± 0.26
20	35.94 ± 0.25
30	36.90 ± 0.02
40	37.25 ± 0.46
50	35.68 ± 0.84
60	32.12 ± 0.23

Table 1b: D.B.L

Time (Minutes)	Per cent Water Extractives
1	30.57 ± 0.61
2.5	31.29 ± 0.27
5	33.06 ± 0.31
10	37.04 ± 0.24
20	37.62 ± 0.22
30	37.24 ± 1.03
40	36.90 ± 0.21
50	37.73 ± 0.23
60	35.33 ± 0.22

Table 1c: N.R.L

Time (Minutes)	Per cent Water Extractives
1	26.19 ± 0.30
2.5	30.42 ± 0.20
5	31.21 ± 0.29
10	34.23 ± 0.39
20	36.60 ± 0.28
30	35.97 ± 0.26
40	35.61 ± 0.23
50	35.00 ± 0.27
60	34.07 ± 0.29

Table 1d: N.B.L

Time (Minutes)	Per cent Water Extractives
1	31.76 ± 0.21
2.5	32.59 ± 0.23
5	35.50 ± 0.22
10	36.58 ± 0.28
20	37.48 ± 0.23
30	37.14 ± 0.30
40	37.53 ± 0.32
50	36.04 ± 0.31
60	35.12 ± 0.53

Appendix B

Table 1e: T.B.L

Time (Minutes)	Per cent Water Extractives
1	28.01 ± 0.51
2.5	28.89 ± 0.21
5	29.90 ± 0.24
10	30.11 ± 0.30
20	31.46 ± 0.14
30	31.28 ± 0.32
40	31.95 ± 0.30
50	30.46 ± 0.26
60	29.41 ± 0.20

Percentage Water Extractives of the Coffee Samples

Table 1f: C.D

Table (Minutes)	Per cent Water Extractives
1	20.05 ± 0.35
2.5	20.74 ± 0.31
5	21.34 ± 0.26
10	22.28 ± 0.29
20	27.30 ± 0.17
30	26.14 ± 0.22
40	29.65 ± 0.27
50	27.99 ± 0.33
60	26.45 ± 0.75

Appendix C

Table 1g: C.FI

Time (Minutes)	Per cent Water Extractives
1	23.25 ± 0.23
2.5	25.16 ± 0.24
5	26.04 ± 0.30
10	26.46 ± 0.27
20	26.56 ± 0.36
30	27.69 ± 0.77
40	29.03 ± 0.25
50	29.94 ± 0.33
60	30.96 ± 0.04

Table 1h: C.FII

Time (Minutes)	Per cent Water Extractives
1	20.51 ± 0.20
2.5	22.35 ± 0.50
5	23.11 ± 0.45
10	23.99 ± 0.33
20	24.68 ± 0.23
30	26.10 ± 0.22
40	26.12 ± 0.26
50	27.08 ± 0.21
60	31.17 ± 0.01

Appendix D

Table 1i: A.G.C

Time (Minutes)	Per cent Water Extractives
1	24.03 ± 0.74
2.5	24.59 ± 0.33
5	25.06 ± 0.21
10	26.24 ± 0.25
20	26.71 ± 0.32
30	26.78 ± 0.57
40	29.65 ± 0.27
50	30.14 ± 0.24
60	27.75 ± 0.08

Appendix B

PARTICLE SIZE DETERMINATION

(i) Percentage Particle Size Distribution of the Tea Sample

Table 2a: Lipton

Mesh size (mm)	Per cent Particle Size
2.00	-
1.70	0.13 ± 0.01
1.40	0.15 ± 0.03
1.18	0.97 ± 0.02
0.71	47.76 ± 0.08
0.50	37.59 ± 0.06
0.43	7.36 ± 0.05
0.36	3.90 ± 0.04

Table 2b: D.R.L

Mesh size (mm)	Per cent Particle Size
2.00	9.00 ± 0.02
1.70	3.69 ± 0.01
1.40	10.02 ± 0.03
1.18	10.03 ± 0.07
0.71	33.30 ± 0.12
0.50	16.17 ± 0.05
0.43	4.42 ± 0.04
0.36	3.77 ± 0.02

Table 2c: D.B.L

Mesh size (mm)	Per cent Particle Size
2.00	-
1.70	0.16 ± 0.05
1.40	1.24 ± 0.01
1.18	4.27 ± 0.04
0.71	42.71 ± 0.02
0.50	26.65 ± 0.03
0.43	7.29 ± 0.06
0.36	3.05 ± 0.02

Table 2d: N.R.L

Mesh size (mm)	Per cent Particle Size
2.00	6.79 ± 0.01
1.70	3.19 ± 0.03
1.40	8.67 ± 0.02
1.18	9.63 ± 0.05
0.71	32.40 ± 0.06
0.50	16.35 ± 0.04
0.43	5.40 ± 0.02
0.36	5.04 ± 0.01

Appendix G

Table 2e: N.B.L

Mesh size (mm)	Per cent Particle Size
2.00	-
1.70	0.04 ± 0.03
1.40	0.07 ± 0.01
1.18	0.52 ± 0.02
0.71	50.51 ± 0.06
0.50	38.60 ± 0.04
0.43	6.28 ± 0.02
0.36	3.17 ± 0.01

Table 2f: T.B.L

Mesh size (mm)	Per cent Particle Size
2.00	-
1.70	0.13 ± 0.01
1.40	0.72 ± 0.07
1.18	2.87 ± 0.05
0.71	31.83 ± 0.10
0.50	39.09 ± 0.12
0.43	11.67 ± 0.03
0.36	6.84 ± 0.01
0.25	3.53 ± 0.08

Appendix H

(ii) Percentage Particle Size Distribution of the Coffee Samples

Table 2g: C.D

Mesh size (mm)	Per cent Particle Size
2.00	0.31 ± 0.01
1.70	2.43 ± 0.04
1.40	25.60 ± 0.02
1.18	41.20 ± 0.10
0.71	19.39 ± 0.07
0.50	0.99 ± 0.02
0.43	0.28 ± 0.03
0.36	0.11 ± 0.01

Table 2h: C.FI

Mesh size (mm)	Per cent Particle Size
2.00	-
1.70	0.37 ± 0.02
1.40	3.30 ± 0.04
1.18	9.59 ± 0.01
0.71	64.74 ± 0.13
0.50	10.53 ± 0.11
0.43	7.49 ± 0.03
0.36	1.57 ± 0.01

Table 2i: C.FII

Mesh size (mm)	Per cent Particle Size
2.00	-
1.70	0.57 ± 0.01
1.40	8.33 ± 0.08
1.18	22.15 ± 0.10
0.71	54.65 ± 0.14
0.50	3.63 ± 0.05
0.43	0.61 ± 0.01
0.36	0.17 ± 0.03

Table 2j: A.G.C

Mesh size (mm)	Per cent Particle Size
2.00	0.05 ± 0.01
1.70	1.52 ± 0.05
1.40	9.90 ± 0.08
1.18	15.42 ± 0.13
0.71	63.11 ± 1.01
0.50	6.50 ± 0.03
0.43	1.38 ± 0.02
0.36	0.26 ± 0.07

Table 3

Peak Particle Sizes for the Tea (a) and Coffee (b) Samples

Table 3a

Sample	Peak Particle Sizes (mm)
Lipton	0.71
D.R.L	0.71
D.B.L	0.71
N.R.L	0.71
N.B.L	0.71
T.B.L	0.50

Table 3b

Sample	Peak Particle Sizes (mm)
C.D	1.18
C.FI	0.71
C.FII	0.71
A.G.C	0.71

Appendix K

Table 4

DETERMINATION OF PARTICLE SIZE WITH HIGHEST EXTRACTION

(i) Per cent Water Extractives of Various Particles Sizes of the Tea Samples

Table 2a: Lipton Tea

Particle Size (mm)	Per cent Water Extractives
0.71	35.01 ± 0.32
0.50	35.79 ± 0.25
0.43	36.13 ± 0.29
0.36	35.42 ± 0.18

Table 4b: D.R.L

Particle Size(mm)	Per cent Water Extractives
2.00	30.51 ± 0.17
1.70	31.37 ± 0.56
1.40	32.01 ± 0.75
1.18	32.22 ± 0.28
0.71	33.75 ± 0.24
0.50	35.97 ± 0.25
0.43	35.55 ± 0.26
0.36	35.09 ± 0.61

Table 4c: D.B.L

Particle Size (mm)	Per cent Water Extractives
1.18	32.82 ± 0.24
0.71	33.15 ± 0.27
0.50	33.35 ± 0.31
0.36	32.79 ± 0.25

Table 4d: N.R.L

Particle Size(mm)	Per cent Water Extractives
2.00	25.32 ± 0.29
1.70	25.92 ± 0.28
1.40	26.66 ± 0.24
1.18	27.44 ± 0.27
0.71	28.39 ± 0.25
0.50	32.40 ± 0.30
0.43	30.41 ± 0.26
0.36	29.50 ± 0.31

Table 4e: *N.S.L*

Particle Size (mm)	Per cent Water Extractives
0.71	33.60 ± 0.29
0.50	35.68 ± 0.24
0.43	33.37 ± 0.48
0.36	32.05 ± 0.26

Table 4f: T.B.L

Particle Size (mm)	Per cent Water Extractives
0.71	28.19 ± 0.34
0.50	30.20 ± 0.05
0.43	31.00 ± 0.28
0.36	29.43 ± 0.25

Table 4g: C.D

Particle Size(mm)	Per cent Water Extractives
1.70	23.38 ± 0.25
1.40	23.94 ± 0.41
1.18	24.47 ± 0.24
0.71	23.08 ± 0.30

Table 4h: C.FI

Particle Size (mm)	Per cent Water Extractives
0.40	19.54 ± 0.21
0.18	20.69 ± 0.25
0.71	22.49 ± 0.19
0.50	23.86 ± 0.26
0.43	20.90 ± 0.20

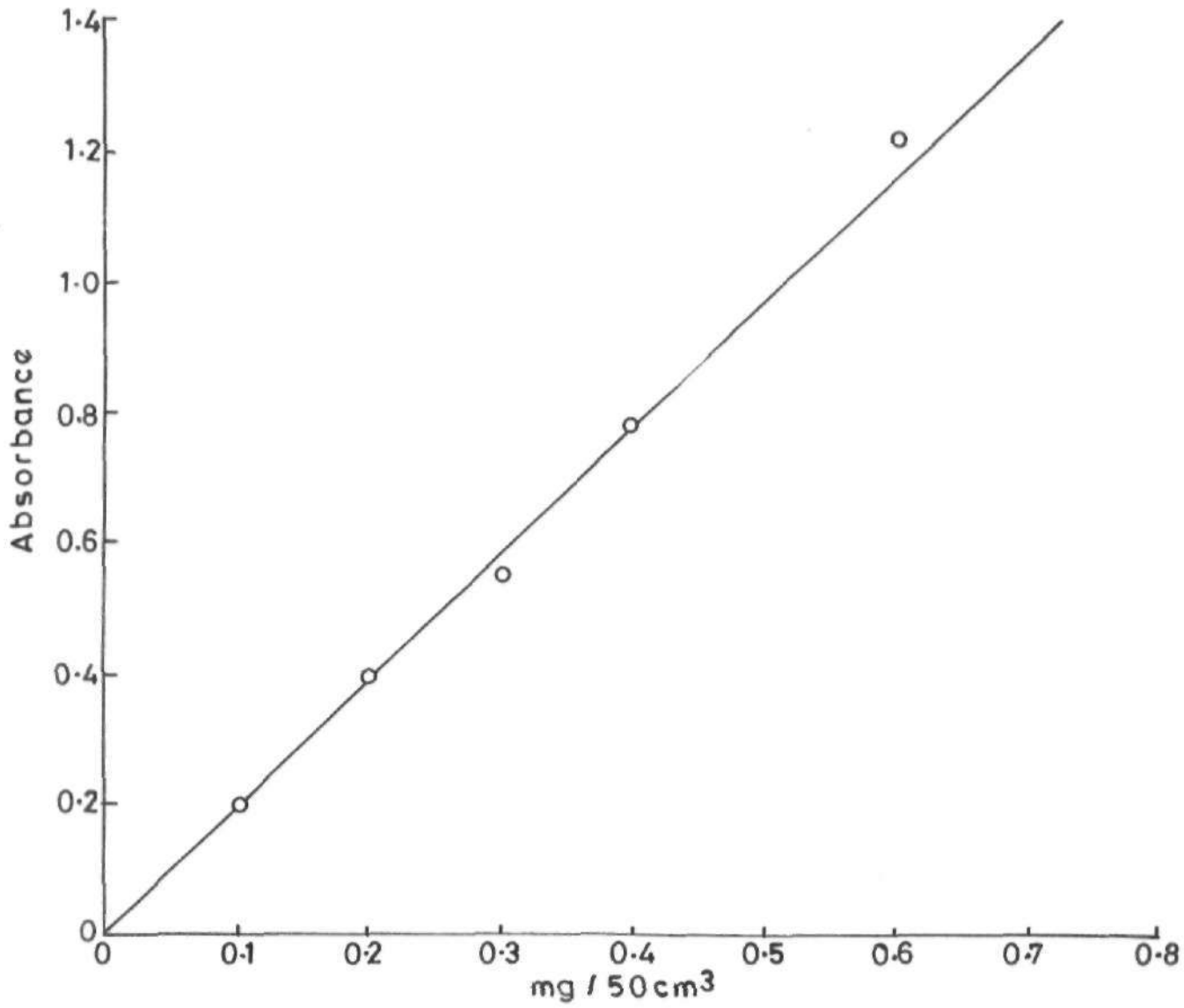
Appendix N

Table 4i: C.FII

Particle Size(mm)	Per cent Water Extractives
1.40	23.17 ± 0.25
1.18	26.83 ± 0.21
0.71	23.72 ± 0.23
0.50	23.21 ± 0.22

Table 4j: A.G.C

Particle Size (mm)	Per cent Water Extractives
1.40	21.62 ± 0.30
1.18	21.80 ± 0.26
0.71	22.06 ± 0.25
0.50	25.26 ± 0.19
0.43	21.99 ± 0.30



Appendix. P: Standard curve of catechin

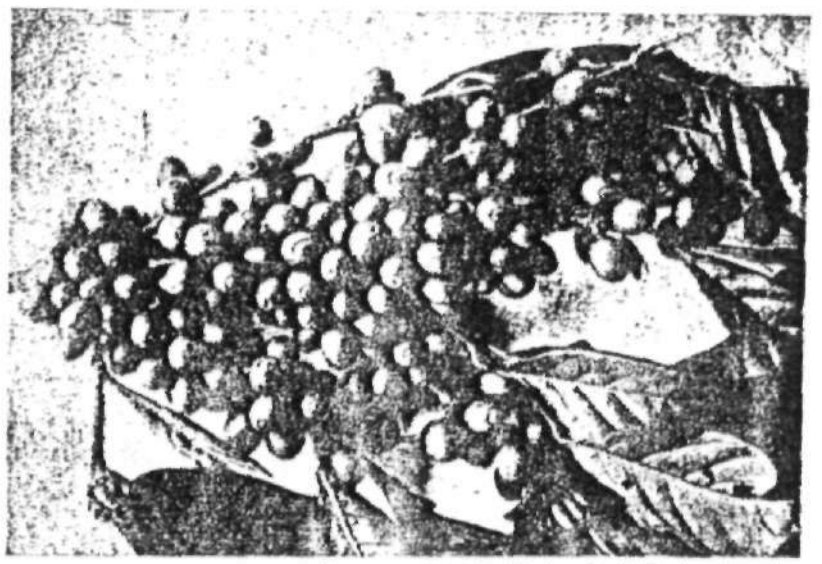


Drawn by Mrs. E. Milne-Redhead

Frontispiece: *Coffee arabica* L. var. *arabica*

Obtained from Modern Coffee Production - By A.E.Haarer

APPENDIX Q



By courtesy of the Royal Institute for the Tropics, Amsterdam

(*a*) A fruiting branch of *Coffea liberica* Bull ex Hiern

(*b*) Said to be flowers of excelsa coffee. They are rather large for excelsa coffee and may be a form of Liberian coffee

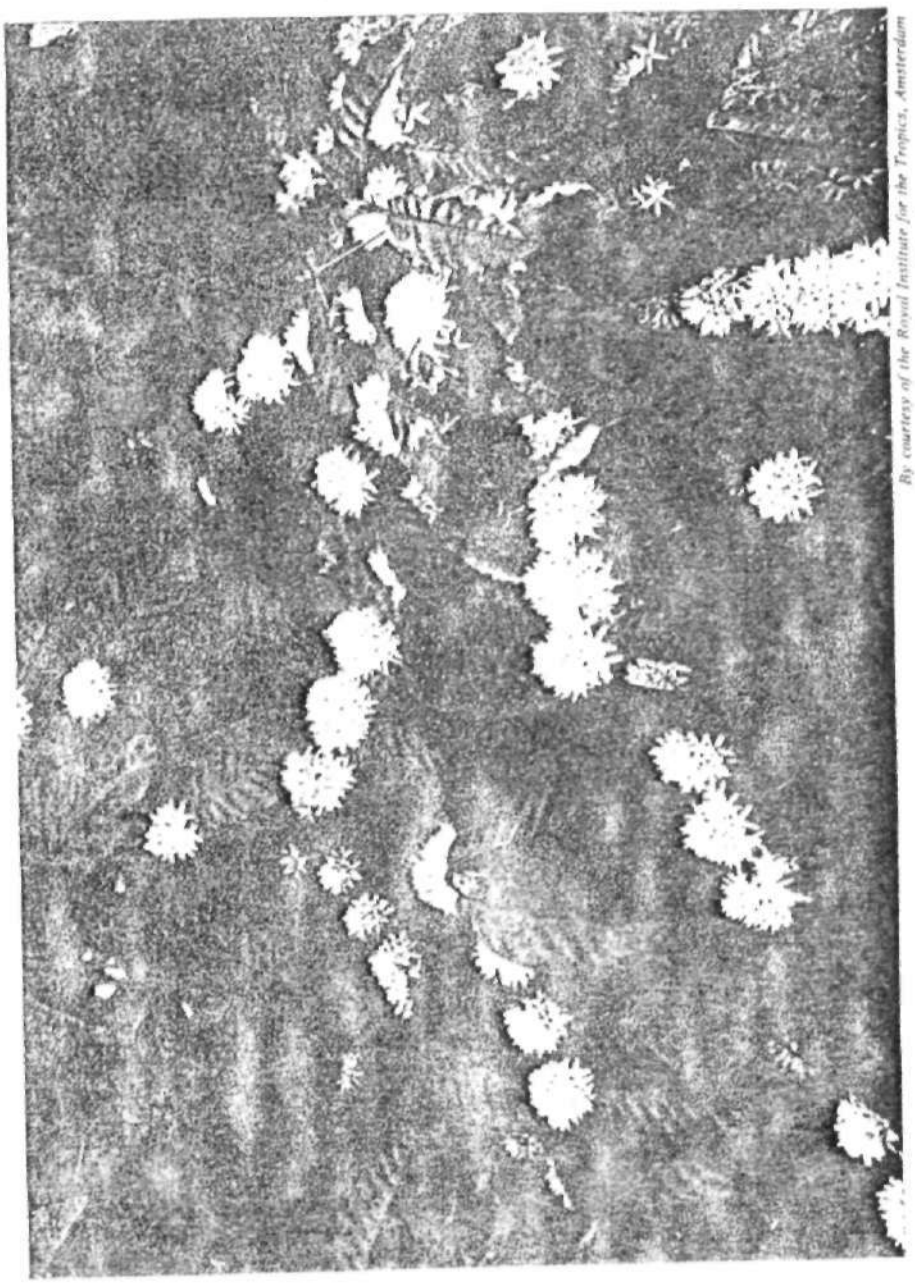


By courtesy of the Royal Institute for the Tropics, Amsterdam

PLATE IX

Obtained from Modern Coffee Production - By A.E. Haarer

APPENDIX R



By courtesy of the Royal Institute for the Tropics, Amsterdam

Coffea canephora Pierre ex Froehner. Branches in full flower. Note the corrugations of the leaves

PLATE III

Obtained from Modern Coffee Production - By A.E.Haarer

APPENDIX S



By courtesy of Licenciado Don Juan Rebolledo Clemens

Coffea arabica var. *bourbon* (B. Rodr.) Choussy, growing in Mexico. Note exuberant growth of laterals, the rather slender main stem and the flowering on young wood, i.e. environmental effects.

PLATE II

Obtained from Modern Coffee Production - By A.E.Haarer

APPENDIX T



By courtesy of World Crops

(*a*) *Coffea canephora* (robusta) growing in Uganda

(*b*) *Coffea canephora* Pierre ex Froehner. Fruiting branches of a tree in Java. Note the corrugated leaves and the manner in which the fruits are borne in whorls



By courtesy of the Royal Institute for the Tropics, Amsterdam

PLATE IV

Obtained from Modern Coffee Production - By A.E.Haarer



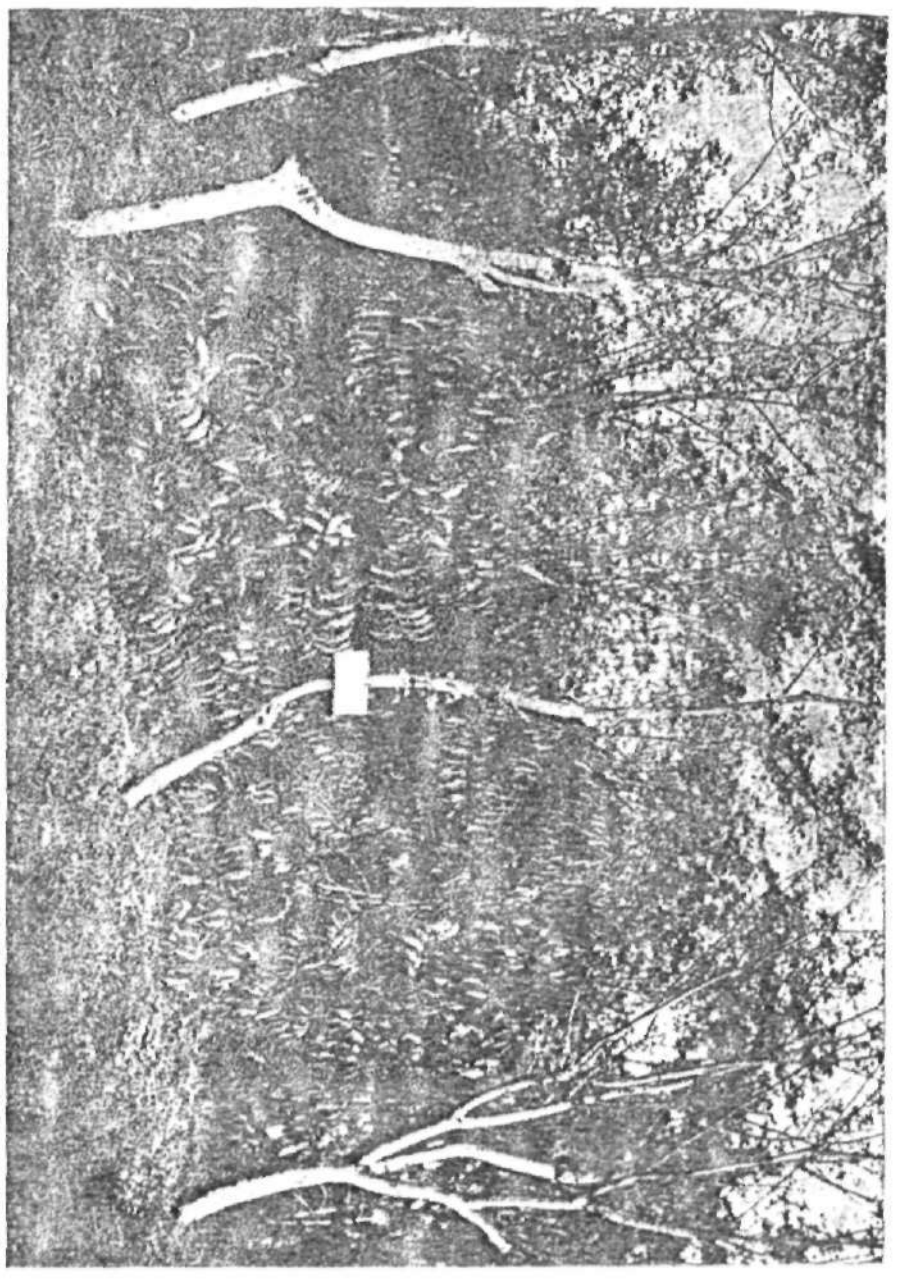
PLATE VIII

Said to be excelsa coffee growing on an estate in Java under *Erythrina* shade. Note the shrubby form of growth. This may well be a form of Liberian coffee or a hybrid

By courtesy of the Royal Institute for the Tropics, Amsterdam

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APPENDIX V



Coffea canephora Pierre ex Froehner. Quillou coffee in Java growing under shade of *Erythrina* sp. Said to be like the *nganda variety of Uganda*

By courtesy of the Royal Institute for the Tropics, Amsterdam

PLATE VII

Obtained from Modern Coffee Production - By A.E.Haarer

APPENDIX W



By courtesy of Dr. J. D. Tothill and the Oxford University Press

(*a*) Mature trees of *Coffea canephora*, spreading form in Uganda, now named var. *nganda*

(*b*) Mature trees of *Coffea canephora*, erect form in Uganda



By courtesy of Dr. J. D. Tothill and the Oxford University Press

PLATE VI

Obtained from Modern Coffee Production - By A.E.Haarer



By courtesy of Dr. J. D. Tothill and the Oxford University Press

(*a*) Young trees of *Coffea canephora*, with spreading habit of growth; now named var. *nganda*

(*b*) Young trees of *Coffea canephora* with upright habit of growth, in Uganda; the No. 9 selection



By courtesy of Dr. J. D. Tothill and the Oxford University Press

PLATE V

Obtained from Modern Coffee Production - By A.E.Haarer

APPENDIX Y