EFFECT OF PROCESSING ON THE DIETARY FIBRE COMPOSITION OF TRADITIONAL BREAKFASTS

By

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DECLARATION

The work described in the thesis was carried out by me at Industrial Technological Institute (ITI) and Faculty of Applied Sciences under the Supervision of Dr. Jaanaki Gooneratne and Dr. K.K.D.S.Ranaweera. A report on this has not been submitted to any other university for another degree.

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ABSTRACT

Dietary fibre is defined as "remnants of edible plant cell walls, polysaccharides, lignin and associated substances resistant to hydrolysis (digestion) by alimentary enzymes of humans". It includes macro constituents of plant foods e.g. Cellulose, hemicellulose, pectins and other substances such as lignin, gums, mucilages, waxes and suberin.

The physical properties of dietary fibre show physiological effects in human systems. From the technological aspects, dietary fibre shows functional properties. The physiological role of dietary fibre is demonstrated in analytical methods as insoluble dietary fibre (IDF) and soluble dietary fibre (SDF) fractions.

The objectives of this study were, a) to determine total dietary fibre (IDF & SDF) of breakfast preparations, b) to study the effect of processing on the dietary fibre fractions (Insoluble & Soluble) of breakfast preparation and c) to compare the dietary fibre fractions of traditionally prepared and commercially available breakfast preparations.

Rice flour, wheat flour, black gram and semolina were used as raw materials. In the processing these raw materials, dry milling, wet-milling, roasting, fermentation, steaming techniques were used, depending on the type of breakfast preparations. The commercial preparations included two types of bread (100% wheat flour and 85%: 15% of wheat flour: Kurrakan).

The results showed that the highest contribution of dietary fibre was from breakfast preparations containing rice flour (8.7%). Wheat flour bread contributed the least as dietary fibre (1.8%). This could be attributed to the high extraction rate (72%) of milling of the wheat flour.

Of the two milling processes of rice flour, 'wet milling + roasting' contained a higher SDF% and IDF%. The total dietary fibre (TDF) content of string hoppers made with wet milled flour and dry milled flour were 9.7% and 8.8%, respectively. Steaming of the extruded flour increased the TDF in the string hopper preparation by

approximately 13 %. Similar observations were made with the wheat flour where the increase in the soluble fibre accounted to over 20.4%. This can be attributed to the formation of resistant starch, which is precipitated in the dietary fibre analysis. Today resistant starch, which has the property to ferment in the gut, is also considered as dietary fibre.

Black gram contains a high dietary fibre as a raw ingredient but in the preparation of idly, it contributes moderately to the dietary fibre (4.25%) intake. Idly is formulated using semolina and black gram in the ratio of 2:1. In preparation of idly, removal of seed hull from the black gram after soaking, reduced its dietary fibre content.

In bread, substitution of wheat flour with 15% Kurakkan increased the total dietary fibre to 3.2%. (IDF: 2.85% and SDF:0. 33%).

The study concludes that processing of foods increase the dietary fibre content of breakfast preparations during steaming and roasting, which can be attributed to the formation of resistant starch. The contribution of dietary fibre from commercially available breakfast preparations (e.g.bread) is less than that of the traditionally prepared breakfasts (idly, string hoppers). Rice based breakfast preparations (eg.180 g) contribute approximately 56% of the fibre requirement to the daily diet.

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ABBREVIATIONS

IDF - Insoluble dietary fibre
SDF - Soluble dietary fibre
TDF - Total dietary fibre
DF - Dietary fibre
ADF - Acid detergent dietary fibre
NDF - Neutral detergent dietary fibre
NSP - Non starch polysaccharides
GLC - Gas liquid chromatography
AOAC - American Association of Cereal Chemistry
CTAB - Cetyl Trimethyl Ammonium bromide
SDS - Sodium Didecyl Sulphate
DMSO - Dimethyl sulfoxide

CHAPTER 1

1.1 Introduction

"Dietary Fibre" refers to the skeletal remains of the plant cell walls in the diet that are resistant to hydrolysis in the human digestive tract. Today, it has been extended to cover all polysaccharides and lignin in the diet, which also includes food additives. The dynamics of the dietary fibre matrix as a structural and functional entity during gut transit is an integral part of the dietary fibre hypothesis. Today, dietary fibre is considered an essential component of the diet, with the recognition of its physiological role in reducing metabolic diseases .e. g. Diabetes, Coronary heart disease, Colonic cancer, Gallstones, Hiatus hernia, Constipation, Diverticular disease, Appendicitis, Obesity etc.

For analytical purposes, dietary fibre measures simply the fibre content in the food. Dietary fibre is measured using both chemical and enzymatic methods replacing the other method such as crude fibre. Dietary fibre also refers to Non- Starch Polysaccharides and lignin in the diet, and methods have also been developed to quantify these components in foods, for use in food labeling and Food Table Compositions. Fibre in the food may be altered by different compositions of food intake and by methods of processing. It is well established that dietary fiber for various food sources differ in its composition in terms of pectin, cellulose & hemicelluloses, which are the major constituents of plant cell walls. It is recommended that approximately 25-32 g of fiber should be included in an adult diet, originating two cereals, legumes, fruit & vegetables.

The physiological effects of dietary fibre depend not only on the type of fibre ingested or on the dose of fibre, but also on the composition of the rest of the meal. In the upper intestine, fibre is classified as soluble and insoluble, depending upon its solubility. All soluble fibres are not viscous, but viscous polysaccharides have shown greater effect on the gastric and small intestine function and play a role reducing metabolic diseases such as hypercholesterimia and hyperglycemia. On the hand, the role of insoluble fibre is solving problems of the large intestine and colon, by improving fermentability, stool bulking and water – holding capacity is also well established.

This study reports on dietary fibre fractions (soluble and insoluble) of traditional breakfast preparations as compared to a commercially available preparation.

1.2 Objectives

- To determine the total dietary fibre content (Insoluble & Soluble) of breakfast preparations.
- To study the effect of processing on breakfast preparation of dietary fibre fractions
  (Insoluble & soluble)
- To compare on the dietary fibre fractions of traditionally prepared and commercially available breakfast preparations.

CHAPTER 2

2.0 Literature Review

2.1.Breakfasts

2.1.1. Introduction of breakfasts

Nutritionally the breakfast is the most important meal of the day as it breaks the fasting for the day. (Niness. K, 1999)

2.1.2. Different types of breakfasts

Those day's people have to prepare their breakfasts at home, but today it has been changed with the time is used to earn more money, there is not enough time to prepare their breakfasts. Then they used to have that the commercially available breakfasts than to the traditionally prepared one.

As commercially available breakfast the commonest is the bread. However, traditional preparations such as String hoppers, Hoppers, Idly, Pittu, Boiled Mung bean etc; are available at food outlets. The nutritional compositions of these food materials are presented in Table 2.1.

Table 2. 1: Nutritional value of ingredients used in breakfast preparations

Ingredients	Moisture	Protein	Carbohydrate	Fat	Dietary fibre
Wheat flour -Refined (*Triticum aestivum*)	13.3	11.0	73.9	0.9	0.3
Rice (*Oryza sativa*)	13.3	7.5	76.7	1.0	0.6
Black gram (*Phaseolus mungo*)	10.9	24.0	59.6	1.4	0.9
Semolina (*Triticum aestivum*)	14.0	10.7	77.5	1.8	2.5

Source: Tables of Food Composition (1989)

2.2. Dietary Fibre

2.2.1. Definition and availability of Dietary Fibre

2.2.1.1. History of the definition

The term "Fibre" was in vogue in the early days, but confined largely to refer to animal forages. The concept of "Crude Fibre" determined routinely in food and feed as a part of proximate analysis was evolved to refer to the residue left over after treatment with acid and alkali. Crude fibre values include only variable portions of the cellulose, hemicellulose & lignin present in dietary fibre.

This portion of food was paid little attention to explain its chemical, physical and physiological properties for a long time, till observation of distinct pattern of diseases prevalent in developed countries and the cause of this was attributed to the types of foods consumed by these population (Cleave, 1956)
Hipsley coined the term "dietary fibre" first in 1953 to refer to the non- – digestible residue in foods. (Eastwood, M.A, 1983)

Subsequently became an acceptable terminology for use in food nutritional labelling in place of crude fibre. Trowel, 1972 used the term to apply all the indigestible materials in the diet derived from the plant cell wall. (Eastwood, M.A, et al 1983)

2.2.1.2. Dietary fibre AOAC accepted definition

Trowel et al, 1976 has extended this definition that,
"Dietary Fibre consists of remnants of edible plant cells, polysaccharides, lignin and associated substances resistant to (hydrolysis) digestion by alimentary enzymes of humans".
This definition identifies a macro constituent of foods that includes cellulose, hemicellulose, lignin, gums, modified cellulose, mucilages, oligosaccharides and pectins and associated minor substances such as waxes, cutin and suberin.(Devries J.W, et al, 1999)

2.2.2. Dietary fibre Sources

Dietary fibre as it is known today is a complex mixture of chemical entities and its concentration and composition in different sources are neither constant nor uniform. (Potty V.H, 1996). The chemical nature of dietary fibre is presented in Table 2.2.

There are some food components that behave as dietary fibre, but non-dietary fibre as given in Table 2.3.

Table 2.2: Dietary fibre: Location in plants

Source	Tissue location	Chemical nature
1.Fruit&vegetable	Paranchymatous	Pectic substances, Cellulose, Hemicellulose,Proteins, Phenolics
	Partially lignated	Cellulose, Hemicelluloses, Lignin
	Vascular tissues	Pectic substances, Proteins
	Cutinised epidermal Tissue	Cutin, Waxes
2.Cereals	Parenchymatous (Endosperm and aleurone)	Hemicelluloses,Cellulose, Proteins, Phenolics
	Partially lignated seed Coats	Hemicelluloses,Cellulose, Proteins, Phenolics, Lignins
3.Legumes	Paranchymatous (Cotyledons)	Cellulose, Pectic substances, Hemicelluloses, Proteins
	Cells with thickened Endosperm walls	Galactomannans, Cellulose, Pectic substances, Proteins Mucilages
4.Seed husk	Epidermal Cells	Arabinoxylans

Source: Selvendran et al. (1987)

Table 2.3: Food components that behaves as dietary fibre

Category	Dietary sources		Frequency of Occurrence
Non-carbohydrate	Cutin	Associated with epidermal tissues	most diets at low level
Associated with or	Suberin		most diets at low level
Part of plant	Waxes		
Cell wall	Protein	Present in cell walls	most diets at low level
	Inorganic material	Present in cell walls	most diets at low level
	(Lignin)	In plant tissues	most diets at low level
Non- α glucan	Gums	In fruits & seeds	most diets at low level
polysaccharides	Mucilages	used as food ingredient	
	Polysaccharide	Present in processed	
	Food additives	foods	
Degradation products	Modified carbohydrate	Mainly arising in	most diet at low levels
	Protein-Carbohydrate	thermally treated foods	
	Complexes		
Other non-assimilable	Oligosaccharides	Tri- and tetrasaccharide	depend on choice,
Components		in many Vegetables	many diet at low level
	Sugar alcohols	Used in food additives	Depend on choice,
			many diet at low level
	Hydrocarbon waxes	contaminants from	Infrequently in western
	Hydrocarbon oils	Food processing	diet
	Dyes	Processed foods	depend on choice of
			Foods
	Pigments	naturally occurring	Infrequently in western
	Degraded connective	Animal products	diet
	Tissue proteins.		

Source: Spiller G.A. (1986)

Table 2.4: Plant dietary fibre: Chemical nature

Fiber fraction	Main chain	Side chain
Starch polysaccharides		
Cellulose (1,4,β linkages)	Glucose	None
Hemicellulose		
Arabinoxylan	Xylose	Arabinose
Galactomannan	Mannose	Galactose
Glucomannan	Galactose	Glucouronic acid
Non-starch polysaccharides		
Pectic substances	Galacturonic acid	Galactose
		Glucose
		Rhamnose
		Arabinose
		Xylose
		Fucose
β-Glucans	Glucose	
(1,3 β and 1, 4 β links)		
Mucilages	Galactose-Mannose	Galactose
	Glucose-Mannose	
	Arabinose-Xylose	
	Galacturonic acid-Rhamnose	
Gums	Galactose	
Galactouronic acid-Mannose	Fucose	
	Galactouronic acid- Rhamnose	Galactose
Non-polysaccharides		
Lignin	Sinaphyl alcohol	3 dimensional
	Coniferyl alcohol	structure
	P-Coumary alcohol	

Source: Schneeman (1989)

2.2.3. Chemistry of dietary fibre

Dietary fiber can be fractionated into starch polysaccharides & non-starch polysaccharides.

Starch polysaccharides as cellulose, hemicellulose etc. Non-starch polysaccharides as pectic substances,β-glucans, mucilages and gums. Non Polysaccharides as lignin. (Potty, V.H, 1996)

Cellulose

A linear polymer of glucose with β 1-4 links is the main structural component of plant cell walls. It is considered relatively insoluble. There are 10000 units /per molecule.

Hemicelluloses

Heterogeneous group containing a number of sugars in its backbone and side chains. Soluble in dilute alkali, Hemicellulose exhibits a wide range of solubilities, with greater solubility being associated with a high degree of branching.

There are β-(1,4)-linked glucose units, 50-200 units per molecule. The classification of hemicellulose is done according to dominating monomers (e.g. Pentosoms) this may also contain Uronic acid residues.

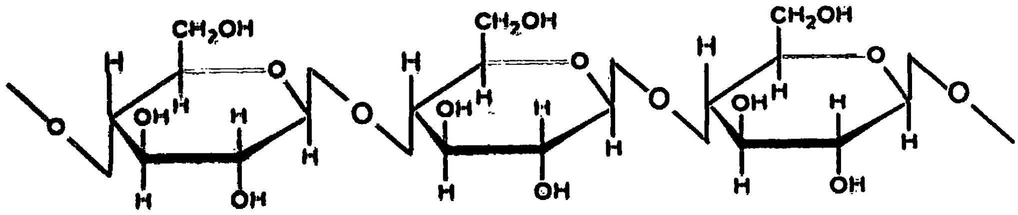
Pectins

It is composed primarily of D-Galacturonic acid, although it can have other Carbohydrate moieties linked to it. Partial methylation of the Carboxyl groups on the Galacturonic acids imparts important properties to pectic substances. Uronic acid residues can have a free Carboxyl group or be present as methyl esters. Neutral sugars (i.e.Rhamnose, galactose) are found in pectins.

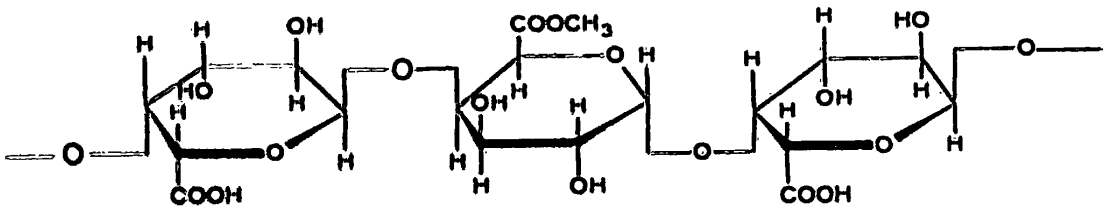
It is soluble in hot water but plant cell wall pectins are less soluble as they are complexed with chelating agents such as EDTA.

Figure2.1: Chemical Structures of Polysaccharide dietary fiber

Cellulose

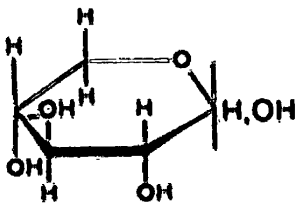


Pectin

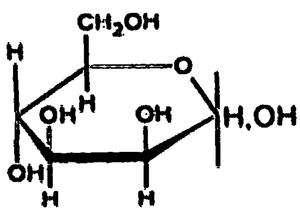


Hemicellulose(major component sugars)

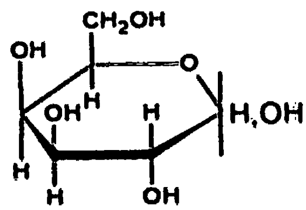
a) Backbone chain



D-Xylose

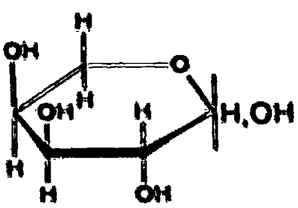


D-Mannose

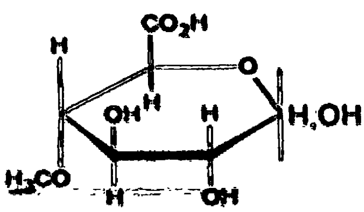


D-Galactose

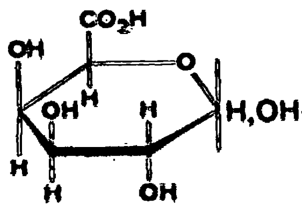
b) Side Chain



L-Arabinose



4-O-Methyl-D-Glucuronic Acid



D-Galactose

Source: Schneeman (1989)

Mucilages (Gums)

They have high water binding capacity, and are found in seeds as reserve non-starchy polysaccharides (e.g. Guar gum). Plant exudate gums have complex and highly branched structures containing both various neutral sugar residues and Uronic acids.

Algal polysaccharides (e.g. Alginates)

Alginates contain sulphated galactose units and Uronic acids.

Lignin

Lignin is a highly complex structure based on phenylpropane units. The 3 dimensional lignin network is covalently linked to hemicellulose (in specialized plant cells after maturity)

Lignins are considered very inert, insoluble and resistant to digestion.

Uronic acids

The main constituent of pectins occurs also in hemicelluloses & gums.
(Asp. G.N, Johansson.C.G, 1984)

2.2.4. Dietary fibre fractions

Total dietary fibre (TDF) is the analytical term for dietary fibre. It includes both soluble and insoluble dietary fibre. Insoluble fibre consists mainly of cell wall components such as Cellulose, Lignin and hemicellulose. Soluble fibre consists of non-cellulosic polysaccharides such as pectin, gum and mucilages. About 75% of the dietary fibre in goods is in the form of insoluble fibre. Products frequently reffered to as soluble or insoluble fibres are actually sources of both types of fibre.

The dietary fibre sources are subdivided into three classes.

1.Soluble dietary fibres – Primarily of soluble fibre e.g. Gums

2.Insoluble dietary fibres – Mostly insoluble fibre e.g. Wheat bran

3.Composite dietary fibres – Blends of soluble and insoluble fibres e.g.Oat bran

Soluble dietary fibres (SDF)

A major class of soluble fibre ingredient is the hydrocolloids, frequently reffered to as gums (Dziezak, 1991). These compounds are long – chain polymers, which dissolve on, disperse in water to give a thickening or viscosity. Hydrocolloides are also used for secondary effects, which include stabilisation of emulsions, suspensions of particulates, control of crystalisation, inhibition of syneresis, encapsulation and the formation of a film, Additionally few hydrocolloides form gels.

Hydrocolloides are generally used at levels of less than 2% to achieve desired properties in food systems. Although using gums can sometimes be tricky, understanding several critical factors will help their selection. Another point to consider is the gum's compatibility with other ingredients and the order of ingredient mixing.

Total gums are obtained from a variety of sources. Gums usually come from

1. Plant materials such as seaweed, seed, roots and tree exudates

2. Microbial biosynthesis

3. Chemical modification of natural polysaccharides

Insoluble dietary fibres (IDF)

Insoluble dietary fibre comes primarily from plant cell walls. There are two distinct types of cell walls, primarily (immature) and secondary (mature). These cell walls consist of a heterogeneous mixture of cellulose, non-cellulose polysaccharides and lignin that are crosslinked (to varying degrees) to form a complex matrix.

About 75% of the dietary fibres in goods are in the form of insoluble fibre. Insoluble fibres consist of fibre sources that are rich in cell wall content such a most cereal brans (e.g. wheat and corn bran), oil seed hulls (e.g. sunflower seed and soybean hulls), and purified cellulose. Their usages in food systems are often improved by pretreatment, which improve functionality. Numerous insoluble dietary fibres are commercially available as supplements for use in foods such as bakery goods. But, insoluble fibre sources can cause undesirable changes in food flavour, texture and mouthfeel. However, many of these functional problems can be overcome by modifying the sources with chemical, physical treatments. (e.g. Reduction of wheat bran particle size on water binding capacity)

Insoluble fibres are most often used to control calories add bulk, or provide a health benefit.

Composite dietary fibre

Blend of soluble and insoluble fibres is known as composite dietary fibre. Although there is no universally accepted threshold for the ratio of insoluble to soluble fibre that results in composite fibre, a level of about 10% soluble fibre appears to be reasonable value with regard to functionality. This can be somewhat of a problem for certain fibre sources such as Soy fibre because the solubility can vary greatly depending on the analytical method, which is use.

Table 2.5: Fractions of dietary fibre

			Other Polysaccharides	Soluble Fibre	Other sugar residues
					Uronic acids
Total Dietary Fibre	Non-starch polysaccharides (NSP)	Non-Cellulosic polysaccharides	Pectin		Rhamnose
					Arabinose
			Hemicelulose	Insoluble Fibre	Xylose
					Mannose
					Galactose
		Cellulose	Cellulose		Glucose
	Lignin	Lignin	Lignin		Lignin

Source: Asp .G.N, Johansson.C.G (1984)

2.2.5. Analytical methods for dietary fibre determination

2.2.5.1. Principles & aims

Methods for dietary fibre determination can be divided into 3 categories.

1. Gravimetric methods
2. Colorimetric methods
3. Gas-liquid Chromatographic (GLC) method

Gravimetric method

It measures on insoluble residue, after chemical or enzymatic solubilisation of non-fibre constituents. Some recent developments of enzymatic methods are capable of measuring also soluble dietary fibre components after precipitation with alcohol, ultrafiltration or dialysis.

Colorimetric methods

Employ reactions yielding colouring complexes with carbohydrates that can be determined colourimetrically. In Southgate's analytical scheme Anthron, Orcinol and Carbazol reagents are used. These are relatively specific for Hexoses, Pentoss and Uronic acids, respectively, making it possible to estimate the relative contribution of these classes of monomers in dietary fibre or Fractions of it.

Gas- Liquid Chromatographic methods

Monomeric constituents of dietary fibre polysaccharides are liberated by acid hydrolysis. Usually derivated to their corresponding Alditol acetates and separated gas chromatographically. Uronic acids need a special determination by colourimetry or by decarboxylation.

(1) Gravimetric methods

(a) Crude fibre

The crude fibre method was developed in the 1850 s for determination of indigestible material in feed and forages.

Due to the lack of simple alternative methods it has come into use also for human food, that 40% of the unavailable carbohydrates were lost.

This method implies sequential extraction with dilute acid (1.25%, H_2SO_4) and Alkali (1.25%, NaOH) and isolation of the insoluble residue by filtrations.

However, the figure obtained does not include soluble fibre and represents only about 15% of hemicelluloses and 10-15%of lignin. (Asp.G.N, Johansson, C.G, 1984)

(b) Detergent method

The losses of fibre components in the crude fibre assay are mainly due to the alkali treatment. Consequently, Walker and Hepburn suggested the normal acid procedure in 1955, in which only the acid extraction step is used. However, the modification gave a considerable protein residue that was corrected by performing a Nitrogen analysis. (Asp.G.N, Johansson, C.G, 1984)

Acid Detergent Fibre (ADF) method

The problem of protein residues was solved by Van Soest (1963) by including a detergent (Cetyltrimethyl Ammonium Bromide, CTAB) in the 1N H_2SO_4.

Cellulose & lignin were determined, but residues of pectin (Belo and de Lumen, 1981) and hemicelluloses (Morrison, 1980) have been reported.

Neutral Detergent Fibre (NDF) method

Van Soest and Wine in 1967 said that the sample is boiled with a neutral, buffered solution of Sodium Didecyl Sulphate (SDS) and EDTA. (This milder treatment also leaves hemicelluloses in the residue, where as pectin are efficiently extracted with the EDTA.This neutral detergent system solubilises protein efficiently and fat to a limited extent, where as in starchy materials such residues cause filtration problems and erroneously high fibre values. Therefore American Association of Cereal Chemists (AACC) adopted a method for insoluble fibre in cereals, which the NDF residue is treated with Amylase and washed to remove starch. (AACC method)
The detergent methods can be used together in the system for analysis of dietary fibre components. The difference between NDF and ADF is Hemicelluloses.

The main advantages are simplicity and rapidity, the work being comparable to that of the crude fibre assay. (Asp.G.N, Johansson, C.G, 1984)

(c) Enzymatic method

Insoluble Fibre

Remy, in 1931 reports that in Enzymatic gravimetric method, for starch and protein solubilisation, Amylolitic & Proteolitic enzymes are employed. Special centrifuge tubes with fritted glass filters were used for separation of the fibre residue, and also were designed that the system of sequential acid hydrolysis for separate determination of hemicellulose, cellulose & lignin in the residue. (Asp.G.N, Johansson, C.G, 1984)

Insoluble & soluble Fibre

Bacillus subtilis **amylase and protease were used in a single over incubation at neutral pH. The method was developed that soluble fibre components were precipitated & were separated by centrifugation. (Schweizer & Wiirsh,(1981) & Asp& Johansson, 1981)**
Starch solubilization was further improved by adding a thermostable Amylose, Termamyl 120 L, in the initial gelatinization step. (Asp etal, 1983)

Another method of that, Insoluble dietary fiber is separated by centrifugation & soluble fiber by ultrafiltratin of the supernatant was developed. The suggested AOAC method (Prosky etal, 1984) was developed on the basis of the common experience of 3 groups. (Asp etal, 1983, Schweize and Wiirsch, 1979)

Figure2.2: Analytical scheme for the method of Prosky et al, 1984 (suggested AOAC method)

1g Sample

↓

Gelatinization and Termamyl incubation pH 6.0, 15 or 30 min, 100^{0}C

↓

Protease incubation, pH 7.5, 30 min, 100^{0}C

↓

Amyloglucosidase incubation pH 4.5, 30 min, 60^{0}C

↓

Precipitation with 4 volumes of Ethanol

↓

Filtration

↓

Washing with Alcohol and Acetone

↓

Drying

↓

Correction for undigestible protein & ash

2) Colorimetric method

In strong acid solution, Carbohydrates undergo condensation reactions with a large number of substances giving coloured products that can be measured spectrophotometrically.

Such reactions, those with Anthron, Orcinol and Carbazole are under certain conditions relatively specific for Hexoses, Pentoses & Uronic acids, respectively and therefore, been used for determination of dietary fibre components. (Southgate, 1976)

The Colorimetric reactions are applied to the soluble & insoluble Non Carbohydrate Polysaccharide (NCP) fractions and to the cellulose fraction, and the results are expressed as Hexoses, without conversion to anhydro-basis.

Uronic acid determination

Decarboxylation of Uronic acids with Hydrophobic Acid was done. (Theander and Aman, 1979) The released CO_2 is trapped in dilute NaOH and measured as change in conductivity. (Buylund and Donetzhuber, 1968)

Different Uronic acid compounds give the same molar response, and ester linkages to Uronic acid residues are cleaved at an early stage of the acid treatment. Thus, esterified and free Uronic acids can be expected to produce the same response.

(3) Gas- Liquid Chromatographic (GLC) method

It is included that following steps in the dietary fibre determination.

1. Acid hydrolysis of dietary fibre polysaccharides to their free monomeric constituents.
2. Derivatizaton of suitable volatile compounds
3. Separation of derivatives with GLC usually 5-6 neutral monomers and quantitation by using internal and external standards.
4. Separate determination of Uronic acids by colorimetry or decarboxylation.
5. Determination of Lignin, usually as Kalson Lignin (residue insoluble in 72% H_2SO_4)

(Asp.G.N. Johansson C.G, 1984)

Table 2.6: Relative specificity of methods for dietary fibre determination

Method	% of theoretical level estimated				
	Cellulose	Hemi Cellulose	Lignin	Pectin	Relation to actual DF
Crude fibre	75	25	50	0	Less
Neutral detergent	100	75	100	0	Less
Acid detergent	100	0-25	10	0-25	Less
Enzymes	100	100	100	100	More

Source: Schneeman (1989)

2.2.6. Properties of dietary fibre

The dietary fibre posses physiochemical, physiological and functional properties, thereby they act in different ways.

2.2.6.1.Physiochemical properties

The properties and functions of dietary fibre vary considerably, depending on composition and structure. Some of the physical properties that influence their behaviour. That includes solubility, particle size, swelling capacity, affinity to bile salts, cation exchange ability, viscosity and fermentability.

Solubility

Some of the non = starch polysaccharides, which we have come to recognise, as dietary fibre are water-soluble. Solubility has such obviously profound effects on functionality common to see on food labels dietary fibre divided into soluble and insoluble fractions. What determines solubility? If the polysaccharide structure is such that the molecules ready to fit together in a crystalline array, then the polymer is likely to be more energetically stable in the solid state than in solution. (Onkenfull, D.G., 1993)

Cellulose is the least soluble of all fibre components being insoluble in cold or hot water, hot dilute acid and hot dilute alkali. In contrast,β-glucans is mostly soluble in water with a small amount remaining insoluble.

Hemicelluloses are insoluble in water but dissolve in dilute alkali. Lignin is highly water insoluble, but dissolves in alkali.

Cutin and Waxes being hydrophobic lipid material are insoluble in water.

Pectins are basically water soluble, the extent of solubility depending on the degree of esterification of galactouronic acid and the make up of the side chain. Most of the gums from seaweed, plant sources and microbial cells are accepted food additives and are soluble in water. These include Agar, Alginate, Carrageenan, Flaxseed gum, Gum ghatti, Guar gum, Gum karaya, Gum tragacnath, Locust bean gum and Xanthaun gum. (Potty, V.H., 1996)

Physical state and particle size

Structure of the fibre in food undergoes change during processing, preparation and mastication, resulting in somecases the structure also is modified. While large sized fibre particles have low bulk density, progressive size reduction increases the bulk density significantly. Coarse cereal brans, when consumed invariably yield light stools, while finer bran produces a denser residue in the colon. (Potty, V.H., 1996)

Absorption of water

Adsorption and absorption take up when fibre is treated with water substantial quantity. Besides, some water is retained outside the fibre matrix. The water holding capacity (WHC) of fibre is greatly influenced by its chemical composition, physical structure and particle size. (Eastwood, 1984)

Polysaccharides are hydrophobic molecules; consequently soluble and insoluble polysaccharides alike have the ability to hold water. This is particularly so in polysaccharides containing sugar residues with free polar groups. The most obvious demonstration of the ability of soluble polysaccharides to hold water is the phenomenon of gelation.

Insoluble fibre can also absorb water, but move in the manner of a sponge. They can form a hydrophobic matrix in which water is trapped. (Oakenfull. D.G, 1993)

Binding of bile salts

Fibre preparations from different sources exhibit the property of binding bile salts, to varying extents. (Kritchevsky, 1988)

Deconjugated bile salts are known to be bound to pectic substances by hydrogen bonding and in the same way, binding occurs with other fibre constituents also. Such a binding prevents reabsorption of bile salts in the intestine, which in turn, results in reduced cholesterol levels in the blood. (Eastwood, 1984)

Cation exchange property

The most active functional groups of dietary fibre are the carboxyl groups of uronic acids and calcium is known to be bound by these groups in vitro. (James et al, 1978) It is suspected that such fibre mineral interactions may deprive the human body of some of the minerals, which are present in the diet due to their immobilization in the intestine inpresence of fibres and consequent inability to be absorbed. (James, 1980)

The enhanced elimination of bile salts by dietary fibre rich in pectin could be a means of removing hepatic cholesterol resulting in lower blood cholesterol levels. Bran on the other hand has negligible effects on plasma cholesterol levels. But causes a significant increase of faecal bulk and frequency. The bile salt binding properties of purified bran (which consists of lignified tissues) are comparable with those parchment layers in that they are low compared with cell wall material rich in pectic substances (Selvendran.R.R, 1978)

Viscosity effect

Water soluble dietary fibre components such as β-Glucans, pectins and plant gums from colloidal solutions, contributing to high viscosity. Pectins in presence of sugar and acids form gels, while some of the gums like agar yield gels of varying consistancies at relatively low concentrations and room temperature. As they are added to foods as thickeners and stabilizers, their functions extend beyond providing textural modifications, to influence gastric emptying and absorption rates in the small intestine (Leeds, 1979)

Almost all water- soluble polysaccharides produce viscous solutions. Viscosity is caused by physical interactions between the polysaccharide molecules in solution. In simple terms by the molecules becoming entangled. Most polysaccharides exist in solution as conformationally disordered ' random coils', their molecules randomly fluctuating in a shape under the influence of Brownian motion. The viscosity of the polysaccharide solution can be strongly dependent on the rate of shear and concentration of molecules. (Oakenfull, D.G, 1993)

2.2.6.2. Physiological effects

Beneficial effects of dietary fibre have been attributed to its role in modifying some of the physiological activities in the human intestine, which, in turn, influence the metabolic activities in the body. Increasing faecal bulk and improving large bowel function, reducing levels of plasma cholesterol and reducing glycaemic response to a meal are the major beneficial effects attributed to adequate consumption of dietary fibre, while decreasing nutrient availability seems to be the only suspected adverse effect due to inappropriate levels of fiber in the diet. A large volume of data, some of them conflicting are available today on qualitative and quantitative effects of various sources of dietary fibre and it appears some fibre sources are able to elicit more effective response than others. (Southgate et al, 1991)

Nutrient absorption

Though dietary fibres are highly resistant to hydrolysis by mammalian pancreatic enzymes, they are susceptible to physical disintegration during processing, cooking and mastication and dispersal of soluble fibres like β-glucans and pectin in the aqueous phase appear to be causing a delay in the uptake of absorbable nutrients by the epithelial cells that line the mucosa. (Selvendran et al, 1987)

Barrier to digestion

The structure of plant cell walls and their architecture have a decided influence of the accessibility of intestinal enzymes to food nutrients such as starch, proteins & fat, In spite of adequate processing, cooking and mastication, a part of the structure enveloping the nutrients remains intact and slows down the whole process of digestion, further affecting the rate of nutrient assimilation. Fragments of plant cell walls act as a physical barrier between nutrients and digestive enzymes in the intestine. (Potty.V.H, 1996)

Nutrient binding

Iron, Zinc and Calcium are very poorly absorbed in the human system, probably due to formation of insoluble complexes in the intestine lumen. (Prosky and Devries, 1992)

Many polysaccharides and lignin interact with metal ions in the aqueous phase of the intestinal contents and this can result in conversion of soluble minerals into unabsorbable forms to be extracted without being able to get into the circulatory system. (Kay, 1982)

One of the probable reasons for the above findings could be presence of phytic substances in these sources along with polysaccharides and they do possess strong mineral binding capacity.

Mobility of intestinal contents

Under normal circumstances, the gut lumen is well stirred by peristaltic movements of the gut, but in presence of soluble dietary fibres, which increase the viscosity of the intestinal contents, this process is slowed down significantly, thereby reducing the change of nutrients to move towards the villi network for efficient absorption.

Faecal output

Dietary fibre is its ability to increase faecal bulk and frequency of stool in human beings. (Pitch, 1987). Dietary fibres, rich in components that are readily fermented by colon bacteria are not effective in increasing faecal bulk, also increases the dry matter content of faeces. Otherthan, their ability to retain water during transit contributes to soft tools and ease of defaecation.

Faecal transit

High intake of dietary fibre generally causes reduced transit time in the colon and faster bowel emptying; attributed to accelerate colonic motility by increased intraluminal mass. Higher the faecal bulk, lower will be the transit time in the large bowel.

2.2.6.3. Functional properties of dietary fibre in technology

The availability of new dietary fibre sources, for use as food ingredients, has intensified the interest in understanding food functionality, all those parameters that make a food acceptable for processing and to the consumer. Food functionality includes organoleptic, microstructural, mechanical/ physical and chemical properties.

Table 2.7: Parameters related to food functionality

Parameters	Examples
Sensory	Gumminess
	Hardness
Physical	Density
	Viscosity
Microstructural	Porosity
	Crystallinity
Functionality	Water binding
	Emulsification

Source: Stanley (1986)

The factors affecting fibre functionality are composition (e.g. Hexoses, Pentoses, and Uronic acid), cell wall matrix characteristics, functional groups, surface area, cellulose crystalinity, surface characteristics, ionic linkages and degree of branching. Usually the addition of high levels of dietary fibre to foods has an adverse effect on food texture and flavour but when the functionality of fibre is understood or improved the chances of it being successfully incorporated into foods is greatly enhanced.

Wide variety of dietary fibre sources is available to the food industry.the number and availability of dietary fibre sources has been considered as a potential ingredient for fibre enriched foods. (Dreher M.L, 1995)

Table 2.8: General food uses for dietary fibre

Dietary fibre supplement
Bulking (low caloric) agent
Water binding
Fat replacer
Stabilizing
Control of sugar crystallization
Texture modifier
Gelling and viscosity modifier
Thickener
Shelf - life enhancer
Freeze / thaw stabiliser

Source. Benford.D (1996)

2.7. Importance in dietary fibre in health (Nutritional & health Implication)

There has been influence of dietary fibre on health including the list of medical problems prevalent in the western world.

There has been so much of wealth data as we have today regarding the relation ship between dietary fibre consumption and human health & diseases.

There was "fibre deficiency syndrome"(Cleave, 1956)

Progressive industrial development during the past five decades has spawned an entirely new attitude to food, laying heavy emphasis on calories, proteins and micronutrients, ignoring that the potential health role in the non-digestive portion of food materials may play in regular life cycle. The major observations that predominantly occurrence of diseases like appendicitis, Colonic cancer, Constipation, Diverticulosis, Hyperlipidemia, irritable bowel syndrome, maturity on set diabetes, obesity and influence of dietary fibre on some of these major health disorders can be quite significant.

Table 2.9: Dietary fibre intake (g/day) and fibre densities (g/10MJ) of the adult Victorian population 1985 and 1990.

	Males		Females	
	1985	1990	1985	1990
		Daily intake fibre g/day		
Total sample	22.8	26.3	23.7	26.3
Age group				
18-29 yrs	24.1	26.9	23.5	24.4
30-39 yrs	23.9	26.1	23.7	26.8
40-49 yrs	21.5	25.7	23.2	27.0
50-59 yrs	22.1	25.1	24.4	27.6
60+yrs	21.5	27.1	23.7	27.3
Occupational category				
Upper	24.4	28.1	25.5	26.5
Upper-middle	23.2	25.9	24.2	28.1
Middle	22.9	26.1	23.0	26.5
Lower-middle	22.5	25.6	23.6	26.9
Lower	22.4	25.7	22.0	24.5
Location				
Metropolitan	22.8	26.3	23.5	26.2
Township	22.4	25.3	23.9	27.8
Rural	23.4	26.9	24.0	26.6
		Fibre density g/10MJ		
Total sample	25.1	27.3	31.9	33.5
Age group				
18-29 yrs	22.8	24.3	30.3	29.8
30-39 yrs	25.3	25.8	31.7	32.9
40-49 yrs	24.6	27.5	30.1	34.6
50-59 yrs	26.2	28.4	33.9	36.4
60+ yrs	27.3	32.1	34.6	36.6
Occupational category				
Upper	27.6	29.9	33.9	33.8
Upper-middle	25.7	27.4	31.4	35.4
Middle	23.8	26.7	30.3	33.9
Lower-middle	24.0	26.4	31.3	33.4
Lower	21.9	25.6	28.8	30.6
Location				
Metropolitan	25.6	28.1	31.7	33.6
Township	23.9	26.6	31.8	35.1
Rural	23.8	26.2	32.1	33.5

Source: Baghurst, K.I.et al (1993)

2.2.8 Consumption patterns of dietary fibre.

Dietary fibre intake depends on due to various factors as, Age group, Occupation, and location like factors.

It is vary to the western and eastern world also Table shows the dietary fibre intake of an adult of an Australian population in 1985 and 1990.

In Sri Lanka also dietary fibre consumption is vary among the rural and urban population according to the study of the Kurunagala District mean dietary fibre consumption of urban & rural adults subjected to this study were 12.7 grams per day, respectively. This amount is far below the required allowance of 20-35 grams per day.

The sources of D.F of food materials to the urban and rural populations were different. In urban sector, pattern was as follows, vegetable, rice, pulses, green leafy vegetables, bread and tubers & fruits. In rural sector it was as, rice, vegetables, green leafy vegetables, pulses, roots, tubers and fruits.

Rice was the staple food in Sri Lanka. The contribution of D.F from rice was 14.7% in urban population and 21.8% in rural population. (Somathilaka, L.H.M.T, 2000)

Also there it has been changed to the western world.

Dietary fibre contribution of food in Australia is shown in the Table 2.10.

According to the studies in the application of some methods to mixed diets in united kingdom and the United States shows that the average individual intake of dietary fibre is about 20g /day. (Southgate, D.A.T, 1978)

Table 2.10: Top ten individual foods contributing to the soluble and insoluble NSP.

Non-starch polysaccharide component	Food sources	% Contribution
Total NSP	Whole meal bread	13.5
	White bread	7.6
	Breakfast cereals	7.0
	Peas	4.8
	Apples	4.6
	Carrots	2.9
	Brown bread	2.8
	Tomato	2.6
	Roast/baked potato	2.4
	Green beans	2.2
Soluble NSP	White bread	11.2
	Whole meal bread	7.4
	Breakfast cereals	5.1
	Carrots	3.8
	Apples	3.8
	Roast/baked potato	3.4
	Peas	3.2
	Hot chips/French fries	2.9
	Oranges/mandarins	2.8
	Tomato	2.3
Insoluble NSP	Whole meal bread	18.1
	Breakfast cereals	8.5
	Peas	6.1
	Apples	5.2
	White bread	4.9
	Brown bread	3.4
	Tomato	2.7
	Green beans	2.3
	Carrots	2.2
	Crisp breads	2.1

Source: Baghurst, K.I.et al (1993)

2.2.9 Effect of processing on dietary fibre

Dietary fibre content may be modified during processing by the conditions that are applied, and in some cases the content can be increased by the development of such materials as resistant starch. In other cases content is reduced by being transformed into soluble form or into insoluble forms that are more readily absorbed by the body.

Examples of how the amount of dietary fibre in food can be changed, depending on the processing method to which it is subjected, are the effects of microwaving and autoclaving.

Microwave heating or oat bran (5 to 10 minutes) causes the fibre content to drop from 13% to approximately 9% autoclaving (30 minutes) causes a drop to about 10%.

Apple fibre gave a 2 to 3 percent drop by both cooking methods, whereas Soya fibre treated by either method appeared to increase insoluble fibre, whilst corn fibre remained unchanged.

Soluble fibre in apple appeared to increase slightly with both methods, whilst oat and Soya soluble fibre remained unchanged. Corn's low level of soluble fibre decreased further on both types of heat treatment. (Blenford D, 1991)

During milling, polishing, flaking, grinding, puffing and other primary processing operations, the dietary fibre in food is not affected to any significant extent chemically, but reduction of partical size does influence the behavior in the gastro – intestinal tract. Bringing down the particle size from 800 to 160 microns reduced the water holding capacity of wheat bran by 43% and the glycocholate binding capacity by 19% (Mongeau 1993). Auffret et al (1994) observed that in wheat bran, sugar beet and citrus fibres swelling capacity was reduced, whereas pea hull fibre tended to increase the same, as the particle size went down during grinding. The mode of processing often involving application of heat and pressure as in extrusion, frying, baking, toasting, explosion puffing, drying, confectionery making etc. Can cause complex physical and chemical transformation, though it may not be of a magnitude to affect the calorific value of the food to any great extent. However, such changes can affect textural and solubility characteristics, besides changing response to digestive enzymes in the gut (Anderson and Clydesdale, 1980; Stevens and Selvendran, 1980; Margareta and Asp, 1994). Formation of Millard reaction products, caramelized products and resistant starch of some of the examples of artifacts arising out of processing, which invariably end up as a part of TDF fraction (Englyst et al., 1983). Bjorck et al (1986) reported 0.6-0.9% of starch getting retrograded on baking. Englyst et al. (1987) found up to 3% resistant starch in corn flakes and according to them this could increase to as high as 20% in starchy foods, depending on water content, pH, temperature, time of cooking, heating/cooking cycle, freezing, drying and other operations. In a material like coffee, roasting conditions caused a sharp increase in Kalson lignin, but overall TDF did not change much (Valiente et al., 1994). Under baking conditions, bran in high fibre bread formulations showed curling and twisting tendency, which, in turn, made it more susceptible to degradation in the gut (Inglett and Ingemar- Falkehag, 1979). Most of the Millard reaction products formed under high temperature processing conditions are not degraded by colonic bacteria and their effect in the human system is not well under stood (Van Soest et al., 1983)

The dietary fibre problem in the future also the effects of treatment of the food, for instance the effect of grinding (particle size), drying, thermal and chemical treatments.

On the fibre properties. One may as an example drew a parallel with the upgrading of the feeding values of straw for ruminants, by more than 50% compared with untreated straw by rather mild alkaline treatment or brief thermal treatment at higher temperature. (Theander, 1977)

CHAPTER 3

3.1. Materials & Methodology

3.1.1. Materials

These reagents and solutions were used.

Tris Aminomethane (Sigma Chemical Company, Germany)
Maleic anhydride / Maleic acid (BDH Limited, Poole, England)
Sodium Hydroxide (NaOH) (Fisher Scientific, UK)
Acetic acid (Merck, Bombay, India)
Sodium Acetate ($C_2H_3O_2Na .3 H_2O$) (BDH Laboratory Supplies, England)
Termamyl solution - (Amylase from *Bacillus Subtilis* (Novo Industries, Denmark)
Ethanol (Ethyl alcohol) 80% (Fisher Scientific UK Limited)
D.M.S.O. (Dimethyl Sulfoxide) (BDH Laboratory Supplies, Poole, England)
Amyloglucosidase solution from *Aspergillus nigar* (Fluka Chemie AG, Switzerland)
Petroleum ether (Fisher Scientific UK Limited)
Ice
Distilled water

Ingredients were taken from the local market.

Rice (Red rice), Wheat flour, Semolina, Black gram, Yeast, Mung bean

Samples of two types of bread were taken from the Government Food Department's bakery.

100% Wheat flour
15% Kurakkan + 85 % Wheat flour

Following apparatus were used.

Boiling water bath (Buchi water bath B-480)

Centrifuger (Sorvall RC-5B Refrigerated Superspeed Centrifuge)

Feeze dryer (Alpha 1-5)

Volexer (VELP scientifica)

Fritsch mill

Snack master dehydrator (American Harvest)

Analytical balance (AB 204 – S, Mettler Toledo)

Pipette (10 ml / 20 ml)

Drying Oven (Memmert)

PH meter (Metrohm, 744)

Centrifuge tubes

Soxlet extraction apparatus

Watch glasses (for drying samples)

Beakers & Flasks

Measuring cylinders (100 ml)

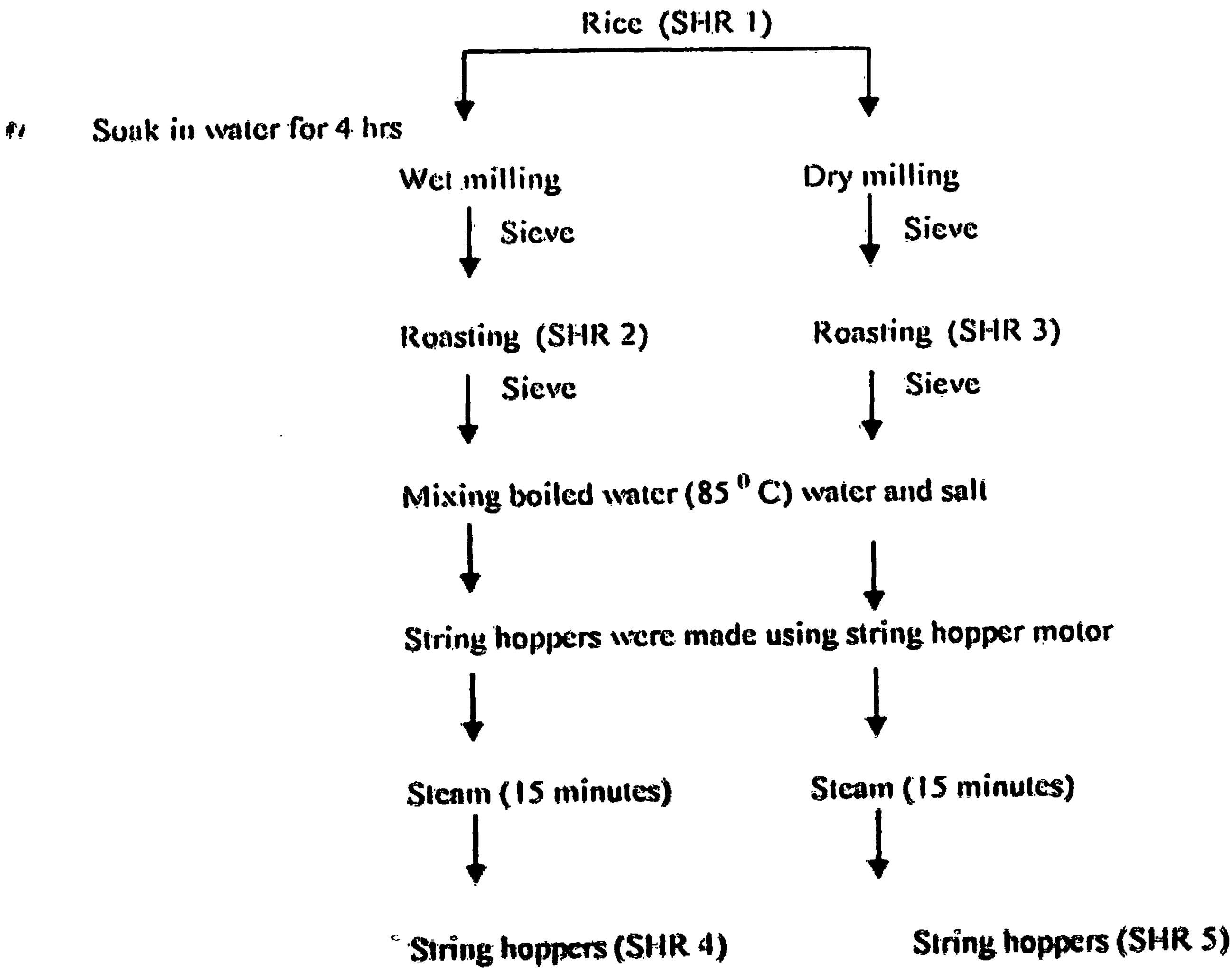
3.1.2 Methods

3.1.2.1 Sample preparation

(a) String hoppers-Rice flour

Rice was thoroughly washed & removed sands & stones.

Figure 3.1: Preparation of string hoppers-Rice flour based



SHR 1, SHR 2, SHR 3, SHR4, SHR 5 samples were taken at each stages.SHR 4, SHR5 samples were dried using the snack master dehydrator (at 35 ^{0} C)
The dried samples were milled by using the Fritsch mill (Sieve size 0.50 mm)

(b) String hoppers-Wheat flour

Figure 3.2: Preparation of string hoppers-Wheat flour based

Wheat flour (SHW1)

↓

Sieve (0.5 mm sieved size)

↓

Steam (1hr)

↓

Sieve (0.5 mm sieved size) (SHW 2)

↓

Mix water (85 ^{0}C) and salt

↓

String hoppers were made using string hopper motor

↓

Steam (15 minutes)

↓

String hoppers (SHW 3)

SHW 1, SHW 2, SHW 3 samples were taken at each stage.

The sample SHW 3 was dried using the Snack Master dehydrator (35 ^{0} C) for 12 hrs.

Dried samples were milled by using the Fritsch mill. (0.5 mm sieve size) *(c) Idly*

Black gram was thoroughly washed and removed stones & sands.

Figure 3.3: Preparation of Idly

Black gram (250 g) (ID 1) → Soak (2hrs) & remove the hull → Blend with 10 ml of water (ID 4)

Semolina (500 g) (ID 2) → steam (15 minutes)(ID 3)

↓

Mix and add 5 ml of water & yeast

↓

Fermentation (ID 5)

↓

Salt add

↓

Steam

↓

Idly (ID 6)

ID 1,ID 2,ID 3,ID 4, ID 5,ID 6 samples were taken each stage.
ID 5 sample was dried by using the Snack Master Dehydrator (35 ^{0} C)
ID 4 sample was taken and add liquid Nitrogen and freeze dried using the Alpha 1 - 5 freeze drier until it was taken the constant weight.
ID 1, ID 2, ID 3, ID 4,ID 5, ID 6 samples were milled by using the Fritsch mill (0.50 mm sieve size)

(d) Bread

100% Wheat flour bread (BR 1)
15% Kurakkan + 85% wheat flour bread (BR 2)
Two types of bread samples were dried by using the Snack Master dehydrator.
Then two samples were milled by using the Fritsch mill. (Sieve size 0.50 mm)
Milled bread samples were de-fatted with petroleum ether to remove the fat by using the Soxlet extraction apparatus.

3.1.2.2 Determination of the dietary fiber content (Total, Soluble Insoluble)

(Faulks R.M & Timms.S.B, 1985)

(a) Preparation of Buffer solutions

Tris aminomethane – maleate buffer - pH 6.7

- 0.2 M solution of Tris acid maleate

2.42 g of Tris aminomethane and 2.3 g of Maleic acid or 1.96 g of Maleic anhydride was dissolved in 100.00 ml of distilled water.

- 0.2 M NaOH solution

0.4 g of NaOH was dissolved in 50.00 ml of Distilled water.

25.00 ml of Tris acid maleate and 21.625 ml of NaOH solution was diluted to 100.00 ml (Volumetric flask) with distilled water and adjusted to the pH 6.7.

Acetate buffer- pH 4.6

- 0.2 M solution of Acetic acid

2.75 ml of Acetic acid is diluted upto 250.00 ml by adding distilled water.

- 0.2 M solution of Sodium acetate

6.80 g of $C_2H_3O_2Na \cdot 3\ H_2O$ in 250.00ml of distilled water.

51.00 ml solution of Acetic acid and 49.00 ml solution of Sodium acetate, were mixed and diluted to 200.00 ml (Volumetric flask) with distilled water, adjusted to the pH to 4.6

(b) *Preparation of Enzyme Solutions*

Termamyl solution

1:24 dilution was done with distilled water.

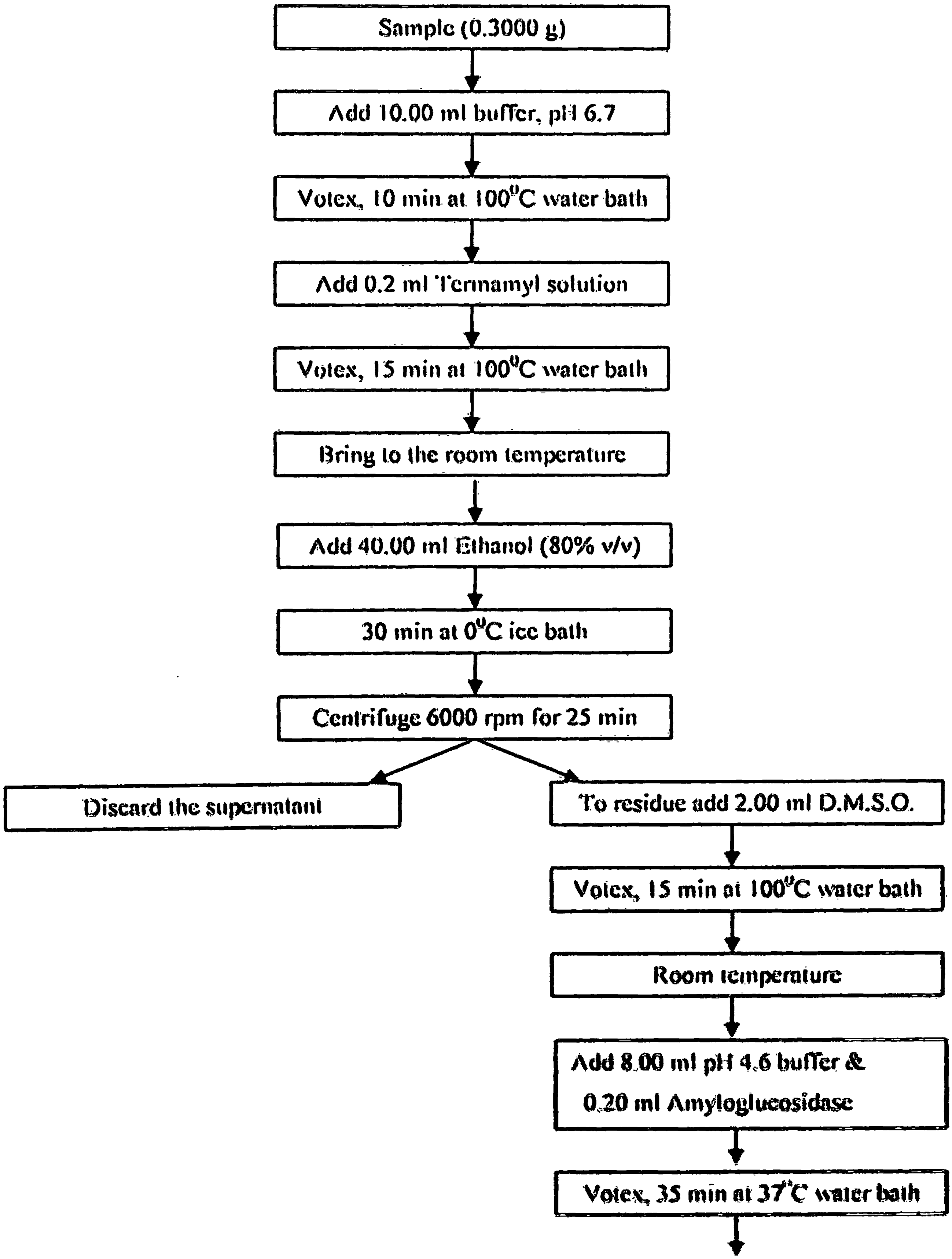
Amyloglucosidase suspension

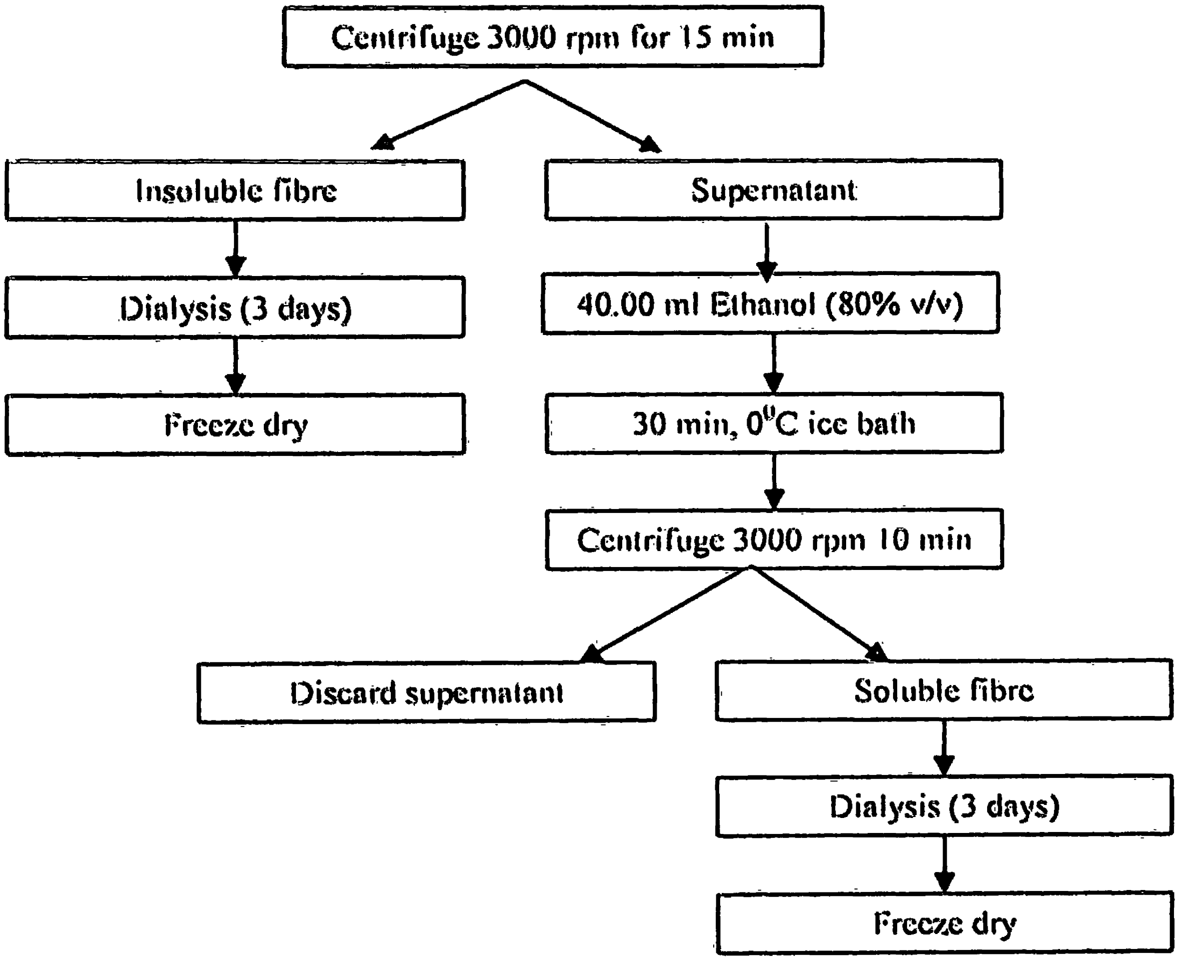
0.025 g of Amyloglucosidase was diluted to 25.00 ml using distilled water.

Estimation of Dietary fibre

- 300 mg of sample was put into a screw cap tube and 10.00 ml of Tri-meleate buffer was added to it.
- Then it was mixed for 10 min at 100^{0}C and 0.20 ml of Termamyl solution was added and mixed for 15 min at 100^{0}C.
- 40.0 ml of 80% ethanol was added and left for 30 min at 0^{0}C.
- Then the supernatant was discarded after centrifugation the sample at 6000 rpm for 20 min.
- 2.00ml of DMSO was added to the pellet and mixed for 5 min at 100^{0}C.
- After cooling, 1.00 ml of Acetate buffer (pH 4.6) and 0.20 ml of Amyloglucosidase solutions were added, and mixed at 37^{0}C for 15 min.
- Then, the insoluble fraction was separated after centrifugation at 2000 rpm for 15 min.
- 40.0 ml of 80 % ethanol was added to the supernatant and left for 30 min at 0^{0}C.
- After centrifugation, then the supernatant was discarded and soluble fraction was separated out.
- Then the insoluble fraction was dialysed for 24 hrs and both soluble and insoluble fractions were freeze dried or oven dried at 60^{0}C.

Figure 3.1: Scheme for estimation of dietary fiber




Centrifuge 3000 rpm for 15 min
Insoluble fibre
Supernatant
Dialysis (3 days)
40.00 ml Ethanol (80% v/v)
Freeze dry
30 min, 0°C ice bath
Centrifuge 3000 rpm 10 min
Discard supernatant
Soluble fibre
Dialysis (3 days)
Freeze dry

CHAPTER 4

4.1. Results & Discussion

The results of the effect of processing of breakfast preparations on the dietary fibre content of foods are presented. Different processing techniques were used in the preparations ranging from milling, steaming, baking, roasting and fermentation. Descriptions of the preparation methods are presented under Materials and Methods.

The dietary fibre content of rice flour is presented in Table 4.1.The soluble dietary fibre is only 12.3% of the total fibre. When rice flour was wet milled and roasted (the traditional method of preparation of rice flour) an increase in the total fibre was observed, contributed both by an increase in the insoluble dietary fibre and soluble dietary fibre.

Rice flour contains approximately 80% starch. The processing technique can alter the starch thereby forming resistant starch. This could be precipitated at dietary fibre in the analysis.

Table 4.1: Effect of wet milling, dry milling/roasting/steaming of rice flour on the dietary fibre content of string hoppers.

SAMPLES	Insoluble Dietary Fibre (%)	Soluble Dietary Fibre (%)	Total Dietary Fibre (%)
Rice flour	7.64	1.08	8.72
Rice flour(wet-milled/ roasted)	8.09	1.63	9.72
Rice flour (dry-milled/roasted)	7.75	1.03	8.79
String hoppers (wet- milled)	8.76	1.33	10.09
String hoppers (dry-milled)	8.47	1.48	9.95

(All analysis are mean of samples)

Table 4.3 represents the changes in the dietary fibre content of Idly, while processing (steaming, wet milling, on fermentation & steaming). When the semolina is steamed, an increase in the soluble fibre from 6.51% to 7.31% is observed. Semolina is the main ingredient in the preparation of Idly. Semolina used along with black gram in the ratio of 2:1.

The black grams undergo a decrease in the total dietary fibre content, resulting from the removal of seed hull after soaking. It is reported that the hull contains higher amount of dietary fibre, contributed largely from lignin.

Table 4.4 Dietary fibre content of bread preparations

SAMPLES	Insoluble Dietary Fibre (%)	Soluble Dietary Fibre (%)	Total Dietary Fibre (%)
Bread (100% wheat)	1.73	0.10	1.83
Bread (85%wheat: 15% Kurakkan)	2.85	0.33	3.18

(All annlysis are mean of samples)

According to the Table 4.4, bread containing 15% Kurakkan contained a higher total dietary fibre and insoluble and soluble fractions. This is because of Kurakkan contains a high dietary fibre content (18.4%).

Table 4.5: Dietary fibre contents of breakfast preparations

SAMPLES	Insoluble Dietary Fibre (%)	Soluble Dietary Fibre (%)	Total Dietary Fibre (%)
Wet milled rice flour string hoppers	8.76	1.33	10.09
Dry milled rice flour string hoppers	8.47	1.48	9.95
Wheat flour string hoppers	1.66	0.15	1.81
Idly	3.88	0.37	4.25
Bread (100% wheat flour)	1.73	0.10	1.83
Bread (15% Kurakkan + 85% wheat flour)	2.85	0.33	3.18

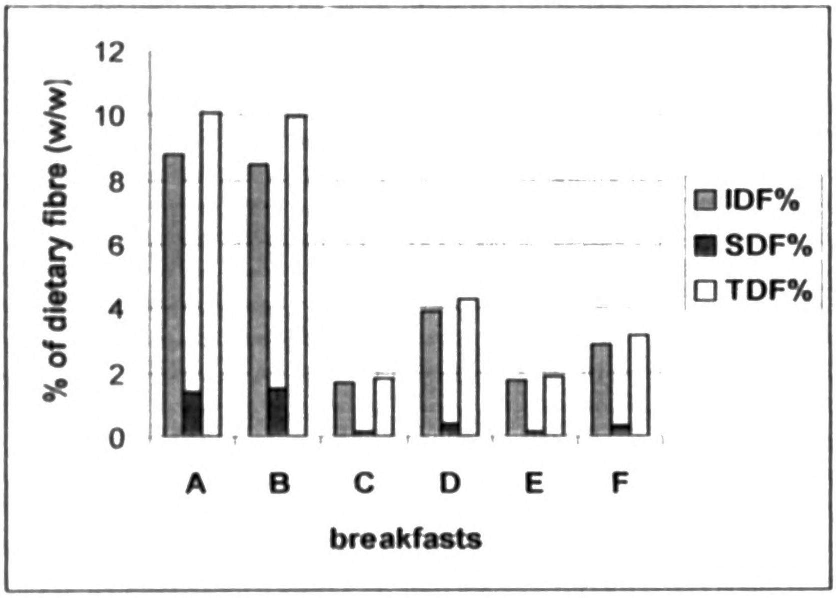
The results obtained from the study are summarized in Table 4.5. It represents the dietary fibre content of traditionally prepared string hoppers, made of rice and wheat flour and Idly. It is compared with the commercially available as bread (100%) and bread containing 15 % Kurakkan.

Less amount of contribution of DF is from the wheat flour based products as shown in string hoppers (1.81%) and bread (1.83%). It is known that the wheat flour sold in Sri Lanka is 72% extraction of grain. Hence it appears that this wheat flour contain lower dietary fibre. On the other hand, rice flour preparations are made of whole grain.

Idly contributes moderately to the dietary fibre (4.25%) in breakfast preparations, the sources of dietary fibre are from semolina and black gram.

Although it is expected that Kurakkan added bread contains a high fibre content, this study shows that its contribution is less than (3.18%) than the rice flour based breakfast preparations. (Wet milled - 10.09%, and dry milled - 9.95%). However, Kurakkan adds variety to the food preparation.

Figure 4.1 Dietary fibre content of breakfast preparations (as determined by Faulks and Timms Method)



(A) Wet milled rice flour string hoppers

(B) Dry milled rice flour string hoppers

(C) Wheat flour string hoppers

(D) Idly

(E) Bread (100% wheat flour)

(F) Bread (15% Kurakkan + 85% wheat flour)

Table 4.6: Contribution of dietary fibre from breakfast preparations to the daily intake of an adult

Sample	TDF(%)	Amount of intake (g)	Contribution of D.F to daily intake (g)	Contribution of DF to daily intake (%)
Wet milled rice based string hoppers	10.09	180	18.16	56.7
Dry milled rice based string hoppers	9.95	180	17.91	55.9
Wheat flour based string hoppers	1.81	180	3.25	10.1
Idly	4.25	200	8.5	26.5
Bread (100% wheat flour)	1.83	200	3.36	10.5
Bread (15% Kurakkan)	3.18	200	6.36	19.8

Contribution of dietary fibre from breakfast preparation to the daily diet of an adult is presented in Table 4.6. Rice based string hoppers, both wet milled and dry milled, contributes 56 % of dietary fibre to the daily intake. The contribution from wheat flour based products to the daily intake of fibre is approximately 10%. Addition of 15% Kurakkan instead of the wheat flour, reasoned for the increase by 9.38% of the dietary fibre to the daily intake.

The formations of resistant starch in food preparation have been reported in previous studies. Today resistant starch is also considered a dietary fibre and has the known physiological effect of fermentation in human gut.

CHAPTER 5

5.1 Conclusions

The following conclusions can be made from this study,

- In breakfast preparations, steaming and roasting procedures can increase the dietary fibre content of the final product that can be attributed to the formation of resistant starch.

- The contribution of dietary fibre from commercially available bread is less than the traditional prepared breakfasts. (Idly, String hoppers).

- A rice-based breakfast preparation (180 g) contributes up to approximately 56% of dietary fibre requirement of the adult.

CHAPTER 6

6.1. Recommendations

Future studies are recommended to carry out,

- To study the physiological effects (Hypochlosterolemic and Hypoglycaemic effect) on dietary fibre fractions of breakfast cereals.

- To optimize wet milling process effect to the dietary fibre of breakfast preparations.

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