

## Forty Second Annual Sessions and Seventy Second Anniversary Celebrations 2013

### Chief Guest's Address

### The Role of Chemistry on Plantation Crops

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Chemistry is a branch of physical science, is the study of the composition, properties and behavior of matter. As it is a fundamental component of matter, the atom is the basic unit of chemistry. Chemistry is concerned with atoms and their interactions with other atoms, with particular focus on the properties of the chemical bonds formed between species. Chemistry is also concerned with the interactions between atoms or molecules and various forms of energy (e.g. photochemical reactions, oxidation-reduction reactions, changes in phases of matter, separation of mixtures, properties of polymers, etc.).

Chemistry is sometimes called "the central science" because it bridges other natural sciences like physics, geology and biology with each other. Chemistry is a branch of physical science but distinct from physics.

The importance of chemistry is that it is the study of you and the world around you. How do they work? Everyone can and should understand basic chemistry, but it may be important to take a course in chemistry or

even make a career out of it. Chemistry is important because there are endless possibilities; you can create a new medicine; you can create a cure for the diseases.

#### Plantation crops at a glance

Let us know something about Plantation crops before going into the subject proper. The plantation crops are high value commercial crops of greater economic importance and play a vital role in the global economy and more particular to the economy of India and Sri Lanka. The crops include tea, coffee, rubber, cocoa, coconut, arecanut, oil palm, cashew nut and spices. The main drawback within this sector of crops in whole of Asia-Pacific Region is that majority of the area is of small and marginal holding with resource poor farmers and hence with varying level of soil fertility gradient which hinders the adoption of intensive cultivation. While coffee, tea and rubber are under organized sector, the other crops like coconut, areca nut, oil palm, cocoa and cashew nut are not organized properly.

Table 1: Area, Production and Productivity of Plantation crops in India, Sri Lanka and World (2011).

| Crops         | Area (ha) |           |          | Production (tons) |           |           | Productivity (kg/ha) |           |         |
|---------------|-----------|-----------|----------|-------------------|-----------|-----------|----------------------|-----------|---------|
|               | India     | Sri Lanka | World    | India             | Sri Lanka | World     | India                | Sri Lanka | World   |
| Cashew Nuts   | 953200    | 23090     | 4707983  | 674600            | 6890      | 4201010   | 707.7                | 298.4     | 893.5   |
| Areca nut     | 400100    | 15640     | 873060   | 478000            | 31600     | 1082549   | 1194.7               | 2020.5    | 1239.9  |
| Cocoa beans   | 56500     | 2550      | 10003270 | 14400             | 1630      | 4395657   | 254.9                | 639.2     | 439.4   |
| Coconuts      | 1960000   | 394840    | 11437523 | 11200000          | 1522560   | 59189887  | 5714.3               | 3856.1    | 5175.1  |
| Coffee, green | 360485    | 8690      | 10476355 | 302000            | 5320      | 8284135   | 837.8                | 612.2     | 790.7   |
| Ginger        | 149100    | 2400      | 313989   | 702000            | 13660     | 2029680   | 4708.2               | 5691.7    | 6464.2  |
| Tea           | 580000    | 221969    | 3256762  | 966733            | 327500    | 4668968   | 1666.8               | 1475.4    | 1433.6  |
| Oil Palm      | 203000    | n.a.      | 16265248 |                   |           | 233810539 |                      |           | 14374.9 |

The vast area and the varied agro-climatic conditions ranging from tropical to temperate make it possible to grow almost all different kinds of plantation crops in both the countries. Plantation crops

play an important role in our countries' economy by earning valuable foreign exchange, providing direct and indirect employment to many people and also by supporting a number of horticultural based industries.

Table 2: Area and production of important spices in the world. Source FAO database (2007).

| Spice(s)                         | Area (thousand ha) | Production (thousand t) |
|----------------------------------|--------------------|-------------------------|
| Anise, badian, fennel, coriander | 661.16             | 467.86                  |
| Chillies and pepper (dry)        | 2,004.81           | 2,662.73                |
| Chillies ad peppers (green)      | 1,725.54           | 24,803.01               |
| Cinnamon (canella)               | 176.98             | 134.8                   |
| Cloves                           | 466.08             | 145.18                  |
| Ginger                           | 338.9              | 1,119.74                |
| Nutmeg, mace and cardamom        | 222.89             | 74.02                   |
| Pepper ( <i>Piper sp.</i> )      | 473.55             | 407.41                  |
| Vanilla                          | 76.44              | 10.36                   |
| Other spices                     | 1,440.67           | 2,034.58                |
| Total                            | 7,587.02           | 31,859.69               |

The fact remains that though the area and production under different plantation crops had increased over years the productivity increase is not encouraging in spite of the fact that many high yielding varieties and hybrids as well as production technologies have been developed through research efforts. The spread of high yielding varieties hybrids have yet to make an impact. The input management such as optimum manures and fertilizers applications, irrigation, weed management etc are inadequate. So the yield gap between the potential and achievable yield is very wide.

**Export of plantation crops:** These crops are highly export oriented earning considerable foreign exchange to countries and help to increase GDP.

**Coconut:** The tree of life, tree of heaven, Nature's super market and Tree of abundance has unlimited scope for export through, many value added products like coconut water, coconut milk, milk powder, desiccated coconut, virgin coconut oil, activated carbon, bio fuel/ bio lubricants coir and coir products. Philippines and Indonesia are the highest export earners. India and Sri Lanka still need to go a long way on value addition except coir products.

**Rubber:** World production of natural rubber was 4.4 million tonnes in 1985, in which the share of Asia was as much as 91% at 4.0 million tonnes. The Asian production is mostly smallholder based, but relatively large, State-owned plantations dominate in China, Vietnam and Cambodia. Asia continues to be the largest supplier NR to the world. The world NR

production rose to 10.29 million tons in 2010 and the Asian share increased to 93% of this at 9.58 million tons.

**Coffee:** Coffee is the world's most widely traded tropical agricultural commodity, accounting for exports worth an estimated US\$ 15.4 billion in 2009/10, when some 93.4 million bags were shipped.

Some 70 countries produce coffee, of which the Exporting Members of the International Coffee Organization are responsible for over 97% of world output. In 2010 total coffee sector employment was estimated at about 26 million people in 52 producing countries.

For many countries, coffee exports are not only a vital contributor to foreign exchange earnings but also account for a significant proportion of tax income and gross domestic product. For seven countries the average share of coffee exports in total export earnings exceeded 10% in the period 2000–2010, although the importance of coffee for many countries is diminishing over time as their economies diversify. This can be demonstrated by the fact that during the period 1996 to 2000, there were 15 countries which fell into this category, i.e. the average share of coffee exports in their total export earnings exceeded 10%.

Consumption has increased on average by around 1.2% annually since the early 1980s, rising to more than 2% in recent years. Probably the most spectacular growth of a major market occurred in Japan, where it initially averaged some 3.5% a year until appearing to have reached a plateau over the last ten years. Japan is now the third largest importer of coffee in the world.

Over the last five years market growth in Europe

has been weak, with consumption showing signs of stagnation and possibly even decline. The situation is only slightly better in the United States, where overall consumption, despite the boom in the specialty sector, has grown at a low rate.

The figures for consumption in some producing countries and in non-member countries point to a surprisingly large upsurge since the turn of the century, growing on average by over 6% per annum, although the economic turmoil of recent years has been a brake on growth.

**Tea:** Sri Lanka is the largest exporter of tea followed by Kenya, China and India in descending order. The domestic and export demand continued to increase.

Table 3: Top tea exporting countries in the world.

| Country              | Exports in US \$' 000 (2008) |
|----------------------|------------------------------|
| Sri Lanka            | 1,258,700                    |
| Kenya                | 934,921                      |
| China                | 713,011                      |
| India                | 590,226,                     |
| United Kingdom       | 324,694                      |
| Germany              | 207,227                      |
| Indonesia            | 158,959                      |
| Viet Nam             | 147,300                      |
| Rwanda               | 125,454                      |
| United Arab Emirates | 11,480                       |

**Cocoa:** Cocoa as a mixed crop in coconut, arecanut and oil palm in India. Switzerland, Liechtenstein, Luxemburg, UK and Belgium are in the order of one to five consumer countries in terms of chocolate confectionery consumer countries.

**Oil Palm:** As of today, Indonesia was the largest producer of palm oil, surpassing Malaysia in 2006, producing more than 24.1 million tones as on 2011 and that of Malaysia is 18.912 million tons. Indonesia aspires to become the world's top producer of palm oil. But at the end of 2010, 60% of the output was exported still in the form of Crude Palm Oil. FAO data show production increase from 16.92 million tons in 1998 to 50.518 million tons in 2011.

**Cashew:** Posting an export turnover of \$1.14 billion in 2010 from shipping abroad 196,000 tons of cashew nuts, Vietnam has been the world's leading cashew exporters for the fourth consecutive year. India, Nigeria and Cote d'Ivoire occupy second, third and fourth positions respectively. Naturally these

countries should be the top in export.

**Spices:** Today, Guatemala is the biggest producer and exporter of cardamom in the world, followed by India. Some other countries such as Sri Lanka have also begun to cultivate it. *Elettaria* pods are light green while *Amomum* pods are larger and dark brown.

It is the world's third most expensive spice by weight, outstripped in market value only by saffron and vanilla.

The Middle East, South Asia, South East Asia and Europe are the main markets for cardamom consumption. From 2006 to 2008, global demand for cardamom rose steadily from 31,448 MTs to 37,712 Mts.

Chemical Composition of crops is highly variable

1. Plants don't have a single fixed composition but vary greatly in composition depending on variety, place of planting, and year of cultivation
2. Commercial GM crops have the same composition as other varieties of the same crop
3. It is particularly important to understand that crop foods are biological materials and as such, they display biological variability.
4. Any discussion of changes in composition must take into account that crops exhibit a range of content for each constituent—no GM crop has ever been approved that has a biologically significant difference in any component.
5. Smith's discussion of "lower" isoflavone content of GM soybeans is a perfect example of a biased and flawed analysis.

Therefore, understanding the Chemistry of these crops is very important for increasing the production productivity as well as developing value added products and utilization of by products.

### Chemistry of Plantation Crops Chemistry of Coconut

Coconut water (coconut liquid endosperm), with its many applications, is one of the world's most versatile natural product. This refreshing beverage is consumed worldwide as it is nutritious and beneficial for health. There is increasing scientific evidence that supports the role of coconut water in health and medicinal applications. Coconut water is traditionally used as a growth supplement in plant tissue culture/micro propagation. The wide applications of coconut water can be justified by its unique chemical

composition of sugars, vitamins, minerals, amino acids and phytohormones.

Coconut water consists of 95 % water, holding in solution proteins, sugars, and salts. It is used as a diuretic. Fermenting the coconut milk for 36 hours, heating slowly and filtering produces clear oil that retains the scent of coconut.

Approximately 50% of the fatty acids in coconut fat are lauric acid. Lauric acid is a medium chain fatty acid. Lauric acid is known to the pharmaceutical industry for its good antimicrobial properties, and the monoglyceride derivative of lauric acid, monolaurin, is known to have even more potent antimicrobial properties, against lipid-coated RNA and DNA viruses, numerous pathogenic gram-positive bacteria, and various pathogenic protozoa.

The coconut milk, which is the product of the expressed juice of the grated endosperm (white meaty stuff), was popular during World War II and was used as a substitute for cow's milk. Research had shown that lauric acid is present, which is also present in human mother's milk. The milk is reported to be refrigerant, nutrient, aperient, diuretic, laxative, and anthelmintic.

It is also believed that coconut water could be used as an important alternative for oral rehydration and even so for intravenous hydration of patients in remote regions. Coconut water may also offer protection against myocardial infarction. Some of the most significant and useful components in coconut water are cytokinins, which are a Class of phytohormones.

Furthermore, micronutrients (nutrients needed in small quantities) such as inorganic ions and vitamins in coconut water play a vital role in aiding the human body antioxidant system. Hyper metabolism gives rise to an increased production of reactive oxygen species (or free radicals), as a result of increased oxidative metabolism.

#### Chemistry of Arecanut

The medicinal components are primarily associated with the nut and betel quid. The nuts contain at least 9 structurally related pyridine alkaloids including arecoline, arecaidine, arecaine, arecolidine, guvacine, isoguvacine, guvacoline, and coniine. However, the most common is the parasympathetic stimulant alkaloid arecoline. The total alkaloid content can reach 0.45%. The methyl esters of arecoline and guvacoline are hydrolyzed in the presence of alkali to the respective acids, arecaidine and guvacine. The hydrolysis is catalyzed by lime, which is added to the quid. Arecoline most likely is present in the nut as a salt

of tannic acid, and the lime facilitates the release of the base from the salt. Ten Components of the betel quid, most likely from *Piper betel* and not betel nuts, contain about 1% of a volatile oil, chabitol, chavicol, cadinene, allylpyrocatechol, and safrole.

Nearly all of the scientific data involve animal or *in vitro* studies. Arecoline is a parasympathetic stimulant and acts on muscarinic and nicotinic receptors. Glaucoma – The alkaloids of betel nut cause pupil dilation, vomiting, diarrhea, and in high doses, convulsions and death. These alkaloids have a cholinergic action, and it is believed that the central stimulating activity of arecoline is greater than that of pilocarpine. Consequently, extracts of the nut have been used for the management of glaucoma in traditional medicine. Betel nuts contain tannin (e.g., Areca II-5-C) with angiotensin- converting enzyme (ACE) inhibitor activity *in vitro*. The activity of this tannin was comparable with that of captopril. Spontaneously hypertensive rats received oral doses of 100 to 200 mg/kg of the tannin extracts and the antihypertensive effects were similar to 30 to 100 mg/kg of captopril. The IV dose of the tannin was equivalent to 5 times the effect of an equivalent amount of captopril. Research reveals that no clinical data are available regarding the use of betel nuts for hypertension.

Antibacterial activity is associated with the extracts of betel nuts. An ethanol extract inhibited *Staphylococcus aureus*, *Salmonella* sp., *Neisseria* sp., *Yersinia enterocolitica*, and *Listeria monocytogenes*. Research reveals no animal or clinical data regarding the use of betel nuts as an antibacterial.

Arecoline is a basic oily liquid that has been used in veterinary medicine as a cathartic for horses and a vermifuge. Betel nut chewing induces a number of physiologic changes, including an increase in salivation, gradual resorption of oral calcium induced by the lime, gingivitis, periodontitis, and chronic osteomyelitis. Arecoline is thought to be responsible for some of the claimed effects of betel quid chewing, such as alertness, increased stamina, a sense of well-being, euphoria, and salivation. An antidepressant effect of the betel nut may be associated with the hexane and aqueous extracts. The extracts inhibit monoamine oxidase type A isolated from the rat brain. The muscarinic cholinomimetic action of the alkaloids may also relieve symptoms associated with schizophrenia.

### Chemistry of Oil palm

The palm fruit (*Elaies guineensis*) yields palm oil, a palmitic-oleic rich semi solid fat and the fat-soluble minor components, vitamin E (tocopherols, tocotrienols), carotenoids and phytosterols. A recent innovation has led to the recovery and concentration of water-soluble antioxidants from palm oil milling waste, characterized by its high content of phenolic acids and flavonoids. These natural ingredients pose both challenges and opportunities for the food and nutraceutical industries. Palm oil's rich content of saturated and monounsaturated fatty acids has actually been turned into an asset in view of current dietary recommendations aimed at zero trans content in solid fats such as margarine, shortenings and frying fats. Using palm oil in combination with other oils and fats facilitates the development of a new generation of fat products that can be tailored to meet most current dietary recommendations. The wide range of natural palm oil fractions, differing in their physico-chemical characteristics, the most notable of which is the carotenoid-rich red palm oil further assists this. Palm vitamin E (30% tocopherols, 70% tocotrienols) has been extensively researched for its nutritional and health properties, including antioxidant activities, cholesterol lowering, anti-cancer effects and protection against atherosclerosis. These are attributed largely to its tocotrienol content. A relatively new output from the oil palm fruit is the water-soluble phenolic-flavonoid-rich antioxidant complex. This has potent antioxidant properties coupled with beneficial effects against skin, breast and other cancers. Enabled by its water solubility, this is currently being tested for use as nutraceuticals and in cosmetics with potential benefits against skin aging. A further challenge would be to package all these palm ingredients into a single functional food for better nutrition and health.

The first group consists of fatty acid derivatives, such as partial glycerides (MGs, DGs), phosphatides, esters and sterols. The second group includes classes of compounds not related chemically to fatty acids. These are the hydrocarbons, aliphatic alcohols, free sterols, tocopherols, pigments and trace metals.

Most of the minor components found in the unsaponifiable fraction of palm oil are sterols, higher aliphatic alcohols, pigments and hydrocarbons. The other minor components, such as partial glycerides and phosphatides, are saponifiable by alkaline hydroxide. The partial glycerides do not occur naturally in significant amounts except in palm oil from damaged

fruits. Such oils would have undergone partial hydrolysis resulting in the production of free fatty acids, water and the partial glycerides. Different isomers of MGs and DGs are found in palm oil.  $\alpha$ -MGs are more stable than their  $\beta$ -isomers. As in most vegetable oils, the  $\alpha,\alpha'$ -DGs (or 1,3 DGs) are the predominant DGs in palm oil.

Several minor nonglyceride compounds are found in palm oil. The nonglyceride fraction of palm oil consists of sterols, triterpene alcohols, tocopherols, phospholipids, chlorophylls, carotenoids and volatile flavor components, such as aldehydes and ketones. Sterols are tetracyclic compounds with generally 27, 28 or 29 carbon atoms. They make up a sizeable portion of the unsaponifiable matter in oil. The content of sterols in palm oil is about 0.03% of its total composition. Cholesterol (2.2- 6.7%),  $\Delta^5$ -avenasterol (0-2.8%)  $\Delta^7$ -stigmasterol (0- 2.8%) and  $\Delta^7$ -avenasterol (0-4%) was also found in the sterol fraction (326- 627 mg/kg) of palm oil. Most of the sterols are relatively inert and do not appear to contribute to any important property to palm oil. However,  $\Delta^5$ -avenasterol has been reported to show antioxidant activity in edible oils.

Crude palm oil has a rich orange-red colour due to its high content of carotene (700-800ppm). The major carotenoids in palm oil are  $\alpha$ - and  $\beta$ -carotene, which account for 90% of the total carotenoids. There are about 11 different carotenoids in crude palm oil.

### Chemistry of Cocoa

The physics and chemistry of cocoa beans and cocoa products is very complex, changing throughout the life of the bean, depending on the processing it receives. The following gives an indication of the changes in the bean through its life.

Cocoa beans are the seeds of the tree *Theobroma cacao*. Each seed consists of two cotyledons (the nib) and a small embryo plant, all enclosed in a skin (the shell). The cotyledons store the food for the developing plant and become the first two leaves of the plant when the seed germinates. The food store consists of fat, known as cocoa butter, which amounts to about half the weight of the dry seed. The quantity of fat and its properties such as melting point and hardness depend on the variety of cocoa and the environmental conditions.

The seeds are fermented, which causes many chemical changes in both the pulp surrounding the seeds and within the seeds themselves. These changes cause the chocolate flavour to develop and the seeds to

change colour. The seeds are then dried and despatched to processors as the raw material for the production of cocoa mass, cocoa powder and cocoa butter. The first stage of processing includes roasting the beans, to change the colour and flavour, and shell removal. After roasting and deshelling an alkalisising process can take place, to alter flavour and colour.

The chemical composition of the bean; however, it must be remembered that this will vary depending on the type of bean, the quality of the fermentation and drying and the subsequent processing of the bean.

Cocoa mass is produced by grinding the nib of the cocoa bean. The quality of the cocoa liquor will depend on the beans used. Manufacturers often blend different types of beans to gain the required quality, flavour and taste. The cocoa liquor can undergo further roasting and alkalisation to alter the colour and flavour which will also alter its chemical composition.

The fat or cocoa butter can be extracted from the bean in a number of ways. Pure press butter is extracted from the cocoa mass by horizontal presses. Sub-standard cocoa beans can be pressed without deshelling by using continuous expeller presses. Pure press butter needs no cleaning but it is often deodorised. A solvent extraction process can be used to extract butter from the cake residue left after the expeller process; this type of butter must be refined. Cocoa butter obtained by pressing the cocoa nib exhibits the following properties: brittle fracture below 20 °C, a melting point about 35 °C with softening around 30-32 °C. Cocoa butter is composed of a number of glycerides.

Cocoa powder is formed from cocoa mass. Presses are used to remove some of the fat and leave a solid material called cocoa press cake. These cakes are then crushed to form cocoa powder. The processing can be altered to produce cocoa powders of different composition and with different levels of fat.

The composition of cocoa powder depends on the roasting, alkalisation and pressing processes undertaken

### **Chemistry of Cashew nut**

Cashew, the king of dry fruits, is not merely the best topping for a delicious last course; it is also an aphrodisiac that can boast of many curative properties. The latent and benign medicinal properties of cashew, of which India is the largest producer worldwide, are enormous, according to research data published by the Cashew Export Promotion Council of India, at Kochi.

Laden with 21% protein and an equally high

percentage of poly unsaturated fatty acids. Cashew helps in reducing the blood cholesterol level considerably preventing possibilities of heart attacks. With an exceedingly low content of saturated fat and soluble sugar, cashew could slim down one's waistline. Besides, cashew kernels, rich in calcium, phosphorous and iron, can help prevent anagemia and nervous system ailments, the research found. In fact, the vegetable proteins contained in cashew kernels stand at par with milk, eggs and meat. Besides, it also contains a high concentration of much needed acids in right proportions, generally very rare in nuts.

A cashew kernel contains 47% fat, 82% of this fat is unsaturated fatty acids. This unsaturated fatty acid helps in lowering blood's cholesterol level. The most prominent vitamins in cashew are vitamin A, D and E. These vitamins help in assimilating the fats and increase the immunity level. Being a rich source of minerals like calcium, phosphorus and iron, consumption of cashew kernels can help protect the nervous system as well.

Cashew kernel is very low on carbohydrates-as low as one per cent of soluble sugar-which means that one is privileged to a sweet taste without worrying about excess calories. One big property of cashew is that it helps in controlling diabetes, says the journal. Cashew kernel oil is also considered a good mechanical and chemical antidote for irritant, poisons, and it is a vehicle for linaments and other external applications, experts point out. The kernel is also used as a substitute for almond mixture, and is a good food for patients suffering from incessant and chronic vomiting.

One of the most popular systems of Indian medicine, ayurveda also lists quite a few unique curative properties of Indian cashewnut and prescribes it as a good stimulant, rejuvenator, appetizer and excellent hair tonic aphrodisiac and restorative. Experts say raw cashew fruit was used as an anaesthetic in leprosy, and also for curing warts, corns and ulcers.

The juice of the nut is used as a substitute for iodine while the oil obtained from the shell is good for cracks in feet. The cashew apple contains 10.44 per cent of fermentable sugars and 261.5 mg per 100gm of vitamins C, giving both the fruit and the wine made of it very good antiscorbutic properties. The liquor is also valued as a diuretic with healthy effect on kidneys and advanced cases of cholera. Apart from its commercial importance as an intoxicant liquor, cashew feni, very popular in Goa, is said to have high medicinal value

and has for centuries been used by the Goans as a cure for ailments ranging from worm sickness in children to diarrhoea and even Cholera. Apart from its commercial importance as an intoxicant liquor, cashew feni is very popular in Goa. Cashew Nut Shell Liquid (CNSL) is a reddish brown viscous liquid, having the honey comb structure of the shell of cashew nut obtained from cashew tree. It contains Anacardic acid 80.9% and Cardol 10-15% and small amounts of other materials notably the methyl derivatives of cardiol under natural condition. CNSL extracted with low boiling petroleum contains Anacardic acid 90% and Cardol 10%.

Using cashew nut shell liquid, novel and cheaper liquid crystalline polyester has been synthesized that can substitute for polymer fibres and films in specialty applications. Liquid crystalline (lc) polymers have attracted much attention in recent years because of their potential use as high performance materials. CNSL is used in the manufacture of dark coloured paints and enamels. Paints and varnishes made from CNSL have superior properties than those of conventional oils or synthetic resins. Varnishes resistant to water and gasoline have been made by incorporating sulphur in CNSL. Lacquers developed from CNSL could be used for insulation, protective or decorative coatings for furniture, buildings, automobiles, etc. The films have toughness and elasticity, excellent gloss and superfine adhesive qualities. The dried films are superior to those of ordinary oil paints in respect of resistance to oils, grease moisture and chemicals. Cashew lacquers are cheaper than ordinary oil varnishes.

Electrical Insulating varnishes are obtained by treating CNSL with formaldehyde and compounding the resulting material with pure phenolic resin varnish or alkyd resin in suitable proportions. Films of those materials are water and chemical resistant and can be used as insulating varnishes with high electrical resistance and as bobbin enamels and laboratory table tops. Cashew polymers react with formaldehyde to give a rubbery gel, which can be used as a cement hardening agent that would be immune to acids and alkali reaction. It can be used for cementing floors exposed to chemical attack.

CNSL modified by heating at 160 °C. in the presence of certain accelerators give stoning enamels that are resistant to alkali and acid solutions, mineral and fatty oils and various organic solvents. Coating compositions possessing insecticidal properties are obtained by adding DDT, Gammexane etc., to CNSL

or chlorinated CNSL after treatment with Formaldehyde gums and resins and drying or semi-drying oils. Apart from the polymeric products, CNSL forms the basic raw material for a vast number of industrially important chemicals and chemical intermediates. Chlorinated products of cardanol and hydrogenated cardanol are found to have pesticide action. The various components of cardanol can be suitably modified to obtain emulsifiers and surface active agents, dyestuffs, antioxidants, plasticizers, stabilizers, accelerators, curatives, reclaiming agents and ion-exchange resins.

### Chemistry of Tea

Tea shoot, contains a full complement of enzymes, biochemical intermediates, carbohydrates, proteins and lipids. In addition, tea shoot is distinguished by its remarkable content of polyphenols and methyl xanthines (caffeine and other purines, such as theobromine and theophylline). Popularity of tea as a beverage may be due to the presence of these two groups of compounds which are mainly responsible for the unique taste of tea, in addition to various compounds associated with tea aroma. Chemical composition of tea shoot varies with agroclimatic condition, season, cultural practice and the type of material.

Flavanols, flavonol glycosides, polyphenolic acids and depsides put together are referred to as total polyphenols and make up about 30% of the dry weight in a tea shoot. Flavanols or catechins are the major compounds that are oxidisable in the tea leaf. (-) epigallo catechin (EGC) and (-) epigallocatechin gallate (EGCG) are the predominant catechins present in tea leaf. The catechins are located in the cytoplasmic vacuoles and play a significant role during fermentation.

The enzyme polyphenol oxidase plays a key role in tea fermentation; it is present in chloroplasts. Polyphenol oxidase (PPO) has remarkable specificity for the ortho-dihydroxy functional group of the tea catechins. In intact plant, the enzyme is not in contact with the substrates, flavanols. The idea behind fermentation is to bring the enzyme and substrate together in the presence of oxygen by rupturing the membrane so that polyphenols can diffuse into the cytoplasm. As a first step during fermentation, the catechins are oxidised to highly reactive, transient orthoquinones by PPO. The quinones, thus derived from a simple catechin and a gallic catechin, dimerise to produce theaflavins which are orange-red substances

that contribute significantly to astringency, briskness, brightness and colour of tea beverage. Theaflavins comprise 0.3 to 2.0% of the dry weight of black tea. Theaflavins of black tea comprise a number of fractions namely theaflavin, theaflavin monogallate and digallate, epigallocatechin gallate and isoflavan-3-ol. As the gallation increases the astringency also increases and the proportions of theaflavin fractions present in black tea depend upon the method and conditions of manufacture.

Quality of tea is determined by the presence or absence of chemical compounds which impart colour, briskness, brightness, strength and flavour in the infusion. Majority of the chemicals imparting quality are produced during processing of the tea leaves. Biogenesis of such precursors is influenced, on one hand by the genetic and environmental factors which cannot be controlled and on the other by the cultural practices adopted in the field as well as by the conditions of processing, which can be controlled. Though biochemical changes start immediately after plucking (the crop shoots) the precise changes required for quality start from withering onwards.

Theaflavins are orange red substances that contribute significantly to the astringency, briskness, brightness and colour of the tea beverage. TF of black tea comprise a number of fractions namely, theaflavin, theaflavin monogallate and digallate, epigallocatechin gallate and isoflavan-3-ol. Thearubigins are complete condensation products of oxidised catechins with theaflavins. Together with HPS, TR contributes to the colour, mouth feel and body of the tea liquor. Caffeine is relatively a stable molecule and is a direct stimulant of the central nervous system. Together with TF imparts briskness to the tea liquor. High levels of caffeine indicate a good leaf standard. Caffeine decreases with the maturity of the crop shoots. Volatile flavour constituents, in addition to the biochemical constituents that give the tea its unique taste, black tea is also well known for its characteristic aroma. Terpenoids and amino acids degrade to produce linalool, phenyl acetaldehyde, phenyl ethanol and methyl salicylate which contribute to desirable aroma of tea.

Black tea also contains minerals such as calcium, phosphorus, iron, sodium potassium and vitamins (A, B1, B2, Niacin & C) besides the biochemical constituents such as amino acids and soluble sugars. Polyphenols work out to about 15-20% in the black tea and it comprises the catechin fractions. Compared to black tea, green tea has a higher content of

polyphenols, almost around 25-30% on dry weight basis. All the above constituents may vary in their content according to the type of tea plants, environment, agronomic practices, pest & disease incidence and manufacturing practices.

Tree leaf contains 25% dry weight of flavanols, 15% protein, 13% polysaccharides, 7% sucrose, 5% each of phenolic acids, 4% amino acids, 3% each of flavanols.

Table 4: Traditional Health Claims for Tea.

| Traditional claims                                  | Possible scientific basis                          |
|---|--|
| Improved blood flow                                 | Vasodilatation and decrease platelet activity      |
| Elimination of alcohol and toxins                   | Increased activity of phase I and phase II enzymes |
| Clear urine and improve flow<br>Relieves joint pain | Diuretic affects<br>Anti-inflammatory activity     |
| Improved resistance to diseases                     | Prevention of cancer and coronary heart disease    |

Chemical reactions during the manufacture of green, oolong, and black teas are responsible for the development of their respective colours and flavours. During tea fermentation the colourless catechins of green tea are converted to a range of products of orange-yellow to red-brown colour through a series of oxidative condensation reactions and numerous volatile flavour constituents are formed. These changes are reflected in the red-amber colour, reduced astringency, and more complex flavour of black tea beverage.

### Chemistry of Coffee

The composition of coffee varies with the species and with the step in the line. The following sections deal with the main components, caffeine, carbohydrates, chlorogenic acids, lipids, other nitrogenous compounds, volatiles, and melanoidins, and include the transformation processes.

The first compound covered here is caffeine, associated even by name to our subject, coffee. Caffeine is a nitrogenous compound that is not affected by the central process in coffee chemistry, roasting.

Caffeine biosynthesis takes place in the leaves and in the pericarp, the outer part of the fruit. In aged leaves the caffeine content is lower. Chemical Composition of crops is highly variable. Food and feed crops exhibit a range of chemical compositions.

Caffeine is a physiologically active compound, and the human exposure to it after a cup of coffee is of interest. Some general calculations can be made: an aqueous extraction at regular brewing conditions

transfers the caffeine almost completely into the beverage, a cup of 100 ml with a brew of 55 g/l of roast and ground coffee, has full compliment of its caffeine.

#### Chemistry of Spices

Spices are woven in to history of nations. Spices impart colour, Aroma, taste to food preparations and some times mask undesirable odours. The volatile oil from spices give the aroma and oleoresins impart the taste.

There is a growing interest in the theoretical and practical aspects of inner biosynthetic mechanisms of the active principles in spices as well as in relationship between biological activity and the chemical structure of these secondary metabolites. The antioxidants properties of herbs and spices are of particular interest in view of the impact of active modifications of low protein, lipoproteins, cholestrols in the development of atherosclerosis. A range of biochemical compounds in herbs and spices have been studied for the anticarcinogenic properties in animals. Some of the chemicals in the major spices are as follows.

**Black pepper:** Caryophyllene rich oils poses sweet floral odours where as oils with high pinene content gives turpentine like off odours. The major compounds in fresh pepper are *trans*-linalool oxide and  $\alpha$ -terpineol, whereas dry black pepper oil contains  $\alpha$ - and  $\beta$ -pinenes, d-limonene and  $\beta$ -caryophyllene as major components.

**Cinnamon :** Cinnamon possesses a delicate, spicy aroma, which is attributed to its volatile oil. Volatile components are present in all parts of cinnamon and cassia. They can be classified broadly into monoterpenes, sesquiterpenes and phenylpropenes. The oil from the stem bark contains 75% cinnamaldehyde and 5% cinnamyl acetate, which contribute to the flavor.

**Cardamom :** In cardamom, the oil has very little mono- or sesquiterpenic hydrocarbons and is dominated by oxygenated compounds, all of which are potential aroma compounds. While many of the identified compounds (alcohols, esters and aldehydes) are commonly found in many spice oils (or even volatiles of many different foods), the dominance of the ether, 1,8-cineole, and the esters,  $\alpha$ -terpinyl and linalyl acetates in the composition make the cardamom volatiles a unique combination.

**Clove:** The minor constituents like methyl amyl ketone, methyl salicylate, etc., are responsible for the characteristic pleasant odour of cloves. The oil is dominated by eugenol (70–85%), eugenyl acetate (15%) and *b*-caryophyllene (5–12%), which together makes up 99% of the oil. *b*-Caryophyllene, which was earlier thought of as an artifact of distillation, was first reported as a constituent of the bud oil by Walter (1972).

**Nutmeg:** The volatile oil of nutmeg constitutes the compounds: monoterpene hydrocarbons, 61–88%; oxygenated monoterpenes, i.e. monoterpene alcohols, monoterpene esters; aromatic ethers; sesquiterpenes, aromatic monoterpenes, alkenes, organic acids and miscellaneous compounds. Depending on the type, its flavour can vary from a sweetly spicy to a heavier taste. The oil has a clove like, spicy, sweet, bitter taste with a terpeny, camphor-like aroma.

**Star anise:** In star anise, the presence of a prenyl moiety in the phenyl propanoids plays an important role in antitumour-promoting activity. Hence, the prenylated phenylpropanoids might be valuable as a potential cancer chemo preventive agent.

The spices have many health benefits namely carminative hypolipidemic, antidiabetic, antilithogenic, antiinflammatory, antioxidant antimutogenic and anticarcinogenic properties. Piperine (1-piperoyl piperidine) in black pepper is shown to possess bioavailability enhancing activity with various structurally and therapeutically diverse drugs. This property of piperine may be attributed to increased absorption, which may be due to alteration in membrane lipid dynamics and a change in the conformation of enzymes in the intestine.

The volatile oil from cardamom is a potential grain protectant by killing various life stages of the stored product insects attacking wheat, viz: *Tetropium castaneum* and *Sitophilus zeamais* Motschulsky, via contact and fumigant action. Cinnamaldehyde in cinnamon has strong insecticidal activity against *Acanthoscelides oblectus* and antifeedant activity against *Ceratitis capitata*, a pest causing damage to fruit crops.

Nutmeg oil also possesses strong antibacterial, antifungal and insecticidal properties. Myristicin, which imparts hallucinogenic properties, is also reported to be an effective insecticide, while the lignin

types of the constituents in the nut are anticarcinogenic Larvicidal properties, against second stage larvae of *Toxocara canis*, are also reported in mace.

### Chemistry of Rubber

All rubber like materials are polymers, which are high molecular weight compounds consisting of long chains of one or more types of molecules, such as monomers. Vulcanization (or curing) produces chemical links between the loosely coiled polymeric chains; elasticity occurs because the chains can be stretched and the crosslinks cause them to spring back when the stress is released. Natural rubber is a polyterpene, i.e., it consists of isoprene molecules linked into loosely twisted chains. The monomer units along the backbone of the carbon chains are in a *cis* arrangement and it is this spatial configuration that gives rubber its highly elastic character. In gutta-percha, which is another natural polyterpene, the isoprene molecules are bonded in a *trans* configuration leading to a crystalline solid at room temperature. Unvulcanized rubber is soluble in a number of hydrocarbons, including benzene, toluene, gasoline, and lubricating oils.

Rubber is water repellent and resistant to alkalis and weak acids. Rubber's elasticity, toughness, impermeability, adhesiveness, and electrical resistance make it useful as an adhesive, a coating composition, a fiber, a molding compound, and an electrical insulator. In general, synthetic rubber has the following advantages over natural rubber: better aging and weathering, more resistance to oil, solvents, oxygen, ozone, and certain chemicals, and resilience over a wider temperature range. The advantages of natural rubber are less build up of heat from flexing and greater resistance to tearing when hot. Natural rubber is one of nature's unique materials. The Native Americans of tropical South America's Amazon basin knew of rubber and its uses long before Christopher Columbus's explorations brought it to the attention of Europeans. The Indians made balls of rubber by smoking the milky, white latex of trees of the genus *Hevea* that had been placed on a wooden paddle, to promote water evaporation and to cure the substance.

Crude rubber is primarily hydrocarbon in nature. In 1826 English chemist Michael Faraday (1791–1867) analyzed natural rubber and found it to have the empirical (simplest) formula  $C_5H_8$ , along with 2 to 4 percent protein and 1 to 4 percent acetone-soluble materials (resins, fatty acids, and sterols). In 1860 English chemist Charles Hanson Greville Williams (1829–1910) confirmed Faraday's analysis and in 1862 distilled natural rubber to obtain the pure monomer, which he named isoprene. He determined isoprene's vapour density and molecular formula, and he showed that it polymerizes to a rubbery product—an observation that led to the notion that rubber is a linear polymer of isoprene, proposed in 1910 by English chemist Samuel Shrowder Pickles (1878–1962).

The molecular weights of rubber molecules range from 50,000 to 3,000,000. Sixty percent of the molecules have molecular weights of greater than 1,300,000. The repeating unit in natural rubber has the *cis* configuration (with chain extensions on the same side of the ethylene double bond), which is essential for elasticity. If the configuration is *trans* (with chain extensions on opposite sides of the ethylene double bond), the polymer is either a hard plastic (naturally occurring gutta-percha, obtained from the leaves of *Palaquium*, a species of sapotaceous Malaysian and East Indies trees) that was used for wire and cable coating during the nineteenth century; or a substance like gutta-percha (balata, obtained from *Mimusops globosa*, trees native to Panama and South America), used for modern golf ball covers.

Chemistry has a greater role to play in plantation crops. Understanding chemistry of plantation crops are very essential right from seed development and germination to end product and also to go for value addition, product diversification and by product utilization. The use of plant growth regulators, soil fertility management through organic and inorganic manures and fertilizers, bio fertilizers, effect of heavy metals on the yield and quality of crops and the chemical pollution caused through use of fertilizer, herbicide, pesticide particularly in tree crops need to be understood very clearly for a better crop production.

## **Sri Lankan Foods: Glycaemic indices and physico-chemical factors affecting the glycaemic indices**

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### **Introduction**

Increased intake of highly refined carbohydrates (sugars, starchy foods made using highly milled grains) is identified as one major factor for the increase in nutrition related non communicable diseases (NCDs) such as diabetes, cardiovascular diseases and some cancers which have become the major causes of mortality, morbidity and disability among Sri Lankans.

In this context glycaemic index (GI) which ranks starchy foods according to their potential to raise the blood glucose level is important as this reflects how the food carbohydrates affect the glycaemic response. GI concept is applied to foods providing 15g-20g or more of glycaemic carbohydrates (glucose, fructose, galactose) per portion and is determined by consuming food portions containing 50 g of digestible carbohydrates. Thus GI reflects the glycaemic response of different foods to the same amount of carbohydrate; thus the quality of the carbohydrates in that particular food. Depending on the blood glucose raising potential, carbohydrates rich foods are classified as low ( $GI \leq 55$ ), medium ( $56 \leq GI \leq 69$ ) or high ( $GI \geq 70$ ) GI foods. GI values are also used to calculate the glycaemic load (quantity) of an edible portion of starchy food in a diet. GL is useful as sometimes the actual carbohydrate load from a normal portion is not similar to a 50g digestible carbohydrate containing portion. The actual blood glucose levels are determined by the GI of the carbohydrate (quality) and quantity (GL) of the carbohydrate in edible portion.

Low GI foods are digested slowly and release glucose gradually into blood which facilitate higher extraction of carbohydrates from liver and periphery and gives rise to low glucose peaks which in turn demands a low insulin dose compared to high GI foods thus decrease the incidence of insulin resistance and development of intermediate risk factors such as obesity, hypertension, the key factors responsible for development of above mentioned nutrition related NCDs. Consumption of low GI/GL diets has shown to decrease obesity, lower the risk of diabetes type 2, reduce insulin resistance and risk of coronary heart diseases and certain cancers.

As Sri Lankan staple is a carbohydrate rich source be it rice, bread or any food made with either flour providing the highest amount of energy in our diets (55- >70 %) their influence on postprandial glucose concentration (GI & GL) is a major factor that would help medical practitioners, dieticians and nutritionists as well as general public in manipulating and controlling the dietary carbohydrates and thus the glycaemic response following a meal and also selection of foods for frequent consumption.

### *Glycaemic indices of Sri Lankan foods*

*Proximate compositions (digestible carbohydrate, protein, soluble dietary fibre (SDF), insoluble dietary fibre (IDF), fat) glycaemic index (GI) and glycaemic load (GL) of edible portions of more than 50 food items of Sri Lankan origin, of which some are given in Table 1 which are available to the public at <http://www.nrc.gov.lk/SAG/index.html> have been determined.*

When considering rice, parboiled Nadu had the lowest GI (40) indicating the suitability of parboiled rice in the dietary regime of individuals with chronic NCDs. Red raw rice with "kiri hodi" and white raw rice with 'pol sambol' had the highest GI. Red raw rice given as a mixed meal, keera samba and basmati (white and red) had GI in increasing order. GL for a normal portion size of red basmati was lower when compared to the white basmati variety we studied due to high fibre. Increased dietary fibre (DF) content had shown to reduce the GI of Sri Lankan rice mixed meal. Effect on lowering GI was by both the increased quantity and use of different sources of fibre (*kohila*) in rice meals. Rice mixed meal had the most desirable GL indicating the suitability of a mixed meal in controlling the glycaemic response. However, the quantity of rice (starchy base) has to be taken into account when consuming rice. Beneficial effect of the meal would not be seen if a large rice portion is consumed as part of the meal. When the GI and insulin index of red rice mixed meal were determined in diabetic individuals, higher values (64; medium GI) than obtained with healthy individuals were observed but indicating good glycaemic control.

Table 1: GI, GL for 50g digestible carbohydrate portion, GL for normal edible portion and proximate compositions of some Sri Lankan foods

| Food/meal   | GI | GL for the portion given for GI determination | GL of a normal portion             | Carbohydrate % FW    | Protein % DM              | Fat % FW                     | Total dietary fibre (IDF+SDF+UC <sup>a</sup> ) % FW |
|---|----|---|------------------------------------|----------------------|---------------------------|------------------------------|---|
| <b>RICE</b>   |    |   |                                    |                      |                           |                              |   |
| Red raw rice+kirihodi only                              | 80 | 40  | 40                                 | 21.5                 | 3.0                       | 5.0                          | 2.3   |
| Red raw rice+gotukola+dhal+egg+kirihodi*                | 47 | 23  | 16                                 | 14.3<br>(24+12)      | 4.8 (3.3<br>+ 8+12.4)     | 6.1<br>(0.7+11+11.7)         | 4.3<br>(4.6+5.3+7.5)                                |
| Red raw rice+gotukola+dhal+egg+kirihodi+kohila sambol * | 43 | 21  | 21                                 | 14.2<br>(24+12+ 2.5) | 4.8<br>(3.3+8+<br>12.4)   | 6.1<br>(0.7+11+1.1+<br>11.7) | 4.3<br>(4.7+5.3+7.5+6.4)                            |
| Parboiled Nadu+pol sambol                               | 40 | 20  | 20                                 | 25                   | 3.0                       | 1.0                          | 4.0   |
| Keera samba+pol sambol                                  | 66 | 33  | 33                                 | 22                   | 3.0                       | 1.0                          | 1.6   |
| Samurthi basmati+ pol sambol                            | 73 | 37  | >37                                | 33                   | 4.0                       | 1.0                          | 1.7   |
| Red basmathi+pol sambol                                 | 73 | 37  | 27                                 | 19.1                 | 1.3                       | 0.6                          | 1.9   |
| Sudu kekeulu+pol sambol                                 | 81 | 40  | 40                                 | 27.3                 | 1.2                       | 1.1                          | 1.4   |
| Sudu kekulu mung milk rice                              | 55 | 28  | 28                                 | 12.0                 | 3.5                       | 2.0                          | 5.3   |
| <b>BREAD</b>  |    |   |                                    |                      |                           |                              |   |
| White sliced bread(Prima)                               | 77 | 39  | 20<br>(4 slices)                   | 44                   | 7.2                       | 2.8                          | 3.4   |
| Whole meal bread(brown)                                 | 76 | 38  | 16<br>(3 slices)                   | 39                   | 8.9                       | 2.7                          | 8.0   |
| Whole meal bread/lentil curry*                          | 61 | 30  | 19<br>(3 slices/<br>100g<br>curry) | 22<br>(39+12)        | 8.3<br>(7.2+ 8)           | 6.8<br>(2.8+11)              | 6.7<br>(8+7.5)                                      |
| <b>CEREAL BASED FOODS</b>                               |    |   |                                    |                      |                           |                              |   |
| Hoppers (rice)+lumumiris                                | 90 | 45  | > 45                               | 41.8                 | 6.6                       | 8.4                          | 3.5   |
| Wheat roti (1:coco1)+ lumumiris                         | 54 | 27  | 27                                 | 35.0                 | 9.0                       | 22.3                         | 9.6   |
| Kurakkan/wheat (3:2:1coco)                              | 52 | 26  | <26                                | 33.2                 | 12.2                      | 21.8                         | 18.4  |
| Rice/wheat roti (1:1:coco2)+lumumiris                   | 50 | 18  | 18                                 | 34.4                 | 8.5                       | 20.0                         | 6.0   |
| Attafloor roti (1:Coco1)+ lumumiris                     | 51 | 25  | 25                                 | 33.4                 | 15.2                      | 16.6                         | 11.3  |
| Rice stringhoppers + egg +kirihodi+coconut sambol*      | 79 | 40  | 26                                 | 18.5<br>(31+0.4)     | 4.0<br>(3.5+3.9+<br>12.4) | 13.3 (1.2+39+<br>11.7)       | 4.3<br>(3.4+14.2)                                   |
| Wheat stringhoppers +egg+ kirihodi+coconut sambol*      | 72 | 36  | 24                                 | 18.5<br>(31+0.4)     | 6.2<br>(7+ 3.9+<br>12.4)  | 13.3<br>(1+39+11.7)          | 4.3<br>(3.4+14.2)                                   |
| Rice flour pittu (1:Coco 1)+ lumumiris                  | 76 | 38.5  | 38.5                               | 26.9                 | 4.6                       | 17.4                         | 6.6   |
| Wheat pittu (1:1Coco)+ lumumiris                        | 75 | 37.5  | 37.5                               | 32.0                 | 8.2                       | 15.1                         | 6.7   |
| Kurakkan pittu (1:coco1)                                | 64 | 32  | 20                                 | 26.5                 | 4.1                       | 17.1                         | 14.7  |
| Godamba roti  | 81 | 41  | <41                                | 50.1                 | 4.0                       | 6.7                          | 5.8   |
| <b>LEGUMES</b>  |    |   |                                    |                      |                           |                              |   |
| Chickpea  | 22 | 6   | 6                                  | 13.4                 | 8.8                       | 3.0                          | 14.0  |
| Cowpea  | 34 | 9   | 9                                  | 14.5                 | 10.8                      | 1.4                          | 10.1  |
| Mungbeans   | 47 | 11  | 11                                 | 14.4                 | 10.0                      | 0.9                          | 9.7   |
| <b>TUBERS/STARCHY VEGETABLES</b>                        |    |   |                                    |                      |                           |                              |   |
| Manioc + onion sambol                                   | 86 | 43  | 43                                 | 25.6                 | 0.8                       | 0.6                          | 3<br>(1.7+0.7+0.6)                                  |
| Jakfruit meal (boiled)* (Fruits & seeds)                | 55 | 28  | 13                                 | 10.5<br>(82+53)      | 1.4<br>(0.9+4.7)          | 2.4<br>(0.8+1.3)             | 4.2<br>(1.5+1.1+0.3)+<br>(7.9+3.2+8.0)              |

|                                   |       |       |       |           |         |         |         |
|-----------------------------------|-------|-------|-------|-----------|---------|---------|---------|
| Breadfruit+coconut                | 47    | 12    | <12   | 9.3       | 1.1     | 0.5     | 2.7     |
| Rajaala (dioscorea) white /violet | 52/48 | 26/24 | 19/18 | 12.5/12.5 | 5.9/9.2 | 0.2/0.3 | 1.9/2.5 |
| <b>BANANA</b>                     |       |       |       |           |         |         |         |
| <i>Kolikuttu</i>                  | 46    | 23    | 6     | 26.5      | -       | 2.1     | 9       |
| <i>Embul</i>                      | 46    | 23    | 4     | 23.2      | -       | 1.4     | 8       |
| <i>Anamalu</i>                    | 50    | 25    | 7     | 17.9      | -       | 2.4     | 7.2     |
| <i>Seeni</i>                      | 52    | 26    | 5     | 22.6      | -       | 2.4     | 4.2     |
| <b>GREEN LEAFY PORRIDGES</b>      |       |       |       |           |         |         |         |
| <i>Hathawariya</i>                | 37    | 9     | 9     | 4.9       | 0.5     | 2.2     | 0.6     |
| <i>Heenbovitiya</i>               | 55    | 14    | 14    | 3.8       | 0.6     | 0.9     | 0.6     |
| <i>Polpala</i>                    | 32    | 8     | 8     | 4.3       | 0.4     | 1.7     | 0.6     |
| <i>Wal koththamalli</i>           | 38    | 9     | 9     | 5.4       | 0.5     | 1.3     | 0.5     |

#UC-undigestible carbohydrate; SDF- soluble dietary fibre; IDF- insoluble dietary fibre; FW-fresh weight; DM-dry basis

\*mixed meals: total carbohydrate / fat/ protein / fiber in the meal and in parenthesis % carbohydrate / protein / fat / fibre of different components of the meal

Bread (white, brown) consumed without any accompaniments had high GI and high GL. However, the actual portion size that a person could consume contained a less carbohydrate load (GL). Brown bread eaten alone elicited a high GI which when given with a dhal curry produced a medium GI causing the GI to decrease. Though the GL was high in all three varieties, the metabolic response (lower peak eliciting lower insulin response) to the same carbohydrate load was better in the mixed meal.

Above observations clearly indicated the importance of addition of other accompaniments to the carbohydrate staple as these would contribute to lowering of the GI by virtue of reducing the portion size of starchy staple and addition of other nutrients which helps in reducing GI.

GI and GL of hoppers was high and the portion size was considered not adequate by the participants. Thus the GL of hoppers would be much higher and is not a suitable food for daily consumption as this would induce a high insulin response. *Roti*, irrespective of the flour used in the preparation elicited low or medium GI. Among different *roti*, *kurakkan roti* elicited the lowest GL due to high DF which decreased the digestible carbohydrate in a portion and induced satiety. Irrespective of flour (red or white) used in preparation and when given with as many accompaniments as with red raw rice meal, string hoppers elicited a high GI and high GL which were similar to that of brown bread. Compared to string hoppers, rice mixed meal where the GL as well as the glucose peaking after the meal was lower produce a better metabolic response.

*Pittu* when prepared using wheat or rice flour elicited high GI and had a high GL even for a normal portion. When *kurakkna* was used in the preparation, GI and the GL both decreased due to the high DF which makes the normal edible portion smaller by inducing satiety and decreasing digestible carbohydrate. Ingestion of *kurakkan pittu* elicits a better glycaemic profile with a lower peaking. Addition of other accompaniments (curries) may lead to a further lower GL.

Among the many tubers studied, *raja ala* (Dioscorea), consumed as a traditional breakfast with coconut scrapings elicited low GI in contrast to manioc which gave high GI and contained more protein (9%) and polyphenols. In contrast to popular belief, jack fruit and breadfruit eaten with coconut as a meal elicited lower GI. Thus addition of starchy fruit vegetables as accompaniments in a meal will not contribute to a higher glycaemic response and is suitable in a diabetic meal.

Boiled legumes, chickpea, cowpea and *mung* beans when consumed as breakfast had low GI and constituted a low GL. Incremental increase in blood glucose was low leading to lower insulin demand. Incorporation of *mung* beans when making milk rice decreased the GI. Thus increased consumption of legumes should be encouraged as a healthy option among public. Porridge made with different green leaves elicited a low GI and low or medium GL and good satiety thus proving the health benefits of these in dietary management. Further studies carried out with diabetes induced rats have shown that *wal koththamalli* porridge to be superior in controlling diabetic

parameters and led to produce a marketable product.

#### Physico-chemical factors affecting the glycaemic indices

When considering only rice (not the meal) GI was not affected as the DF in whole grain is not adequate to cause an effect on GI and thus all rice varieties produced high GIs. Parboiled rice had high DF (14% DM) due to the processing (starch retrogradation) it is subjected and elicited low GI. Likewise when rice or bread is consumed as a meal or boiled legumes or *pittu* made with kurakkan had lower GI due to high DF. Dietary fiber delays gastric emptying and thus absorption of carbohydrates, increases satiety and contributes to decreasing GI. Our studies showed that DF content in Sri Lankan foods correlate negatively with GI indicating if the diet is properly formulated we might be able to add adequate fibre to have beneficial effects. Correlation was more significant with IDF than with SDF indicating that the SDF in our meals to be less. Studies also showed the benefits of both the increased quantity and different sources of fibre in rice meals. Impact of protein on GI was not apparent when food groups with low protein such as green leafy porridges were considered. Nevertheless foods such as legumes, mixed rice meal or *mung* milk rice whose protein content was high had a GI lowering effect.

Fat in a portion given to determine the GI had no correlation with GI clearly indicating that fat in our diets is moderate and thus major source of energy is carbohydrates and therefore to reduce the incidence of NCDs more attention needs to be paid to the carbohydrates in our diet.

Moisture in a food is a major factor that determines the portion size. Higher the moisture in food lower the edible portion size. This was seen with different rice varieties where the moisture increased in order of white *basmati* < *nadu* < *samba* and a 50g carbohydrate containing portion increased as 150g > 200g > 225g where the participants said that *basmati* portion was inadequate. Moisture therefore was seen to be a major factor in determining the GL.

We proved that wet processed foods such as *pittu*, rice, string hoppers, manioc tends to have a higher GI compared to dry processed food such as *roti*. This was due to increased disintegration of the starch granule and gelatinization of the starch which was apparent when the starch granules of raw wheat flour and *roti* and *pittu* were compared. A clear correlation between starch granule destruction and GI was observed. Thus excessively wet processed foods may lead to higher

glycaemic responses as starch is more available for enzymic attack. Legumes and *raja-ala* were exceptions where starch granules were inside a protein matrix which delayed digestion of starch. Effects due to wet processing of the starchy staple can be overcome to a certain extent by addition of foods rich DF and protein as seen with rice only and mixed rice. If the processing is excessive as in string-hoppers this may not be possible and it would be better to consume these foods less frequently.

Effect of particle size of flour on GI was illustrated when two flour samples of *kurakkan*, one made using the stone-grinder and other industrial mill were used to make *roti* and *pittu* whose compositions were same except for the flour. Significant reduction in GI was observed with food made with stone-ground flour and was due to the higher particle size distribution in stone ground flour compared to industrially milled flour. A similar observation was made when porridges were made industrially by extruding.

Since GI will be a reflection of all these factors when selecting food/preparing meals careful selection of foods and combination of high and medium or low GI foods can be used to control the energy intake and the glycaemic control. This knowledge would help nutritionists, dieticians or individuals to plan meals utilizing low or medium GI regularly or to mix high GI foods with low or medium GI foods so the glycaemic responses can be brought lower and help prevent/reduce the increasing incidence of NCDs.

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### **Applications invited for Graduateship (36<sup>th</sup> Intake) and Diploma in Laboratory Technology (DLTC) (41<sup>st</sup> intake) Programmes in Chemistry to be conducted on weekdays as well as weekends**

Applications are invited from those having three GCE (A/L) passes in recognized scientific disciplines (including Chemistry) or approved equivalent such as Diploma in Chemistry, or awaiting results. Admissions to the programme is possible for those having passes in the Diploma in Laboratory Technology (DLTC) programme conducted by our Institute. Prospective BSc Graduates from recognized universities can also apply directly for admission to the last two years of the Graduateship programme from September 2013 (2013-2015) while they are in the third year of a BSc Programme of a recognized University.

Those with GCE (O/L) qualification OR only one A/L pass in Chemistry can apply for the two year DLTC programme scheduled to commence in December 2013.

Application forms and further details are now available at the Institute office and on our website [www.ichemc.edu.lk](http://www.ichemc.edu.lk)