PLANTATION PRODUCTS AND BYPRODUCTS - BIOCHEMICAL ASPECTS

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INTRODUCTION

Plantation products and by-products have high commercial value. These are used for edible and industrial purposes. Commonly known consumables such as tea, coffee, coconut, copra, coconut oil, palm oil, cashewnuts, arecanuts, etc. are direct plantation products whereas some other consumables contain modified plantation products like chocolates contain cocoa product. Apart from these, plantation products and by-products are widely used for industrial purposes. Use of coconut oil in soap, detergent, dye and shampoo making, rubber usage in various industries, etc., come under this category. Since the market value of these products is mainly influenced by the quality of product, which in turn is predominantly determined by the biochemical composition, it is important to assess their quality in terms of biochemical parameters. This chapter deals with the biochemical composition of plantation products and by-products. The plantation crops dealt with are coconut, oil palm, rubber, cocoa, coffee and tea.

COCONUT

Coconut has a number of products and by-products. Main edible products of commercial importance are coconut oil, copra and tender nuts. Non edible products include oleochemicals, fibre, etc.

Biochemical composition of edible parts:

(i) Coconut kernel or copra: The ripe kernel derived from 11-12 month old nuts consists proteins (5.5%), fat (44%), carbohydrates (10%), crude fibre (3%) and minerals (2.1%). However, desiccated copra with a moisture content of 2% consists of fat (67%), proteins (9.3%), carbohydrates (5.9%), minerals (2.4%), fibre (3.9%) and pentosans (8.9%). It also has vitamins A, B, C and E.

(ii) Coconut oil: Dry copra contains about 65 % coconut oil which is mainly a triglycerol, a substance consisting of fatty acids chemically bound to glycerol in the ratio of 3:1. It contains around 87% of saturated fatty acids, causing oil to have a high melting point (23-26°C). These fatty acids have a carbon chain mostly of 12 and 14-C (medium chain fatty acids). Saponification value of coconut oil is the highest and iodine value is the lowest among oils so it is classified as non-drying oil. The physio-chemical property of oil are: Specifi gravity at (25°C) 0.918, Vircosity at (25°C) 1.45, Iodine value 8.0-9.6 and Saponification value 251-263.

(iii) Coconut milk: Coconut milk contains protein (2.4-4.1%). The fat content varies from 12.5% in dehydrated whole milk to 40% in canned cream milk. Coconut skim milk is rich in proteins and fats (26.4 and 19.6% on dry weight basis, respectively). Reducing sugars are also present in small amount. The milk has a slightly acidic pH (6.0 - 6.3).

(iv) Coconut flour: Coconut flour, nutritionally comparable to most of the

common grain flours, contains protein (22 - 24 %), crude fibre (10%) and ash (5%).

(v) Coconut water: Coconut water is rich in minerals and vitamin B, apart from other components like sugars.

(vi) Coconut cake: It consists of moisture (7%), fat (6.7%), protein (21.2%), nitrogen free extract (47.4%), fibre (11.2%) and minerals (6.5%).

Biochemical composition of non-edible products:

(i) Oleochemicals: Coconut oil is split into various industrially useful component chemicals like glycerol, fatty acids, fatty acid methyl esters, fatty alcohols and fatty amines. This oil has the highest percentage of glycerol (a major by-product) compared to other oils and fats. Because of its high lauric acid content, coconut oil is also catageorized under lauric oils. These oleochemicals are used in soap, non soap detergent, textile and cosmetic industries.

(ii) Coconut husk: A mature ripe nut contains 35-45% of its weight as husk.From husk several coir products like coir dust or pith and fibre are obtained.

Coir pith: Coarse coir pith or dust contains more lignin (43.65 %) and pentosans (13.1 %) as compared to the fine coir pith which has 37.71% lignin and 11.5% pentosans. Coir pith is a source of furfural, oxalic acid and zypsum.

Fibre: Fibre obtained from mature nut is mainly made of lignin (46%) and cellulose (43%). Pectin (4%) and hemicellulose (1%) are also present in lesser amounts.

(iii) Coconut shell: It is rich in cellulose (50.99%) and lignin (32.22%). Other components include moisture (6.76%), pentosans (3.01%), hot water extract (1.76%), ether extract (0.17%), ethanol-benzene extract (1.98%) and Ash (1.32%).

Storage of copra and oil - biochemical aspects:

The important aspects in storage of copra and oil are i) proper drying of copra, ii) storage conditions of dried copra and oil and iii) shelf life of oil. A systematic investigation is carried out at CPCRI, Kasaragod , on different methods of drying and storage of copra using various preservatives and storage containers for increasing the shelf life. The study, based on the data collected on quality parameters, indicates that the most effective treatment for storage of copra in rainy season is to keep them in an atmosphere saturated with either biogas, neem leaf gas or sulphur dioxide. The fungal and bacterial infestations are negligible in the successful treatments. Other experiments revealed that soaking of copra in 1000 ppm propeonic acid arrests the microbial activity during drying.

The quality of oil mainly depends on 1) quality of copra, 2) extraction conditions and 3) storage conditions. Unrefined coconut oil contains Free Fatty Acids (FFAs) and hence has a tendency to become rancid due to the hydrolysis and oxidation of FFAs. With storage time, the peroxide value and FFAs of oil increase thus developing rancidity. The shelf life of coconut oil can be improved by adding either citric acid (500ppm), common salt (1%) or tamarind (2%) and packing it in plastic containers or brown bottles to prevent the rancidification of oil.

OIL PALM

Oil palm has two commercially important oil products, the mesocarp oil and the kernel oil. Oil extracted from fleshy orange-red mesocarp is known as crude palm oil (CPO). It contains two fractions, the palm stearin and the palmolein. Stearin fraction contains mainly saturated fatty acids and is solid at room temperatures. While palmolein has more unsaturated fatty acids and remains liquid at room temperatures.

Mesocarp oil also contains carotenoids, antioxidants (tocopherols and tocotrienols - Vit E), triterpenes, phytosterols, phospholipids, glycolipids, aqualene, sterols, aliphatic alcohols and Cu and Fe in trace amounts. Among the edible oils, palm oil has the highest concentration of carotenoids (500-700 ppm) in which α and β carotenoids constitute about 90%. These are the precursors for Vitamin A synthesis. Carotenoids are generally removed or destroyed while refining. Palm kernel oil contains high proportions of saturated fatty acids. One gram of palm oil provides 9 kcal of energy. The presence of antioxidants in abundance make palm oil stable against developing rancidity.

Processing biochemistry:

The mesocarp consists of fat globules. The lipase enzyme is bound to the membrane of fat globules. This enzyme is extreamly active and catalyses the cleavage of acyl groups from glycerophospho lipids and glycosyl acyl glycerols thus releasing the free fatty acids. Any damage to the membrane triggers the activity of enzyme and the free fatty acids (FFAs) released thus can be as high as 60% depending on the severity of damage. The released FFAs not only make the oil inedible but also hasten the rancidity development apart from fixing colour and increasing the refining losses. So, proper care should be taken during harvesting of fresh fruit bunches, transport, handling and subsequent processing of fruits. The fruits should be processed immmediately after harvest (within 24 hrs.) Sterilization of fresh fruit bunches inactivates the lipase enzyme and also loosens the fruits from bunch. It also softens the cell wall and coagulates the proteins that faciliteate oil extraction in later stages. Immature fruits have less oil and over mature fruits have high FFAs. For milling a good quality oil, the FFAs should be less than 2%.

RUBBER

Major source of rubber is *Hevea brasiliensis*. Rubber is a latex, formed in the laticiferous vessels present in the bark of the rubber tree.This latex is the modified cytoplasm from the inner regions of the laticifers. Latex consists of rubber particles and non-rubber particles. All these particles are suspended in a soluble phase called C-serum constituting an isotonic osmotic medium. C-serum posseses large amount of carbohydrates, proteins and ions like K^+.

Presence of active acid phosphatase in high concentrations in latex damages the lutoids. The disruption of lutoid vesicles releases B-serum which causes the flocculation of rubber particles leading to the stoppage of latex flow. So, high lutoid stability increases the latex stability and flow. Increased concentrations of triglycerides and phosholipids in latex lead to a high stable lutoid vesicles and thus stable rubber. Volume of the latex tapping can be increased by application of ethylene generating chemicals

as ethylene is found to lower the plugging and prolong the duration of latex flow.

COCOA

Beans are the commercially important products of cocoa plant. The cocoa powder and cocoa butter are the products obtained from beans. After harvesting the fruits the beans, embedded in pulp inside the fruit, are fermented and roasted, during which the chocolate flavour develops. The quality of the product is determined during fermentaition. For good fermentation, the mass of cocoa beans should be well insulated to retain the heat generated during fermentation and ensuring good circulation of air is important.

The beans along with pulp (minimum of 90-100 kg) are put for fermentation. Pulp contains 80% water, 10 -15 % glucose and fructose, 0.5% non-volatile acids (largely citric acid), and small amounts of sucrose, starch and salts. The low pH (3.5) of pulp facilitates the good growth of micro-organisms. Beans covered with mucilage or pulp are pink to white and have a pH of 6.6. They turn reddish brown upon fermentation and the cotyledons become pale in the centre with a brownish ring around the outerside.

During fermentation, yeasts proliferate and convert sugars in pulp to alcohol. Increase in CO_2 due to yeast activity causes anaerobic condition facilitating the development of lactic acid bacteria which assists in breaking down of sugars to alcohol. During this period the liquid (sweatings) run off takes place. When bean mass is physically turned, aerobic conditions are restored and acetic acid bacteria grows. These bacteria convert alcohol to acetic acid. and thus the pH decreases further and temperature increases approximately to 48°C. These conditions make the testa of the bean to become more permeable. Citric acid penetrates into the bean lowering its pH to 4.8. However, fermentation of bean increases its pH to 5.5 and this is the usual pH obtained in the dried bean. During fermentation of bean, break down of internal cellular structures and proteins takes place. The polyphenolic compounds are hydrolysed to cynidin, reducing sugars, etc. These changes reduce the bitterness and astringency and give chocolate flavour.

Based on the degree of fermentation the quality of product depends. The International Cocoa Standard guidelines for assessing the degee of fermentation as follow: (i) Fully fermented: Should include all fully fermented beans, eventhough the colour cannot properly be described as brown. (ii) Partly brown and partly purple: Should include all beans showing any blue, purple or voilet colour on the exposed surface, whether suffused or as a patch. (iii) Fully purple: all beans showing a complete blue, purple or violet colour over the whole exposed surface. (iv) Slaty: irrespective of colour, any beans which are slaty but not predominantly so (not > 50%).

The fully fermented beans are dried to a moisture content between 6 and 7% for safer storage. Fully dried cocoa beans contain moisture (6-8%), fat (55-58%) with a pH of 5.8. Apart from these, the cocoa products also contain minerals like Ca, Na, K, Mg, Fe, Cu, P, S and Cl.

COFFEE

Caffeine is the major alkaloid present

in coffee. The content of caffeine varies depending on the species and type of coffee. *Coffea arabica* contains 1% caffeine whereas *C. robusta* contains 2%. However it varies from 2.8 to 4% in instant coffee. Coffee also contains trigonelline (1%) apart from proteins, carbohydrates, fats and minerals.

Coffee attains its aroma and taste on roasting, during which the pyrolytic reactions take place. Upon roasting, trigonelline yields nicotinic acid, and chlogenic acid and other organic acids reduce to 90%. These acids give astringent taste. Roasted arabica has proteins (10-15%), carbohydrates, free amino acids, and citric (0.5%), malic (0.2%), lactic (0.1%), qunic (1%), pyruvic (0.1%) and acetic (0.3%) acids. Lipids (14-17% in arabica and 7-11% in robusta) are not affected by roasting. About 800 flavour and volatile compounds are identified in coffee.

TEA

Tea has polyphenolic compounds such as thea flavins and thea rubigins. Tea wastes contain 1.7% caffeine.

With the storage period moisture content of tea increases from 4.9 to about 9 %. Thea flavins increase during storage upto 150 days then decrease, whereas thea rubigins increase during first 50 days of storage and then decrease. The valuation score of tea decreases beyond 150 days of storage.

REFERENCES

Chadha KL and Retinam P (1994). Plantation and Spice Crops (part 2, Vol 10). Advances in Horticulture (ed. KL Chadha). Malhotra Pub. House, New Delhi, India.

Champakam B and Rajagopal V (1994). Coconut industry - challenges ahead. Paper presented at the National Seminar on Newer Challenges in Agriculture, Horticulture and Industry: Role of Palnt Physiologists and Biochemists, at UAS, Bangalore. Jan 11-13.

Enig MG (1995). Health and nutritional benefits from coconut oil and its advantages over competing oils. Coconut Development Board Pub. No. 44. Kochi, Kerala.

George KV (1980). Processing technology and marketing . Proceedings of the third annual symposium on plantation crops. ISPC Pub. CPCRI, Kasaragod.

Gopalan C, Ramasastri BV, Balasubramanian SC, Narasinga Rao BS, Deosthale YG and Pant KC (1995). Nutritive Value of Indian Foods. National Institute of Nutrition Pub. Hyderabad, AP.

Luckwill LC and Cutting CV (1970). Physiology of Tree Crops. Academic Press. London.

Nair MK and Nampoothiri KUK (1992). Oil palm - production technology. CPCRI Pub. Kasaragod.

Peter KV, Sarma YR, Rajagopal V, Ramana KV, Devasahayam S and Krishnamurthy KS (1996). Proccedings of International Symposium on Plantation Crops (PLACROSYM XI) Nov 30-Dec. 3, 1994 at Calicut. ISPC Pub. CPCRI, Kasaragod

Sethuraj MR and Raghavendra AS (1987). Tree Crop Physiology .No.18 Developments in Agricultural and Managed Forest Ecology series, Elsevier Sci. Pub. BV., Amsterdam, Netherlands.

Wood GAR (1975). Cocoa, Tropical Agricultural Series (III edn.) Longman Group Ltd., London.

Table 1 : Fatty acid composition of coconut oil

Fatty acids	% of total fatty acids	Type	C chain length and unsaturation
Lauric acid	47.3	Sat	12-C
Myristic acid	17.0	Sat	14-C
Palmitic acid	8.8	Sat	16-C
Caprylic acid	8.7	Sat	10-C
Capric acid	7.2	Sat	8-C
Stearic acid	2.3	Sat	18-C
Caproic acid	0.5	Sat	6-C
Arachidic acid	0.1	Sat	20-C
Linoleic acid	1.9	Unsat	18-C:2
Palmitoleic	1.0	Unsat	16-C:2
Oleic acid	6.3	Unsat	18-C:1

Table 2 : Biochemical composition of coconut water

Components	Tender nut water	Mature nut water
Values in mg %		
Total solids	6.5	5.4
Total sugars	5.7	2.0
Reducing sugars	4.4	0.2
Minerals	0.6	0.5
Protein	0.01	0.1
Fat	0.01	0.1
pH	4.5	5.2
Vit B	rich	
Values in mg %		
Acidity	120.0	60.0
K	290	247
Na	42	48
Mg	10	15
P	9.2	6.3
Fe (µg)	104	79
Cu	26	26

Table 3 : Biochemical composition of chocolates and cocoa powder

Components	Chacolates		Powder
	4 plain	2 milk	
Fat (%)	35.3	37.6	25.6
Protein (%)	5.6	8.7	20.4
Available carbohydrates (%)	52.5	54.5	35
Energy (cal/100g)	544	588	452

Table 4 : Polyphenolic pigments in black tea

Components	%
Thea flavins	0.808
Thea rubigins	7.72
High polymerised substances	8.76
Pheophytin index	0.724
Relative blackners	100

Table 5 : The fatty acid composition and chemical characteristics of mesocarp and kernel oil

Fatty acids and chemical characteristics	C chain length and unsaturation	Mesocarp Oil (%)	Kernel oil (%)
Lauric acid	12-C:0	0.1-0.4	40.0-52.0
Myristic acid	14-C:0	0.6-1.7	14.0-17.0
Palmitic acid	16-C:0	41.1-47	7.0-9.0
Stearic acid	18-C:0	3.7-5.6	1.0-3.0
Caprylic acid	8-C:0	-	3.0-5.0
Capric acid	10-C:0	-	3.0-7.0
Caproic acid	6-C:0	-	0.3
Arachidic acid	20-C:0	0.1-0.8	0.1
Oleic acid	18.-C:1	28.2-43.5	13.0-19.0
Linolenic acid	18.-C:2	10	0.5-2.0
Linolenic acid	18.-C:3	0.1-0.5	-
Palmitoleic acid	16-C:.1	0-0.6	-
Iodine value		52	
Refractive index		1.4553	
Vitamin E		rich (-600ppm)	