Potential of coconut dietary fiber

K.S.M.S. Raghavarao, S.N. Raghavendra and N.K. Rastogi

Department of Food Engineering, Central Food Technological Research Institute, Mysore - 570 020, INDIA

Abstract

The present work is aimed at the production of dietary fiber from underutilized coconut residue left after extraction of milk, by subjecting it to physical treatments such as water wash, hot water wash, boiling water wash and pressure cooking as well as solvent extraction. The fat content was reduced from 62 per cent to 45 per cent and to 41 per cent by treating with boiling water and pressure-cooking, respectively. Water holding, water retention and swelling capacity increased with decreasing fat content. A marked increase was observed in hydration properties when the fat content decreased from 10 to 2 per cent. The hydration properties were maximum for 550 µm particle size coconut fiber. For higher particle size (1127 µm), the oil got trapped inside the fiber matrix, resulting in decreased hydration properties, whereas for lower particle size (390 µm) the rupture of fiber matrix was responsible for low hydration properties. An attempt was made to compare the hydration properties of coconut dietary fiber with other commercially available dietary fibers.

Coconut fiber has maximum capacity to swell when compared to other fibers, which is the most desirable parameter for physical functioning of dietary fiber. Coconut fiber showed highest water holding, water retention and swelling capacity when compared to other dietary fibers.

Introduction

Dietary fiber refers to the plant substances including plant cell wall (cellulose, hemicellulose, pectin and lignin) as well as intracellular polysaccharides such as gums and mucilage that are not digested by human digestive enzymes [1]. The main components of dietary fiber are cellulose, hemicellulose, starch, pectin substance (polygalacturonic acid components) and lignin [2]. Amongst these, only cellulose and a portion of retrograded starch (called resistance starch) are insoluble in water, while the other are soluble. The non-starch polysaccharides act as bulking agent or roughage in the food. Dietary fiber is considered as a physiologically inert material although the bulking and laxative properties of many fiber sources have long been appreciated [3]. It has been shown to play an important role in the prevention of the risk of carcinogenesis, atherosclerosis and in the control and proper management of diabetes mellitus [4]. Adequate amount of dietary fiber in food is good for the proper bowel moments. Consumption of cereal-based dietary fiber has been promoted for its prophylactic value in regulating colonic function [5].

Incorporation of dietary fiber in our food also serves nutritional, technological as well as physiological purposes. Insoluble fibers in biscuits, cooked meat products, confectionery, drinks, sauces, desserts and yogurt act as bulking agent and reduce the calorie content [6]. Fibers are added to cooked meat products to increase the cooking yield owing to their water and fat retention properties. In fried food products, addition of fiber reduces lipid retention and increases moisture content. A wide range of dietary fibers is available in the market. Dietary fibers from different sources differ in chemical composition and physico-chemical properties and they have been extensively studied for their ability to regulate transit time due to increased stool bulk and other beneficial properties such as hydration properties like swelling capacity, water holding and water retention capacities [7]. Hydration properties of dietary fibers determine their optimal usage levels in food because a desirable texture must be retained [8].

Practically no reports are available in literature regarding the utilization of spent coconut fiber as dietary fiber, except the one by Trinidad *et al* [4], in which only the physico-chemical and nutritional properties of coconut fiber are emphasized.

The present work deals with the technological aspects of the production of dietary fiber from underutilized coconut residue (after separation of milk) by physical treatment (such as cold water, hot water and boiling water treatments) as well as solvent extraction. The effect of residual fat and particle size on the hydration properties of coconut fiber has also been investigated. Attempts have been made in comparing the hydration properties of coconut dietary fiber with commercially available dietary fiber.

Materials and methods

Preparation of sample

The coconut endosperm after removal of shell and paring was passed through Krauss-Maffei (Rotary wedge type) cutter having a sieve plate (3 mm hole) through which shredded coconut meat was forced out. The resulting coconut gratings were expressed in a screw press to extract coconut milk. Material balance of the process for 100 kg of coconut has been provided in Fig. 1. The coconut fiber was given the following physical treatments as well as solvent extraction to reduce the fat content.

Size separation

One hundred gram of sample was taken in a set of standard sieves (BSS mesh number 12, 18, 25, 30, 36 and 44) and the following fractions were separated: 12/18 (1127 µm), 18/25 (725 µm), 25/30 (550 µm), 30/36 (462 µm) and 36/44 (390 µm).

Physical treatments

Coconut fiber was washed with running tap water at ambient temperature (treatment 1); with hot water at 90^0C (treatment 2); with boiling water (treatment 3); and pressure-cooked for 10 min (treatment 4).

Solvent extraction

Coconut fiber (100 g) was mixed with hexane (1L). The samples were withdrawn after 1, 2, 3, 4, 5 and 9 h, and kept in a hot air oven at 45 ^{0}C for 3 h to remove hexane, and weighed.

Determination of hydration properties

The clear definition and standards for measurement of properties were major considerations for hydration property [7]. Water absorption property of dietary fiber is an important determinant of stool bulking effect, which is due to the manner in which water is held, rather than the absolute amount held. Strongly bound water has been found to have no effect on stool weight, where as loosely associated water readily increases stool weight [9]. The maximum amount of water

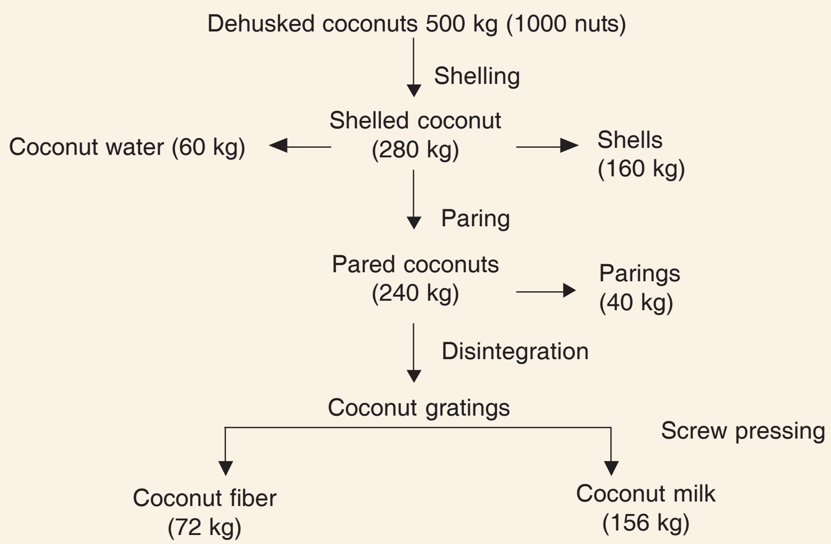


Fig. 1: Flow chart for the production of coconut fiber

that the fiber can hold is a function of the fiber source and its chemical, physical and structural characteristics.

Water holding capacity

Water holding capacity is defined by the quantity of water that is bound to the fibers without the application of any external force (except for gravity and atmospheric pressure). Accurately weighed dry sample (1g) was taken in a graduated test tube, around 30 ml of water was added and hydrated for 18 h. The supernatant was removed by passing through sintered glass crucible (G4) under vacuum. The hydrated residue weight was recorded and it was dried at 105°C for 2 h to obtain residual dry weight [7].

Water holding capacity (g/g)

=(Residue hydrated weight - Residue dry weight) / Residue dry weight

Water retention capacity

Water retention capacity was defined as the quantity of water that remains bound to the hydrated fiber following the application of an external force (pressure or centrifugation). Accurately weighed dry sample (1 g) was taken in a graduated centrifuged tube, around 30 ml of water was added and hydrated for 18 h, centrifuged (3000 x *g*; 20 min) and the supernatant solution was removed by passing through sintered glass crucible (G4) under applied vacuum. The hydrated residue weight was recorded and then sample was dried at 105°C for 2h to obtain its dry weight [7].

Water retention capacity (g/g)

=(Residue hydrated weight after centrifugation - Residue dry weight)/ Residue dry weight

Swelling capacity

Swelling property is defined as ratio of volume occupied when the sample is immersed in excess of water after equilibration to the actual weight. Accurately weighed dry sample (0.2 g) was taken in a graduated test tube, around 10 ml of water was added and hydrated for 18 h. After 18 h, the final volume attained by fiber was measured [7].

Swelling capacity (ml/g)

= Volume occupied by sample / Original sample dry weight

Determination of fat content

The fat content of the sample was determined by using Soxhlet extraction with petroleum ether (40 - 60^{o}C) [10].

Determination of soluble and insoluble dietary fiber

Total soluble and insoluble dietary fiber content in coconut was determined by Enzyme-Gravimetric method. Dry sample was suspended in phosphate buffer (pH 6.0) and treated with different enzymes such as termamyl (pH 1.5), pepsin (pH 6.8) and pancreatin (pH 4.5) for one hour at specific pH as provided in the brackets. In order to find out insoluble dietary fiber, the fiber was separated after enzymatic digestion, washed with ethanol and acetone, finally incinerated and weighed. Soluble dietary fiber was estimated by precipitating the filtrate by ethanol. The precipitate was washed with ethanol and acetone, dried, incinerated and finally weighed [11].

Results and discussion

Effect of processing treatments on hydration properties of dietary fiber

Coconut fiber after extraction of milk contains about 62% of fat on

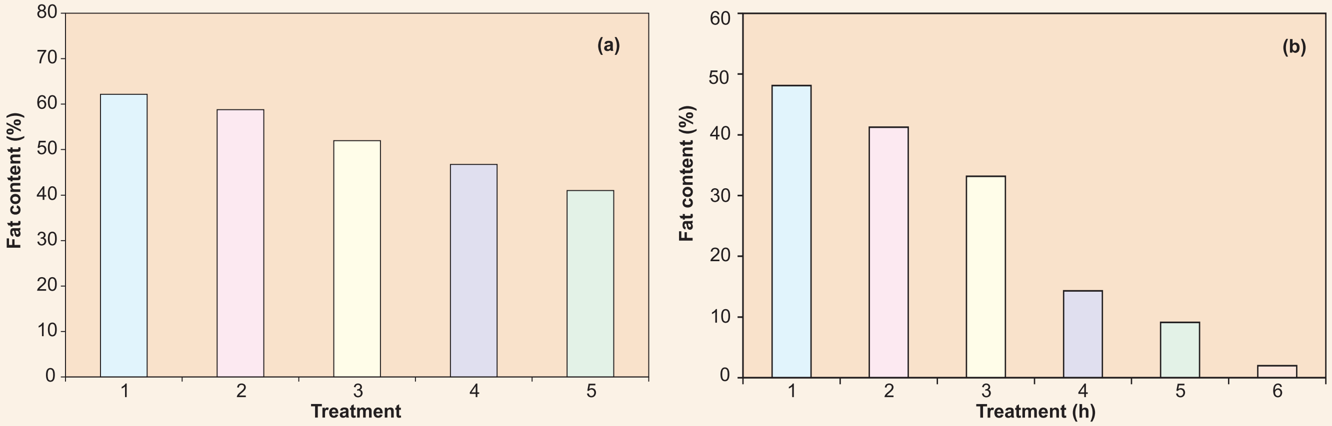
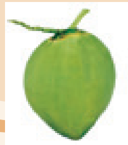


Fig. 2. Effect of (a) different physical treatments (1 Control; 2 Water wash; 3 Hot water wash; 4 Boiling water wash; 5 Pressure cooking) and (b) solvent extraction on fat content of coconut fiber



dry basis. The fiber was given different physical treatments as well as solvent extraction to reduce fat content.

Effect of physical methods

The coconut fiber was given treatments such as water wash, hot water wash, boiling water wash and pressure-cooking to remove the fat. Fig. 2(a), shows that at ambient temperature, water wash as well as hot water wash were not effective for fat reduction. The fat content of the sample (62 per cent) was reduced to 45 and 41 per cent by boiling water wash and pressure-cooking, respectively.

Effect of solvent extraction

The fat present in coconut fiber was removed by treating with hexane. The experiments were conducted for different immersion time intervals (1, 2, 3, 4, 5 and 9 h of solvent extraction) and the fat content was determined (Fig. 2 (b). It can be seen that increase in the immersion time resulted in decrease in fat content from 48.1 per cent to 2 per cent.

Effect of fat content on hydration properties

Fat content of the dietary fiber plays an important role in determining the hydration properties such as water holding, water retention and swelling capacities. Fig. 3 (a, b and c) shows the variation of these properties when the fat content is reduced from the original fat content of 62 per cent (fresh residue without any treatment) to 2 per cent (solvent extracted for 9 h), for three typical particle sizes (390, 550 and 1127 µm). Water holding, water retention and swelling capacity increased with decreasing

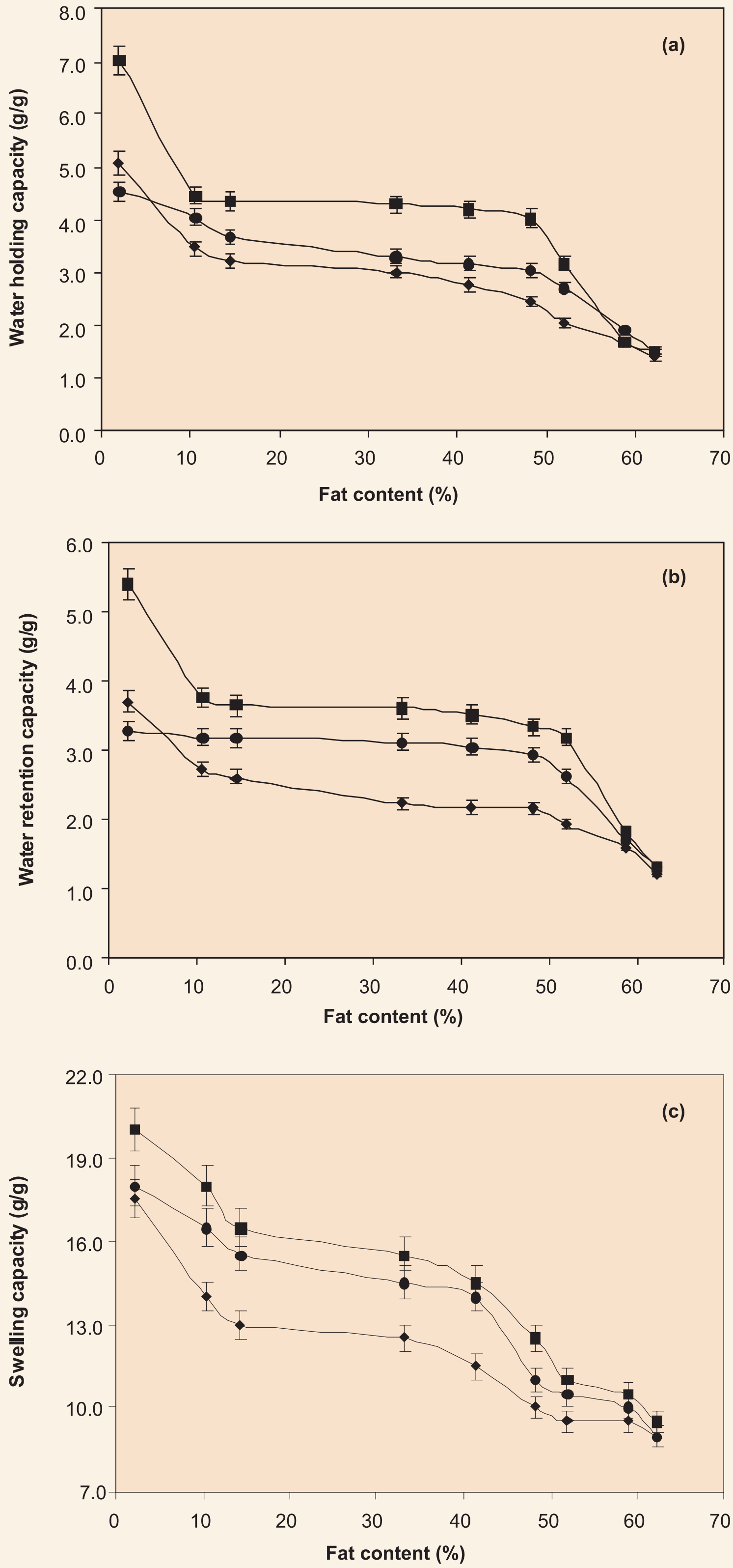
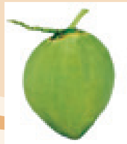


Fig. 3. Effect of fat content on hydration properties (a) water holding (b) water retention and (c) swelling capacities of coconut dietary fiber of different particle sizes (◆= 1127 µm, ●= 390 µm, ■ = 550 µm).



fat content and a marked increase was observed in the hydration property when the fat content decreased from 10 per cent to 2 per cent for all particle sizes.

Effect of particle size on hydration properties

Fig. 4 shows the hydration properties (water holding, water retention and swelling capacity) of coconut dietary fiber having 2 per cent fat content. Decrease in particle size from 1127 μm to 550 μm resulted in an increase in hydration properties. For higher particle size of 1127 μm, the residual oil got trapped inside the fiber matrix restricting the entry of water molecules and resulting in decreased hydration properties. However, further decrease in particle size from 550 to 390 μm resulted in decrease in hydration properties. This may be attributed to the damage of the fiber matrix and collapse of the pores during grinding [12]. Smaller particles will have higher packing density, although particle composition and structure will contribute to the overall distribution of water [7]. The results show that the hydration properties are found to maximum 550 μm for coconut fiber.

Comparison of hydration properties of coconut dietary fiber with other dietary fibers

Hydration properties of coconut dietary fiber was compared with other commercially available dietary fibers (Fig. 5.) Except for apple fiber (5.43 g/g) and citrus fiber (10.66 g/g), the water retention capacity of coconut dietary fiber (5.4 g/g) was higher compared to all the other samples. Water holding capacity of coconut fiber (7.1 g/g) was also more than that of the other samples. Coconut fiber showed highest swelling capacity (20 ml/g) as compared to any other fiber studied. This shows that coconut fiber has maximum capacity to swell when compared to other fibers, which is the most desirable parameter for physical functioning of dietary fiber. Total soluble and insoluble dietary fiber content of coconut residue and some other natural source of dietary fibers are listed in Table 1.

Conclusion

The physical treatment such as water wash, hot water wash, boiling water wash and pressure-cooking could not reduce the fat content significantly. Solvent extraction could reduce the fat content down to

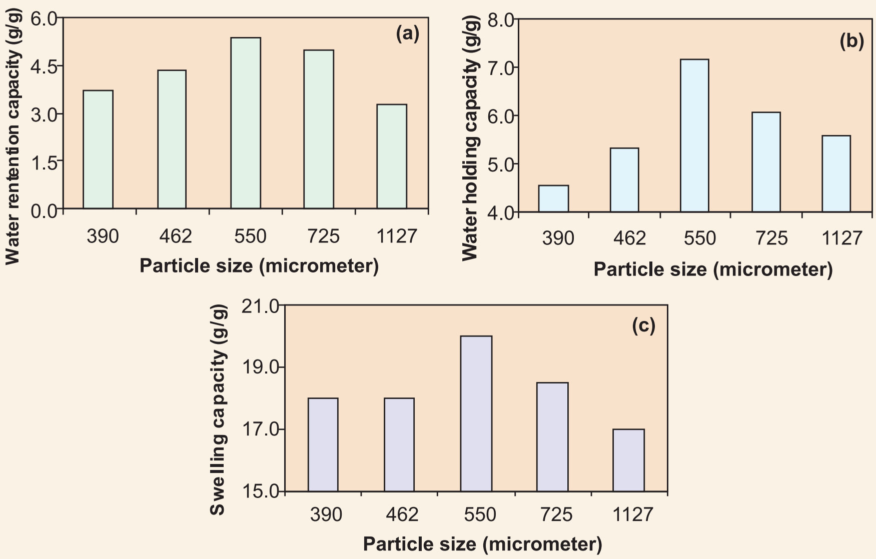


Fig. 4. Effect of different particle size on hydration properties (a) water retention (b) water holding and (c) swelling capacities of coconut dietary fiber

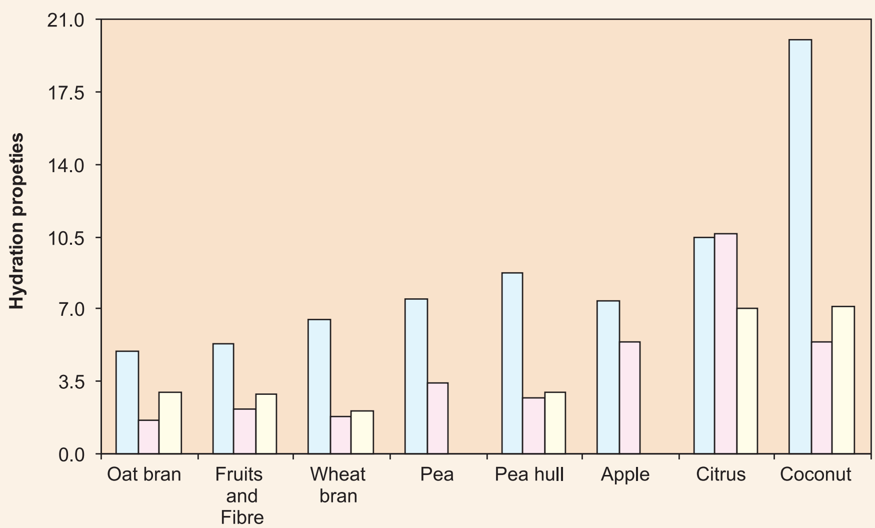


Fig. 5. Comparison of hydration properties (water holding, water retention/ binding and swelling capacities) of coconut dietary fiber with those from other sources such as Oat bran; Fruits and fiber; Wheat bran; Pea [8]; Pea hull [12]; Apple [8]; Citrus [12]. (☐ Swelling capacity, ☐ water retention capacity, ☐ water holding capacity)

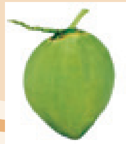


Table 1: Dietary fiber content of some natural sources

Source of dietary fiber	Soluble dietary fiber, % (SDF)	Insoluble dietary fiber, % (IDF)	Total dietary fiber, % (TDF)	Reference
Barley	5.02	7.05	12.25	[13]
Oat bran	7.17	9.73	16.92	[13]
Soy bran	6.90	60.53	67.14	[13]
Soya meal	8.32	12.01	20.33	[14]
Carrot fiber	23.75	34.40	58.15	[14]
Potato	38.6	45.2	83.15	[14]
Apple	6.2	10.8	17.0	[14]
Banana	2.9	6.7	9.6	[14]
Orange	11.9	8.2	20.1	[14]
Citrus pulp	1.20	9.30	10.70	[14]
Cauliflower	12.2	21.5	33.7	[14]
White cabbage	13.7	18.5	32.2	[14]
Coarse wheat bran	5.6	56.3	61.9	[15]
Milled wheat bran	7.8	47.9	55.7	[15]
Coconut	3.80	56.80	60.91	[4]
Coconut	4.53	58.71	63.25	Based on the present work

2 per cent. Reduction in the fat content resulted in an increase in hydration properties. Hydration properties were found to increase with decrease in particle size from 1127 to 550 μm, further decrease in particle size resulted in decrease in hydration properties. Coconut fiber showed highest water holding, water retention and swelling capacity when compared to other dietary fibers.

Acknowledgements

Authors are thankful to Dr. V. Prakash, Director, Central Food Technological Research Institute (CFTRI), Mysore, for his constant encouragement. Authors are also thankful to Dr. R.N. Tharanathan, Senior Scientist, Department of Biochemistry and Nutrition, CFTRI, Mysore. Thanks are also due to Coconut Development Board. Kochi, India, for their keen interest as well as for financial support.

References

1. Spiller GA (2000) CRC *Hand book of: Dietary fiber in human nutrition.* CRC Press, New York pp 9-10
2. Wolthuis MS, Albers HFF, Jeveren JGC, Jong JW, Hautvast JGAJ, Hermus RJJ, Katan MB, Brydon WG, Eastwood MA (1980) *The American Journal of Clinical Nutrition* 33: 1745-1756
3. Roehrig KL (1988) *Food Hydrocolloids* 2: 1-18
4. Trinidad TP, Valdez D, Mallillin AC, Askali FC, Maglaya AS, Chua MT, Castillo JC, Loyola AS, Masa DB (2001) *Indian Coconut Journal* 7: 45-50
5. Mongeau R, Brassard R (1982) *American Association of Cereal Chemists* 59: 413-317
6. Larrauri JA (1999) *Trends Food Science and Technology* 10: 3-8
7. Robertson JA, Monredon FD, Dysseler P, Guillon F, Amado R, Thibault JF (2000) *Lebensmittel Wissenschaft -und- Technologie* 33: 72-79
8. Thebaudin JY, Lefebvre AC, Harrington M, Bourgeois CM (1997) *Trends in Food Science and Technology* 8: 41-48
9. Cadden AM (1987) *Journal of Food Science* 52:1595-1599
10. Association of Official Analytical Chemists (AOAC) (1990) *15th Edition: Vol. II, method* No 920.85, page 780, Arlington, Virginia USA
11. Asp NG, Johansson CG, Hallmer H, Siljestrom M (1983) *Journal of Agriculture Food Chemistry* 31:476-482
12. Auffret A, Ralet MC, Guillon F, Barry JL, Thibault JF (1994) *Lebensmittel Wissenschaft -und- Technologie* 27:166-172
13. Lee SC, Prosky L, Vries JW (1992) *Journal of Association of Analytical Chemist.* 75: 3
14. Schweizer TF, Wursch P (1979) *Journal of Food Agriculture* 30: 613-619
15. Caprez A, Arrigoni E, Amado R, Neukom H (1986) *Journal of Cereal Science* 4:233-239

Paper presented in the Seminar on Coconut for Health held on 31st July 2005

Coconut harvest

Twelve months old nuts are harvested for seed as well as copra making. However, for tender nut purposes 7 to 8 months old nuts are harvested. In case of tall the nuts harvested for seed purpose can be stored for 2 to 3 months period before sowing, whereas in case of dwarfs and hybrids, nuts should be sown with in a period of 10 -15 days of harvest. On an average, we can have eight harvests, though the coconut palm produces inflorescence every month. For oil extraction, nuts are generally sun dried for copra making. In this case there is a chance of dirt accumulation followed by oil quality deterioration, nuts can be dried in various types of driers available (Kiln, electric and solar driers). Good quality copra can be obtained in short time by using these driers. Moisture content in copra for final use should be around 5-6%. The oil yield of WCT palms under rainfed condition will be around 1.7 to 2 tons/ha.

- CPCRI