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Nutrient composition of *kopyor* coconuts (*Cocos nucifera* L.)

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Kopyor coconuts (matured coconuts with broken meat particles in the watery endosperm due to abnormal formation of the kernel during the development of the fruits) were analysed for their proximate composition, minerals, vitamins, dietary fibres, sugars, organic acids, fatty acid composition and amino acid profile. The chief constituent of *kopyor* water was sucrose (about 92% of the total sugar); in contrast, the young or normal-mature nut water contained glucose and fructose as the main sugars. α-Tocopherol was detectable in the *kopyor* water. Total amino acid content of *kopyor* water was higher than that of the young or normal-mature water. Like the young or normal-mature nut water, *kopyor* water seemed to be a good source of dietary minerals, with potassium as the predominant one.

The relatively high contents of sucrose, glucose, fructose, citric and malic acids might contribute to the deliciousness of *kopyor* meat. The lipid content of *kopyor* meat was lower than that of the normal-mature meat, but fatty acid profiles were similar. Copyright © 1996 Elsevier Science Ltd

INTRODUCTION

Indonesia is a leading coconut-producing country with a production of 14 million tons in 1991 (FAO, 1992), and this crop plays an important role in the economic and social life of the country (Haumann, 1992; Salunkhe *et al.*, 1992). Today the potential use of coconuts is threatened by the development and increased production of other oil crops for the world fats and oils market (Persley, 1992; Anonymous, 1994). Thus, research leading to diversification of the product derived from coconut, especially for food use, is needed to realize the potential of the crop.

The young or green coconut is consumed in coconut-producing countries as a refreshing drink. The tender nut is regarded as a delicious and nutritious natural drink (Fernandez, 1988; Pue *et al.*, 1992). However, from a nutritional standpoint, the young coconuts for food use have not yet received broad and intense study. Studies on their chemical composition are limited and are confined to certain constituents (Jayalekshmy *et al.*, 1986).

In Indonesia, besides the young fruits, there are *kopyor* coconuts, which are also consumed as a favourite refreshing drink. *Kopyor* is a Javanese term for the matured coconuts whose meat (kernel) is soft and uncompact, some parts becoming detached from the shell and filling the watery endosperm. Although it has an embryo, *kopyor* will not germinate due to abnormality of the kernel which is the supporter of the growth. Related to *kopyor* is *makapuno* in the Philippines, in which the meat develops into a spongy, amorphous soft mass with hardly any watery endosperm (Adriano & Manahan, 1932; Rosario & Gabuya, 1980). Unlike *makapuno*, *kopyor* water has meat particles floating in it. *Kopyor* can be considered as coconut fruits which are abnormal in the formation of the kernel during their development, and this has been shown to be genetic (Hastjarjo, 1989). This type of coconut is valued for its combination of specific taste, aroma and texture of the meat and the water, which makes it a particularly delicious refreshing drink. *Kopyor* can rarely be found from coconut trees grown in Java island; a bunch may contain one or two *kopyor* nuts but this is very unusual. Thus, *kopyor* commands a higher price, about ten times the price of normal nuts in markets.

In composition, *makapuno* meat was found to be slightly different from non-*makapuno* in that the crude fat was lower and carbohydrate was higher in *makapuno*

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than in non-*makapuno* (Adriano & Manahan, 1932). Rosario & Gabuya (1980) reported that the chief fibre in *makapuno* meat was pectin while that in non-*makapuno* was hemicellulose. To our knowledge, no report on the nutritive value of *kopyor* coconuts has been published. The purpose of the present study was, therefore, to determine the nutrient composition of *kopyor* along with that of the young and normal-mature coconuts for comparison.

MATERIALS AND METHODS

Material

Five *kopyor* coconut fruits were purchased from the local market in Yogyakarta, Indonesia. They were mature nuts although it was difficult to ascertain the age of the fruits from the appearance of the skin and the meat. The young and mature coconuts, Malayan tall variety, were obtained from a privately owned tree grown in the Yogyakarta area. Two bunches of the young and mature fruits were harvested and lowered from the palm by means of a rope to avoid rupturing the shell. The young nuts were 6 months old (6 months after fruit setting, a stage of maturity in which the fruits are the most preferred as a refreshing drink) and the mature nuts 12 months old. From each bunch (consisting of 12 nuts) six sound fruits were selected and used as sample nuts. Table 1 shows the size and some physical properties of the coconut samples.

Preparation of sample

The nuts were dehusked, split using a knife, and the coconut water (watery endosperm) was poured into a beaker glass through a gauze filter. The white meat was scooped by a stainless steel spoon and care was taken not to scrape off the testa. The water and the meat of the three kinds of coconut fruits were separately pooled to form a composite sample. These were then freeze-dried or stored at −30°C before proximate analysis and analysis of minerals, dietary fibres, vitamins, sugars, organic acids, fatty acid and amino acid composition. The data presented are the average of at least triplicate determinations.

Proximate composition and mineral analysis

Proximate analysis of the coconut meat or water was performed for moisture, crude protein (6.25×%N), ash and carbohydrate by difference using the standard method of AOAC (1990). Total lipid was extracted using chloroform–methanol (2:1) (Folch *et al.*, 1957). Mineral analysis was conducted using a Shimadzu ICPS-1000II inductively coupled plasma spectrophotometer after wet ashing with nitric acid.

Vitamins

Thiamin and riboflavin were determined fluorometrically according to AOAC (1990). The fluorescence of thiochrome was read on a of Shimadzu RF-5000 spectrofluorophotometer at 375 nm excitation and 430 nm emission. For riboflavin determination the fluorescence was read at 445 nm excitation, 530 nm emission. Niacin and vitamin B_6 were determined microbiologically using *Saccharomyces cerevisiae* (*Saccharomyces uvarum*) ATCC 9080 and *Lactobacillus plantarum* ATCC 8014, respectively.

Vitamin C (total ascorbic acid) was determined spectrophotometrically by the dinitropenylhydrazine method (Omaye *et al.*, 1979).

Tocopherols were determined by high-performance liquid chromatography on a Shimadzu Model LC-9A chromatograph with a TSK gel NH_2-60 column and mobile phase of 2% isopropanol in n-hexane. The flow rate was 2.0 ml min^{-1} and injection volume 5 μl. The fluorometric detector (Shimadzu RF-535) was read at 292 nm excitation, 325 nm emission, and the internal standard used for reference was 2,2,5,7,8-pentamethyl-6-hydroxychroman.

Dietary fibres

Acid detergent fibre (ADF), neutral detergent fibre (NDF) and lignin contents were measured according to Van Soest (1973) and McQueen & Nicholson (1979). The difference between NDF and ADF is used for the presumptive estimation of hemicellulose; the difference between ADF and lignin content is used for the presumptive estimation of cellulose (McAllan, 1985). Total pectic substances were determined by the carbazole method (McCready & McComb, 1952) with galacturonic acid solution as a reference standard.

Sugar analysis

Sugar analysis was conducted using a Shimadzu LC-10A high-performance liquid chromatograph equipped

Table 1. Size and physical properties of coconut samples

Sample	Weight (kg)	Cirumference (cm)	Length (cm)	Water			Meat	
				Volume (ml)	pH	Specific gravity	Thickness (mm)	Weight (g)
YC	3.0±0.2	56.0±0.0	19.3±0.5	553±23	4.7±0.1	1.023±0.0	1∼3	77.20
MC	2.5±0.0	61.8±0.8	20.7±0.6	385±51	5.2±0.1	1.023±0.0	10.1	359±21
KC	2.3±0.4	61.0±2.0	23.3±1.8	416±15	5.9±0.1	1.021±0.0	—	392±100

YC, young coconut (six fruits); MC, mature coconut (six fruits); KC, *kopyor* coconut (five fruits).

with an Asahipak NH_2P-504E column with the following conditions: mobile phase, acetonitrile–water (8:2); flow rate, 0.8 ml min^{-1}; temperature, 40°C; injection volume, 40 μl.

Organic acid analysis

Organic acid contents of coconut samples were determined using a Tosoh HPLC 8010 Series high-performance liquid chromatograph equipped with column of TSK gel OApak-P and TSK gel OApak-A. The operating conditions were: mobile phase, 0.75 mM H_2SO_4; reaction reagent, BTB–15 mM Na_2HPO_4 (pH 8.6); flow rate, 0.8 ml min^{-1}; temperature, 60°C; detector, Vis spectrophotometer read at 450 nm.

Fatty acid analysis

The fatty acid composition of the total lipid extracted with chloroform–methanol (2:1) was determined after methylation with boron trifluorides (Metcalfe & Schmidz, 1961), and analysis was conducted using a Shimadzu GC-9A gas chromatograph equipped with a flame ionization detector. The column used was an Ulbon capillary column HR-SS-10, 0.25 mm in diameter and 50 m in length (Shinwa Chemical Industry Ltd.). The column temperature was programmed as follows: 150°C for 5 min, then increased to 180°C (0 min) with a gradient of 4°C min^{-1} and from 180°C (0 min) to 210°C (10 min) with a gradient of 2.4°C min^{-1}. Injection temperature was 250°C.

Amino acid composition

Amino acid composition of coconut protein was determined after hydrolysis of defatted samples with 6 N HCl at 110°C in a sealed tube for 20 h under vacuum (Jayalekshmy & Mathew, 1990); analysis was conducted using a Shimadzu LC-6A (liquid chromatography) amino acid analyser system equipped with column oven (Shimadzu CTO-6A), system controller (Shimadzu SCL-6A) and auto injector (Shimadzu SIL-6A), and a column of Shim-pach Amino-Li 6 mm×100 mm. Conditions were: eluent, lithium-citrate buffer with a gradient pH from 2.60 to 10.00; reaction mixture, NaClO (0.2 ml min^{-1}) and *o*-phthaladehyde (0.2 ml min^{-1}); the column and oven temperatures were 39 and 55°C, respectively. Detection was by a fluorescence detector read at excitation 348 nm, emission 450 nm.

RESULTS AND DISCUSSION

Coconut water

The proximate composition and dietary fibre content of coconuts are shown in Table 2. Expressed on a dry matter basis, the composition of *kopyor* coconut water was mainly carbohydrate, of which sucrose constituted 92% of the total sugar (Table 3). In contrast, the chief sugars in the young and the normal-mature water were glucose and fructose, and were higher in the young than

Table 2. Proximate composition and dietary fibre content of coconuts

Sample	Dry matter (DM) (%)	Ash (%DM)	Crude protein[a] (%DM)	Total lipid (%DM)	Carbohydrate by difference (%DM)	Lignin (%DM)	Hemicellulose (%DM)	Cellulose (%DM)	PS (%DM)
YW	5.82	14.89	2.10	1.26	81.8	ND	ND	ND	ND
MW	5.55	8.42	9.36	2.67	79.5	ND	ND	ND	ND
KW	5.28	12.00	10.4	4.79	72.8	ND	ND	ND	ND
YM	7.58	7.94	16.0	20.22	54.9	0.97	3.09	8.09	2.65
MM	52.29	1.15	7.10	62.64	29.1	6.69	6.73	7.09	0.74
KM	24.22	2.11	4.93	30.71	62.3	3.50	17.38	6.51	1.67

YW, young water; MW, mature water; KW, *kopyor* water; YM, young meat, MM, mature meat; KM, *kopyor* meat; PS, pectic substances. ND, not detectable.
[a]6.25×%N.

Table 3. Sugar and organic acid composition of coconuts

Sample	Sugar (%DM)					Organic acid (mg per 100 g DM)				
	Sucrose	Maltose	Xylose	Glucose	Fructose	Tartaric	Citric	Malic	Lactic	Acetic
YW	1.02	ND	ND	44.9	43.9	1.6	ND	317	ND	ND
MW	9.24	ND	ND	26.7	25.7	2.4	24.8	307	ND	1.3
KW	60.8	ND	ND	6.29	5.24	5.6	16.3	162	ND	1.6
YM	15.3	ND	ND	2.85	3.22	ND	63.0	2210	ND	ND
MM	4.77	ND	ND	0.24	0.46	ND	62.3	740	ND	ND
KM	10.7	ND	ND	2.42	2.08	ND	114.0	1713	ND	ND

YW, young water; MW, mature water; KW, *kopyor* water; YM, young meat; MM, mature meat; KM, *kopyor* meat. DM, dry matter; ND, not detectable.

in the normal-mature water. Some studies have shown that the reducing sugar content decreases and non-reducing sugar increases as the nut matures (Child, 1974; Jayalekshmy *et al.*, 1986; Pue *et al.*, 1992). Child & Nathanael (1950) reported that reducing sugar content increases during the development of the fruit until it reaches a maximum at about 6–7 months, then decreases. The high content of sucrose in *kopyor* water suggested that the fruits were very mature, or that the abnormality of the fruits during development led to the high content of sucrose in the watery endosperm. A study of sucrose metabolism in *kopyor* is necessary to elucidate this phenomenon.

Kopyor water was found to contain α-tocopherol as well as thiamin, riboflavin and vitamin C (Table 4). Malic acid, the chief organic acid, was lower in *kopyor* than in the young or normal-mature water (Table 3). Tulecke *et al.* (1961) reported that shikimic and quinic acids were also detected in the young or mature water, but in the present study these acids were not detectable under the conditions used.

Like the young or normal-mature water, *kopyor* water was rich in dietary minerals, with potassium the most abundant (Table 5). Some studies on the mineral composition of coconut water have been conducted (Carpenter *et al.*, 1964; Jayalekshmy *et al.*, 1986; Pue *et al.*, 1992), and the result of this present study is in agreement with these.

The fatty acid composition of lipid from *kopyor* water was dominated by lauric acid, while in the lipid from the young and normal-mature water palmitic and oleic acids were predominant (Table 6). It was also found that the young and normal-mature water contained arachidic acid, but this was not detectable in *kopyor* water. A study of the fatty acid composition of coconut water lipid during maturation of the fruits was carried out by Jayalekshmy *et al.* (1986), and the results were similar to the present study.

In the amino acid profiles, the abundant amino acids in *kopyor* water protein were glutamic, aspartic, arginine and alanine (Table 7). This profile was slightly different from that of the young and normal-mature water, particularly for the low proportion of lysine. The content of total amino acids in *kopyor* water was higher than that in the young or normal-mature water. Arginine content of the young or normal-mature water observed in the present study was lower than that found by Pradera *et al.* (1942) and Tulecke *et al.* (1961).

Kopyor is different from *makapuno* in the Philippines in that the latter hardly contains any watery endosperm (Rosario & Gabuya, 1980).

Coconut meats

The chief constituent of *kopyor* meat was carbohydrate, followed by lipid, in contrast to that of the normal-mature meat which is an oil source (Table 2). This result is similar to *makapuno* (in the Philippines), which are abnormal coconuts widely consumed as a food (Adriano & Manahan, 1932; Rosario & Gabuya, 1980). Estimated by the method of ADF and NDF determination (McAllan, 1985), the main dietary fibre of *kopyor* meat was hemicellulose while that of the young meat was cellulose. The dietary fibre of the normal-mature meat was found to be composed of cellulose, hemicellulose and lignin in proportional amounts. Rosario & Gabuya (1980) reported that the main cell wall material of the normal-mature meat was hemicellulose and that of *makapuno* was pectin. The polysaccharides in meat of coconut have been reported to be mainly cellulose;

Table 4. Vitamin content of coconuts (mg per 100 g dry matter)

Sample	Vitamin B_1	Vitamin B_2	Vitamin B_6	Niacin	Vitamin C	α-Tocopherol	β-Tocopherol	γ-Tocopherol
YW	Trace	0.01	ND	ND	7.41	ND	ND	ND
MW	0.01	0.01	ND	ND	7.08	ND	ND	ND
KW	0.04	0.04	ND	ND	2.42	0.01	ND	ND
YM	0.26	0.14	0.41	11.6	37.8	38.1	ND	0.29
MM	0.10	0.02	0.14	1.49	5.27	0.94	ND	0.05
KM	0.17	0.04	0.15	1.83	12.3	2.34	ND	0.09

YM, young meat; MM,mature meat; KM, *kopyor* meat; YW, young water; MW, mature water; KW, *kopyor* water. ND, not detectable.

Table 5. Mineral composition of coconuts

Sample	%DM						ppm					
	Ca	Mg	K	Na	P	S	Mn	Fe	Zn	Cu	B	Al
YW	0.47	0.11	3.50	0.03	0.08	0.01	20.3	4.06	11.3	0.96	8.49	12.8
MW	0.57	0.17	4.64	0.29	0.23	0.07	14.4	2.94	3.51	5.32	14.3	11.6
KW	0.32	0.36	6.08	0.10	0.49	0.16	59.4	20.9	14.8	12.2	20.2	9.63
YM	0.29	0.43	4.47	0.10	0.39	0.15	42.9	43.6	36.5	6.19	7.73	9.60
MM	0.03	0.12	0.68	0.02	0.19	0.11	16.4	35.9	17.8	36.2	3.34	5.06
KM	0.11	0.14	1.73	0.02	0.18	0.09	35.2	25.6	17.5	8.83	6.58	10.3

YW, young water; MW, mature water; KW, *kopyor* water; YM, young meat; MM, mature meat; KM, *kopyor* meat.

Table 6. Fatty acid composition of coconut lipids (expressed as % total lipids)

Fatty acid	YM	MM	KM	YW	MW	KW
8:0	0.03	4.34	4.05	ND	ND	2.06
10:0	0.07	6.22	4.52	0.95	1.90	3.95
12:0	2.25	48.6	46.9	2.7	18.5	45.6
14:0	3.99	19.2	19.9	3.16	12.8	22.8
16:0	22.5	9.64	10.3	29.8	21.6	12.6
16:1	ND	ND	ND	1.54	0.98	ND
17.0	ND	ND	ND	1.18	1.06	ND
18:0	0.04	3.23	2.06	5.28	7.28	2.95
18:1	38.3	7.18	10.0	26.5	20.4	8.94
18:2 *n*-6	32.6	1.59	2.23	15.5	4.36	1.17
20:0	ND	ND	ND	2.19	2.23	ND
20:1	ND	ND	ND	6.63	2.63	ND
20:4 *n*-6	ND	ND	ND	1.89	2.96	ND
22:1	ND	ND	ND	1.47	3.10	ND

YM, young meat; MM, mature meat; KM, *kopyor* coconut meat; YW, young water; MW, mature water; KW, *kopyor* coconut water. ND, not detectable.

Table 7. Amino acid composition of coconut proteins (expressed as mg g^{-1} defatted sample)

Amino acid	Sample					
	YM	MM	KM	YW	MW	KW
Asp	8.96	12.6	9.06	1.60	0.76	7.89
Thr	3.43	4.69	3.28	0.20	0.33	2.22
Ser	5.72	7.09	5.13	0.64	1.06	4.00
Glu	19.9	27.5	17.0	3.44	3.75	13.6
Pro	3.93	4.98	4.01	0.52	0.95	3.01
Gly	4.61	5.72	3.77	0.43	0.11	1.39
Ala	9.18	7.10	6.47	1.13	3.88	6.33
Val	4.75	6.76	4.64	0.91	0.82	3.98
C-C	0.82	1.33	0.59	0.00	0.00	0.14
Met	1.65	2.53	1.45	0.22	0.21	1.48
Ile	3.30	4.59	3.05	0.26	0.27	1.53
Leu	6.74	9.17	5.77	0.66	0.58	2.05
Tyr	1.74	2.70	1.58	0.00	0.00	1.42
Phe	4.01	5.73	3.68	0.26	0.00	1.14
His	3.08	4.10	3.24	0.39	0.67	2.44
Lys	5.28	17.4	3.34	4.72	3.41	1.78
Arg	16.8	24.3	14.7	0.13	0.81	6.80

YM, young meat; MM, mature meat; KM, *kopyor* meat; YW, young water; MW, mature water; KW, *kopyor* water.

however, results of investigations seemed inconclusive (Balasubramaniam, 1976). A study by Balasubramaniam (1976) found that coconut meat contained high amounts of galactomannan and mannan.

The mineral composition of *kopyor* meat was comparable with that of the young or normal-mature meat (Table 5); this shows a good source of dietary minerals with potassium as the chief mineral. The vitamin content of *kopyor* meat was also comparable with that of the normal-mature meat but with markedly higher content of vitamin C and α-tocopherol (Table 4). The sweet taste of normal coconut is largely due to sucrose (Caray, 1921; Jayalekshmy & Mathew, 1990), and the present study shows that the contents of sucrose, glucose and fructose in *kopyor* meat are higher than those in the normal-mature meat (Table 3). The relatively higher contents of these sugars in combination with higher contents of citric and malic acids might in part contribute to the deliciousness of *kopyor* meat. Essentially, the composition of coconut water or meat varies, depending on factors such as palm variety, degree of maturity and the nature of the soil on which the coconut is grown (Rosario *et al.*, 1989; Adriano & Manahan, 1932; Kumar *et al.*, 1975).

The fatty acid composition of lipids from *kopyor* meat remained similar to that of lipid from the normal-mature meat (Table 6), with lauric acid as the chief fatty acid. Lipids from the young meat were found to contain oleic and linoleic acid in high proportions. The results of the present study are in agreement with the results of Padua-Resurreccion & Banzon (1979) and Ceniza *et al.* (1992), namely that the fatty acid composition of coconut endosperm during maturation is characterized by an increase in short-chain fatty acids and a decrease in long-chain fatty acids.

The amino acid profile of proteins from *kopyor* meat is dominated by glutamic acid, followed by arginine and aspartic acid (Table 7). Compared to the proteins of normal-mature meat, lysine was very low in *kopyor* meat. Proteins from normal-mature coconut were reported to have a relatively favourable amino acid profile and a fairly high nutritive value (Molina & Lanchance, 1973; Hagenmaier *et al.*, 1975).

The results of the the present work indicate that *kopyor* coconut water, like the young or the normal-mature water, can be regarded as a drink better than plain water as it contains various nutrients. It seems to be a good source of dietary minerals. *Kopyor* water contained sucrose in higher amounts than the normal coconut water, and its total amino acid content was higher than that of normal coconuts. The contents of sucrose, glucose, fructose, citric and malic acids were higher than in the normal-mature meat. Therefore, the popularity of *kopyor* water as a delicious refreshing drink in coconut-growing regions was shown to be compositionally justified.

The young coconut water is widely consumed as a natural refreshing drink. The mature water is consumed less, mainly because of its bland flavour; however, a study by Rosario & Rubico (1979) showed that the water from mature nut can be formulated into a beverage that is highly acceptable by addition of sugar and citric acid. In the natural state coconut water or meat is sterile (Fernandez, 1988), and coconut as a food is notable for its reported lack of antinutritional factors (Padua-Resurreccion & Banzon, 1979). Thus, the consumption of coconut water should be encouraged as this product is inexpensive and abundantly available in coconut-producing areas. Further study on the properties of *kopyor* coconuts is needed to ascertain that they are in fact the most delicious. Coconut is an exotic fruit and, in order to be promoted as a common drink in non-exotic countries, a sensory evaluation study is necessary to adapt its flavour.

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