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DEHYDRATED COCONUT SKIM MILK AS A FOOD PRODUCT: COMPOSITION AND FUNCTIONALITY

INTRODUCTION

"COCONUT MILK" is the name commonly given to the liquid prepared by aqueous extraction of ground-up coconut meats. The oil content of coconut milk differs markedly from that of cow's milk: while cow's milk has about equal amounts of oil and protein, coconut milk has about ten times as much oil as protein. Removal of the excess oil by centrifugation yields a product generally called coconut skim milk.

Coconut skim milk has been previously considered as a high protein food product (Rajasekharan and Sreenivasan, 1967; Salon and Maniquis, 1969). However, the product is still not available because of problems encountered in large-scale preparation. The problems center around difficulties with certain unit operations, especially the efficient separation of oil from other components (Hagenmaier et al., 1972a). Oil separation is important because the efficiency of oil recovery determines the cost of the coconut skim milk. Recently, a process has been described which achieves ca. 91% recovery of oil and produces a dried, economical coconut skim milk (Hagenmaier et al., 1973).

The purpose of this work is to present a chemical description of coconut skim milk, describe some physical-chemical properties, and present some taste panel evaluations of reconstituted coconut skim milk as a beverage. It is presumed that the analyses presented will provide a chemical basis for interpretation of the physical, chemical and nutritional characteristics of coconut skim milk.

EXPERIMENTAL

AMINO ACID analyses were performed by standard ion exchange separation of protein hydrolysates with cysteine analyzed separately as cysteic acid. No corrections were made for destruction of amino acids during hydrolysis. Each reported value is the average of at least three results. Methionine was not analyzed for separately; however, a N_2 flush was used during hydrolysis to prevent oxidation.

Protein solubility was measured by mixing product with distilled water, agitating for ca. 30 min at room temperature, measuring pH, then centrifuging 10 min at 25,000 × G. The supernatant liquid was filtered through Whatman no. 41 filter paper and analyzed for dissolved protein by Kjeldahl analysis, or by the Lowry technique calibrated against Kjeldahl.

The amount of protein precipitated by heat coagulation was determined by heating an aqueous suspension of product for 20 min, then cooling to 25°C. Any water evaporated off during heating was added back, and the protein solubility then measured after centrifuging and filtering.

Oil content was determined after weighing the lipid extract obtained by the chloroform-methanol extraction method of Bligh and Dyer (1959). The extracted oil was analyzed by standard methods.

Reducing sugars were measured by the Munson and Walker method as described by Triebold and Aurand (1963). Reducing sugars after inversion were measured after heating the water extract for 1 hr at 60°C in 0.7M HCl. Sucrose identification was made by matching gas chromatography patterns with standards (trimethylsilyl derivatives of the samples) before and after inversion.

Equilibrium moisture contents were measured after exposure of samples to air of controlled relative humidity until apparent equilibrium was attained (no further weight change). Viscosity was measured with a Brookfield viscometer, with the spindle rotating at 12 rpm.

The low molecular weight nitrogen is taken as the nitrogen that passes through an ultrafiltration membrane with a rated molecular weight cut-off of 1,000. Membranes were checked for passage of larger molecules by ultrafiltration of bovine serum albumin solutions.

Mineral contents were determined by atomic absorption spectrometry, except for chloride and phosphorus. Chloride was determined by volumetric analysis, and phosphorus from weight of a phospho-molybdate complex.

Samples of dehydrated coconut skim milk were prepared with pilot plant equipment. The preparation was as described by Hagenmaier et al. (1973). The preparation consists of water

Table 1—Chemical analysis of spray-dried coconut skim milk

	% Composition[b]		
	Coconut water used in processing	Tap water used in processing	Standard dev
Protein			
Crude Protein (N × 6.25)	25	30	0.8%
Low Molecular Wt. N (as % of N)	8	7	0.5
Fat			
Crude Fat	5	7	1
Free Fatty Acids (as % of Oil)	3.2	1.4	0.3
Non-saponfiables (as % of Oil)	3.2	–	0.5
Iodine Value (as % of Oil)	6.3	–	0.7
Carbohydrates			
Reducing Sugars	2.8	2.0	0.2
Reducing Sugars after inversion	45	37	1.5
Sucrose	33	–	1.5
Crude Fiber	0.03	0.03	0.02
Minerals			
Phosphorus	0.5	0.5	0.05
Calcium	0.17	0.06	0.01
Magnesium	0.26	0.36	0.03
Potassium	3.6	3.3	0.2
Sodium	0.9	1.4	0.3
Chloride	1.6	1.6	0.2
Ash accounted for[a]	8.2	9.3	0.4
Ash (by analysis)	8.8	9.2	0.5

[a] By calculation from stated mineral contents
[b] At level of 3% moisture

extraction of ground coconut meats, removal of solids by pressure filtration, and separation of aqueous phase from oil phase with a centrifuge. The aqueous phase was dried by spray drying at air outlet temperatures of 85–93°C, except where noted.

The water used in pilot plant preparations was tap water which was very soft; a typical composition: 390 ppm bicarbonate, 130 ppm Na, 54 ppm Cl, 1.5 ppm Ca and 0.5 ppm Mg. Distilled water was used in laboratory work.

All results reported in tables are the averaged results of analyses of at least two independently prepared samples.

RESULTS & DISCUSSION

TABLE 1 shows the chemical content of dried coconut skim milk. The values for protein, fat and ash are similar to the values reported by Rao et al. (1967) for coconut skim milk prepared by the Krauss-Maffei process. In addition to the results shown in the table, the coconut skim milk made with use of coconut water had the following trace mineral contents: 17 ± 4 ppm of iodine, 70 ± 30 ppm of iron, 50 ± 20 ppm of copper, 15 ± 5 ppm of manganese, 3 ± 2 ppm of chromium and less than 2 ppm of cobalt.

Some of the minerals in the products were contributed by the tap water used in processing. The product made with coconut water as the extracting liquid was made with only about 0.5g tap water per g coconut meats. The product made without use of coconut water was made with 4.5g tap water per g coconut meats. In the latter case, the ions in the tap water would contribute the following calculated ion contents to the dried product: sodium, 0.6%; chloride, 0.2%; calcium, 0.007%; magnesium, 0.002%. Based on these data, it is evident that the increased sodium content of product made without coconut water is due to sodium in the tap water.

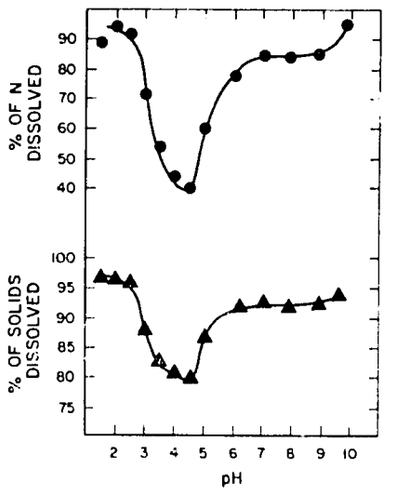

Fig. 1–Solubility as function of pH, for coconut skim milk (at 25°C, 10% solids).

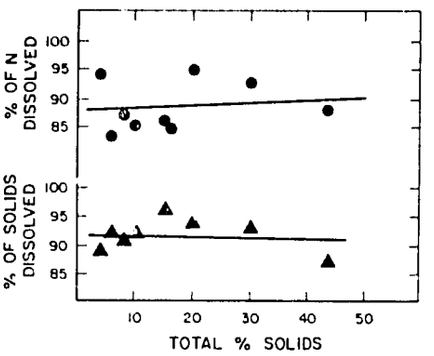

Fig. 2–Solubility as function of concentration for coconut skim milk (at 25°C, pH 7.0).

Table 2–Amino acid composition of spray-dried coconut skim milk

Amino acid	g/16g N[a]	Ratio to egg values[b]	Ratio to FAO pattern[b]
Essential			
Isoleucine	2.6	39%	6?%
Leucine	5.4	61%	11?%
Lysine	4.6[c]	71%	106%
(Total Aromatic)	(6.1)	(61%)	(106%)
Phenylalanine	3.8	65%	132%
Tyrosine	2.3	55%	80%
(Total Sulfur Containing)	(3.0)	(54%)	(70%)
Cysteine	1.7	71%	84%
Methionine	1.3	41%	56%
Threonine	2.4	47%	83%
Tryptophan	0.9	56%	62%
Valine	4.0	55%	93%
Nonessential			
Histidine	2.2		
Arginine	15.5		
Aspartic Acid	7.1		
Glutamic Acid	22.0		
Serine	3.7		
Proline	3.5		
Alanine	4.1		
Glycine	3.8		
TOTAL	90.9		

[a] Standard deviation is ca. 0.1g/16g N

[b] Each amino acid content was divided by amino acid content of egg or 1957 FAO provisional pattern, for same amount of nitrogen. Egg and FAO values used were as reported in FAO/WHO, 1965, Protein Requirements.

[c] Available lysine was 4.3g/16g N for samples freeze dried or spray dried at air outlet temperatures of 88–105°C, decreasing to 3.8g/16g N at air outlet temperatures of 107–116°C. Available lysine was determined by the method of Carpenter (1960).

From the data in Table 1, it is seen that crude protein, plus ash, plus moisture, plus crude fat, plus reducing sugars after inversion equals only 86% for product prepared with or without coconut water. The 14% unaccounted for is currently unidentified and unexplained.

The amino acid content of coconut skim milk was not observably dependent on the amount of coconut water used in the processing. (Not surprising, since the coconut water contains only 3% of the total protein.) The results in Table 2 are averaged amino acid contents of samples prepared with and without coconut water. The amino acid contents in Table 2 are similar to values reported for a similar product prepared by Srinivasan et al. (1964).

The solubility of spray-dried coconut skim milk as a function of pH is shown in Figure 1. The results are averaged from experiments with two independently prepared samples, each prepared with use of coconut water. The product is shown to be highly soluble except in the pH range 3.0–6.0. These data suggest that coconut skim milk might be suitable for a neutral pH beverage.

The effect of concentration on solubility, for the same preparations, is shown in Figure 2. The amount dissolved is shown to be nearly a constant fraction of total solids over the entire concentration range investigated. Approximately 90% of the protein and total solids were observed to be soluble at pH 7.0 and 25°C. Addition-

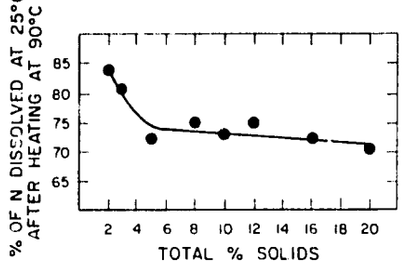

Fig. 3—Protein solubility at 25°C after 90°C heat coagulation, for coconut skim milk (at pH 7.0).

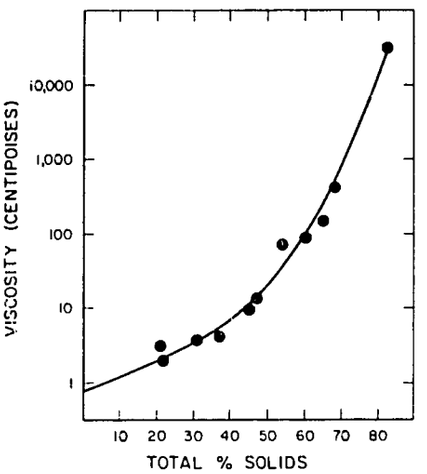

Fig. 4—Viscosity as function of concentration, for coconut skim milk (pH 7.5, 30°C).

al data indicated that solubility continued to be high at 67% solids and 33% water.

The heat coagulation of the proteins in coconut skim milk was also observed. Figure 3 shows the solubility at 25°C and pH 7.0, after heating the samples to 90°C for 20 min. Solubility decreases with increasing concentration. However, increased concentration with no heating did not reduce protein solubility (see Fig. 2). Therefore, the data of Figure 3 indicate that stability to heat coagulation is better at low concentrations (2–3% solids). Although 2–3% solids is below the useful concentration range for economic processing, the heat stability at these low concentrations may be an advantage in some product applications.

The data in Table 3 show the combined effects of pH and temperature on the heat coagulation of the coconut skim milk proteins. The results are averaged from two experiments with independently prepared spray-dried samples (prepared with coconut water). The data indicate that an upward adjustment of pH (from the unadjusted value of 6.0–6.5) will prevent heat coagulation. These results are in agreement with data for purified coconut proteins (Hagenmaier et al., 1972b). The data in Table 3 suggest that coconut skim milk can withstand the heat treatment used to sterilize evaporated milk, without much protein coagulation.

The moisture contents of samples of coconut skim milk solids at regulated values of relative humidity are shown in Table 4. These data show that coconut skim milk is very hygroscopic. The tendency for coconut skim milk to bind water is responsible for the difficulty experienced in drying this product. This difficulty has also been noticed by others (Rajasekharan and Sreenivasan, 1967). The samples lost their powdery character and became glassy or liquid over the entire range of water activity investigated, 0.43–0.91. The hygroscopic nature of this product presents particular problems because tropical coconut producing regions are invariably quite humid. It is assumed that the potassium, sodium and sucrose in the samples (see Table 1) are responsible for most of the water binding. The water binding of isolated coconut protein has been previously reported (Hagenmaier, 1972).

The data in Figure 4 show the viscosity of solutions of coconut skim milk. The viscosities are similar to data for sucrose solutions at the same concentrations over the range 0–65% solids, which is probably due to the high sucrose content of the samples. The solutions used for viscosity measurements were made in the laboratory with coconut water used as an extracting liquid. The viscosity data will be of interest for product applications and in processing work where viscous solutions are handled.

The specific gravity was measured for solutions of coconut skim milk prepared in the laboratory. Data for specific gravity at 30°C was used to develop equation (1), where f_s is taken as the weight fraction of solids:

$$\text{Sp gr} = 1.00 + 0.41\, f_s + 0.12\, (f_s)^2 \quad (1)$$

Eq (1) can be used to get a rapid estimate of solids content from measurement of specific gravity over the concentration range 0–80% solids.

For taste panel evaluations samples of spray-dried coconut skim milk were mixed with tap water and served at room temperature. Preference tests with six-member panels were used to establish best concentration. There was no statistically significant preference over the concentration range 5–15% solids. Therefore, concentration was selected more from nutritional considerations. Selected concentration was 12.5% solids, which would give 3.75% crude protein when formulated with a dry sample containing 30% crude protein.

For a comparison with dairy skim milk each panelist was simultaneously presented two unidentified samples: one of rehydrated coconut skim milk (12.5% solids) and one of rehydrated NFDM (9.4% solids). With 22 panelists and a hedonic score of 1–9, the coconut skim milk scored 6.2 and the rehydrated NFDM

Table 3—Effect of pH on irreversible heat denaturation of the protein in coconut skim milk. Protein solubility at 25°C after heating for 20 min at specified temperature

	% of Protein dissolved[a]						
pH	25°C	55°C	70°C	80°C	90°C	95°C	125°C[b]
8.0	84	82	83	83	80	80	92
7.5	84	83	85	81	80	76	79
7.0	83	83	83	79	75	70	75
6.5	82	81	80	75	49	44	43

[a] Each sample was 5% solids and 95% water. Standard deviation is ca. 4%.
[b] The samples at 125°C were autoclaved.

Table 4—Equilibrium moisture content of coconut skim milk, at 25°C

	% Moisture after equilibration[a]	
Water activity	Prepared with coconut water	Prepared without coconut water
0.91	51	48
0.84	36	33
0.81	36	33
0.75	24	22
0.43	8	10

[a] Standard deviation is 2.5%.

scored 3.5. The probability (P) that this difference is due to choice was calculated with students' t to be $5\% < P < 10\%$.

Samples of dehydrated coconut skim milk showed no evident deterioration with 6 months storage at 20–30°C as a dry powder in glass containers. Wet samples were stable to microbiological growth at moisture contents of 32% or less.

The data presented in this paper (chemical analysis, functional properties and organoleptic evaluation) suggest that coconut skim milk might be used in the formulation of an acceptable beverage or other food product.

The next stage of our research involves a nutritional evaluation of coconut skim milk and a more detailed look at food uses. Careful consideration is also being given to the construction of a field pilot plant for production of approximately 50 kg per day of dehydrated coconut skim milk. It is assumed that with such a pilot facility a reasonably accurate estimate may be made of production costs.

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