THE ANALYTICAL STUDY OF KECAP - AN INDONESIAN SOY SAUCE

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ABSTRACT

Analytical investigation on the chemical characterization of *"kecap"* were conducted. *Kecap* is one of the major seasoning or dondiment in Indonesia which is made by fermentation techniques from soybean (*Glycine max* MERR). The commercial products could be classified into the sweet, common, salty and sometimes viscous types. Ten *kecap* samples were collected from different areas in Indonesia. The main solid components of kecap are carbohydrate and salt. The highest carbohydrate content was 65.5% in sweet type *kecap*, originated mostly from palm sugar and the lowest one was 3.8% in the salty type kecap. The main components of sugar was sucrose and fructose. The total nitrogen, formol nitrogen and free amino acid contents were much lower than those of the Japanese soy sauce, except one salty type *kecap*. This is due to the excessive dilution during the moromi extraction and the addition of a large quantity of palm sugar. The ash content of sweet, common and viscous types of kecap were lower than the Japanese soy sauce. Lactic acid is the most dominant organic acid in kecap and some were also rich in succinic, pyroglutamic and butyric acid.

INTRODUCTION

Kecap is one of the most popular table seasoning in Indonesia, but quite a few research paper is available on this particular product. There are quite a variety products by the name of kecap in the market. For instance, various kinds of raw materials such as soybean, peanut press cake, trash fish, coconut water and also some other beans like "kara beans" (*Phaseolus lunatus* LINN.), "kecipir beans" (*Psophocarpus tetragonolobus* DC.) are used for the production of kecap. The major kecap products are however made from soybean (*Glycine max* MERR.). Kecap manufactures varied from the very large scale industries to the small scale home industries. Most of those industries, especially the small ones is still using traditional methods. Large and medium industries produce 9000 kl. The small industries produce about the same amount estimated from the raw material consumption in 1979 (Table 1). From those facts the national production in 1980, including home industries could be estimated about 20,000 kl. The production trend from 1975 to 1980 of kecap is shown in Fig. 1, and Fig. 2 shows the export drive from 1975 to 1981. Still a very small portion from the national production was exported which was about 28.7 tons with a value of US $ 50,000 in 1981.

Table 1. Raw Materials Supply and Production of Kecap by Large Scale and Medium Scale Manufactures in Indonesia 1975–1980.

Year	Total number of manufactures	Raw Materials				Value of Raw Materials and Additives Rp. × 1000	Production	
		Soybean					Liters × 1000	Value Rp. × 1000
		Import		Total				
		Ton	Value Rp. × 1000	Ton	Value Rp. × 1000			
1975	32	–	–	704	88,739	339,480	3,652	608,160
1976	31	–	–	930	116,203	–	3,872	748,966
1977	27	–	–	998	154,591	798,583	5,700	1,332,104
1978	37	115	22,950	1200	215,682	1,049,274	6,708	1,779,203
1979	37	57	13,749	1244	281,209	1,326,169	6,737	2,164,946
1980	38	63	15,061	2038	552,572	2,363,910	9,026	3,685,806

Additional data:

1979 299 Small Scale Kecap Manufactures need Raw Materials with a value of Rp. 2,087,801,000.–.

The Central Bureau of Statistics (BPS).

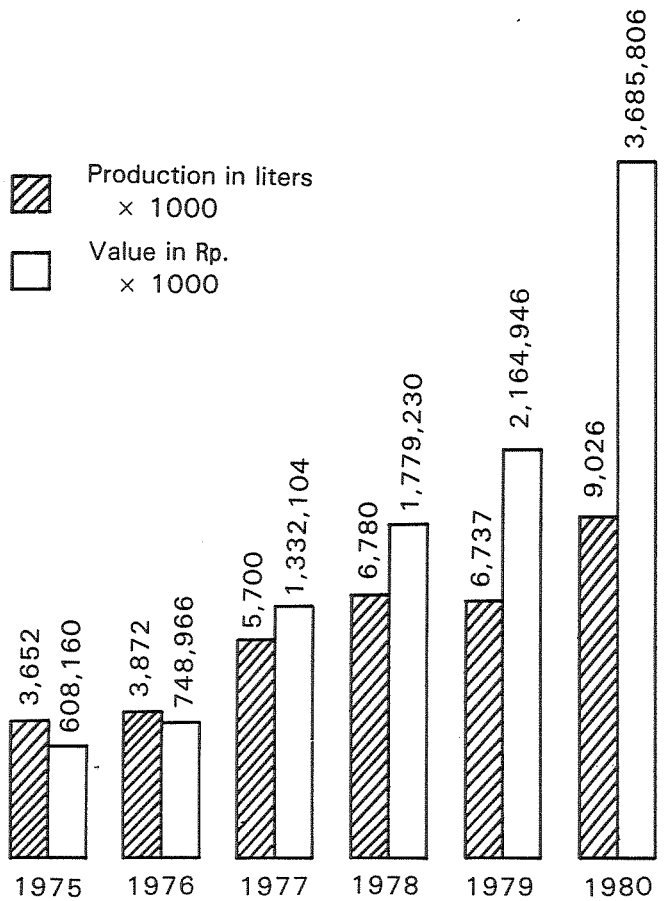

Fig. 1. Histogram of The Production of Kecap in Indonesia 1975-1980.

To avoid any confusion, the term "kecap" in this paper means only the product made from soybean by molding and brewing techniques. So far kecap products could be grouped into 3 to 4 types, namely the sweet, common, salty and some times viscous types. The most popular types among those are the sweet and common or medium types kecap.

Kecap is usually used for table seasoning at a meal or as a condiment for cooking some specific Indonesian or Chinese dishes. There is a strong believe that kecap was originated from China since ancient time and became very popular in Indonesia with some modifications. This kind of product have been used in China for over 3.000 years (SISIR, Hesseltine 1965). In many ways, the salty type kecap is used similarly as soy sauce in Japan.

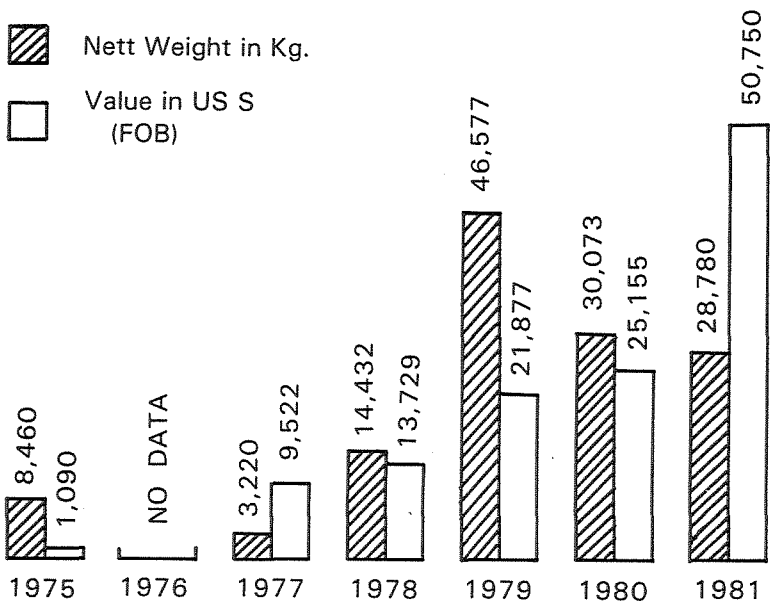

Fig. 2. Histogram of The Export of Kecap from Indonesia 1975-1981.

The final products are also variable in chemical composition. The product higher in sugar content and lower in salt are more preferable for Indonesian dishes and the salty ones is mostly used for Chinese dishes. (See FLOW CHART Fig. 3).

Only few analytical data on kecap have been so far published[1,2]. In this report several types of kecap were collected from different areas in Indonesia in order to conduct a comparative study on the chemical characteristics of kecap. Additionally, this study is also attemted to improve the quality of kecap and to get more data which will serve to the standardization of this product.

MATERIALS AND METHODS

Materials

Several brands of kecap samples were collected from several areas in Indonesia.

Common Celebes was obtained from a retail store in Ujungpandang, South Celebes. Sweet and Salty Celebes was obtained from the largest kecap factory in Ujungpandang. Common, Sweet and Salty Java was obtained from

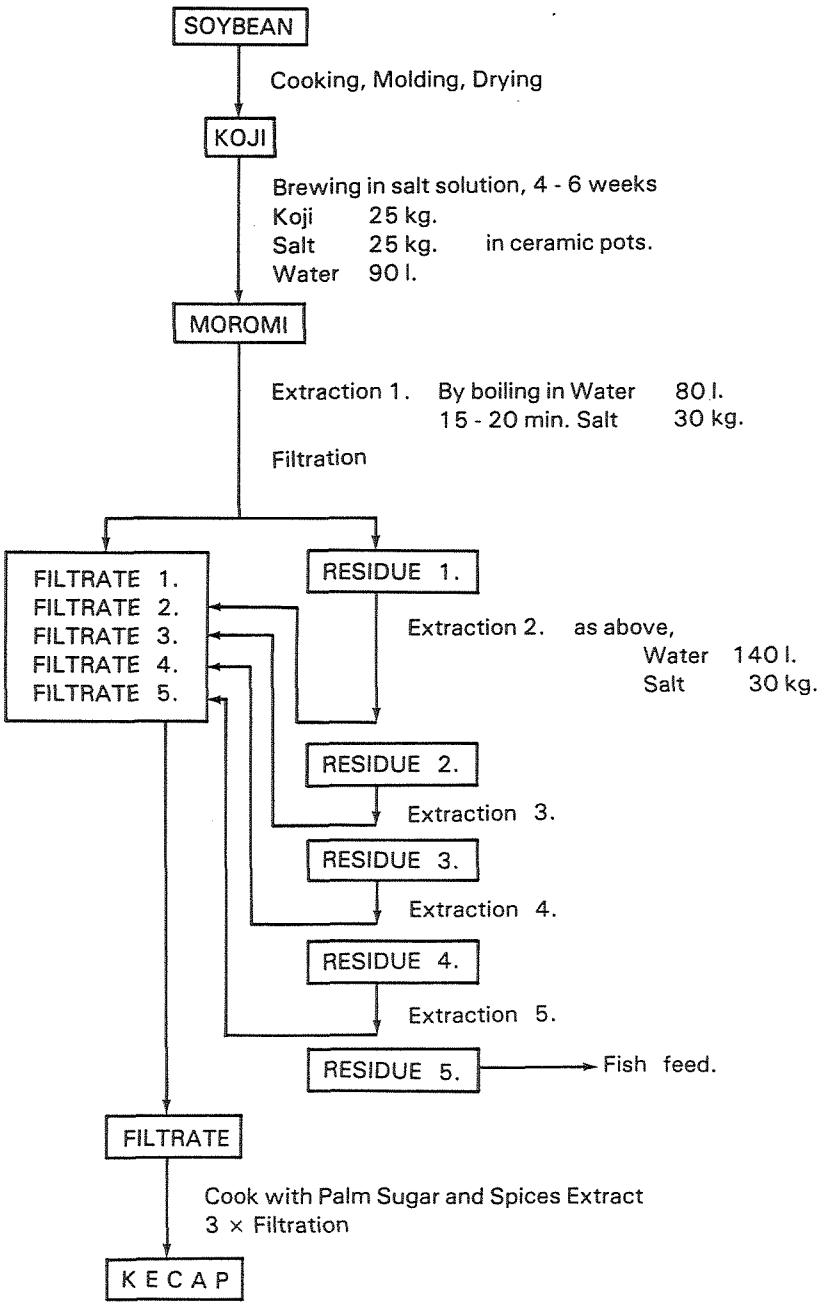

Fig. 3. General Flow Chart of Kecap Manufacturing Process.

retail stores in Bogor, West Java. Sweet and Salty Sumatra was obtained from a manufacture in Padang, West Sumatra. Viscous Java was obtained from a manufacture in Cianjur West Java.

All reagents used were reagent grade.

Methods

(1) *Analytical methods for general composition of kecap*

The analysis of kecap was carried out fundamentally according to the methods of analysis of Japanese soy sauce[3].

Moisture content was measured by heating. Ca. 3g of sample accurately weighed into a flat-bottom glass dish of 4 cm diameter were heated on steam bath until approximately dry, then heated in an air oven at 110°C for 3 hours. After cooling in a desiccator for 30 min, the weight was measured. Heating for additional 1 hour and weighing were repeated until the constant weight was attained.

Nitrogen content was determined by semi-micro Kjeldahl method. Ca. 100 mg sample was digested by heating with sulfuric acid containing $CuSO_4$ and K_2SO_4 as catalyzers. The factor of 5.75 was used for conversion of nitrogen content to protein content.

Amino nitrogen content was determined by the formol titration method. 25 ml of the sample which had been diluted 50 times with water was neutralized with 0.1N NaOH to pH 8.5 using a pH meter as a monitor. After addition of neutralized 20 ml formalin solution, titration was continued with 0.1 N NaOH until pH 8.5 was attained again.

Fat content was measured by extraction with ethyl ether in a Soxhlet apparatus. Sample was dried in a vacuum oven at 60°C for 24 hours before transfer into the Soxhlet apparatus.

Measurement of ash content was done by heating sample in an electric furnace at 600°C for 3 hours. The sample taken into crucible was well carbonated on a small gas flame before it was introduced into the furnace.

NaCl content was determined by titration method using a 1/50 N $AgNO_3$ solution. Five ml of the sample solution diluted 50 times with water was titrated using 2% K_2CrO_4 solution as an indicator.

Free amino acid content was measured using a Hitachi model 835 automatic amino acid analyzer. Sample was introduced into a column after dilution with 0.02 N HCl to 250 times.

Measurement of titrative acidity was done by titrating the mixture of 10 ml sample solution and 40 ml newly boiled water with 0.1 N NaOH using a pH meter as a monitor. Volume of NaOH solution used up to pH 7.0 was shown as acidity 1, and additional volume up to pH 8.3 was as acidity 2.

Carbohydrate content was calculated by subtracting the moisture, protein, fat and ash content from 100%.

(2) *Analytical method for physical properties.*

pH was measured using a Horiba, model M-711 pH meter.

The specific gravity was determined by measuring the weight of sample filled in 25 ml volumetric flask at 15°C. The volumetric flask was calibrated using water before measurement.

(3) *Analytical method of carbohydrate by High Performance Liquid Chromatography (HPLC) and Paper Chromatography (PC).*

One g of kecap sample was shaken with 5 ml of 95% ethanol in screw capped test tube. Ethanol layer was removed and residue was repeatedly extracted 4 times with each 5 ml of 80% ethanol. Ethanol layers were combined and evaporated to dryness under reduced pressure. Residue was disolved into 10 ml water followed by analysis of carbohydrates by HPLC and PC.

HPLC was performed using a Hitachi model 635 S attached with a 834-50 integrator. The column pecked with Hitachi custom ion exchange resin 2618 (0.4 × 50 cm) was eluted by water at flow rate of 0.2 ml/min and 40°C. Carbohydrate was detected using a Shodex refractive indicator model SE-11.

PC of carbohydrates was performed on Toyo No. 51 filter paper using a solvent system of n-butanol-pyridine-water (6 : 4 : 3, V/V). After three times repeated development at room temperature, the paper was stained with silver nitrate solution according to the method of Robyt and Franch[4].

(4) *Analysis of organic acid by HPLC.*

Five grams of kecap sample were diluted with 10 ml of water and acidified to pH 1—2 by 3 N HCl, then extracted with ethyl ether for 20 hours in Soxhlet apparatus modified for the extraction of liquid samples. The extract was alkalinized with 2 N NH_4OH, then the ether was evaporated off. Remaining water layer was collected in 10 ml volumetric flask and filled with water after acidification with 2 N phosphoric acid to about pH 2.

Analysis by HPLC was achieved using the same equipment used for carbohydrate analysis. Column packed with 2618 resin (0.4 × 50 cm) was eluted with 0.05% phosphoric acid at flow rate of 0.3 ml/min and 50°C. The elution was monitored at 210 nm.

RESULTS

Ten kecap samples collected from various areas in Indonesia are classified into 2 common, 4 sweet, 3 salty and 1 viscous types according to the indication on the bottles. There are, however, no legal compositional standards on kecap in Indonesia. The classification of products is usually according to the convenience of manufactures.

Table 2. General composition of kecap.

Kecap Sample No.	Type	Place	Moisture (%)	Crude Protein (%)	Fat (%)	Ash (%)	Carbo-hydrate (%)	Total N (%)	Formol N (%)	Formol N / Total N × 100	NaCl (%)
1.	Common	Celebes	50.96	0.54	0.29	7.70	40.51	0.09	0.05	55.55	6.76
2.	Common	Java	31.56	1.57	0.30	10.90	55.67	0.27	0.06	22.22	8.68
3.	Sweet	Sumatra	44.55	1.19	0.25	6.10	47.91	0.21	0.09	42.86	5.17
4.	Sweet	Sumatra	27.17	1.43	0.13	5.82	65.45	0.25	0.05	20.00	4.37
5.	Sweet	Celebes	66.44	0.80	0.29	6.20	26.27	0.14	0.02	14.28	3.30
6.	Sweet	Java	29.61	1.46	0.14	7.64	61.15	0.26	0.07	26.92	6.27
7.	Salty	Sumatra	58.60	1.84	0.39	19.81	19.36	0.32	0.17	53.12	19.69
8.	Salty	Java	63.84	6.55	0.35	18.48	10.78	1.14	0.65	57.02	18.43
9.	Salty	Celebes	70.86	3.44	0.21	21.65	3.84	0.59	0.33	55.93	20.80
10.	Viscous	Java	42.70	3.42	0.29	10.78	42.81	0.60	0.17	28.33	10.04
	Japanese Soy Sauce	Common	69.5*	7.5*	—	15.9*	7.1*	1.46**	0.83**	56.85**	14.8*

* Cited from Reference 5.

** Cited from Reference 6, average of 12 samples.

Analytical data on general components of kecap are given in Table 2. The most variable and major components was carbohydrate ranging from 3.8 to 65.5%. The carbohydrate of samples especially in sweet, common and viscous types were much higher than the Japanese soy sauce. The content of carbohydrate was directly corelated to the amount of palm or cane sugar added during kecap manufacturing process. The moisture content of kecaps with highest carbohydrate content was lower than 30%. Such kind of kecap is characterized usually by a high viscosity.

The ash content of kecap is, on the contrary, very low in sweet type kecaps. Ash was composed of not only NaCl but also other minerals which were derived from palm sugar. Salty type kecap indicate similar ash content to the Japanese soy sauce, and such ashes are composed mainly of NaCl.

Crude protein and formol nitrogen content of kecap were considerably lower than those of the Japanese soy sauce except one sample. The ratios of formol nitrogen to total nitrogen were also lower in several samples than Japanese soy sauce. These facts indicate that soybean protein is not so well hydrolyzed during fermentation into low molecular components as Japanese soy sauce.

Specific gravity, pH and titrative acidity are shown in Table 3. Specific gravities of kecap containing high carbohydrate are much higher than Japanese soy sauce. Kecaps are somewhat more acidic in pH values than Japanese soy sauce, however, titrative acidities are considerably lower. This indicates that the buffer capacity of kecap is poor mainly due to the low content of nitrogen compounds in kecap.

Table 3. Some Characteristics of kecap.

Kecap sample No.	Specific gravity	pH	Acidity	
			I	II
1.	1.243	4.42	3.28	1.68
2.	1.391	4.26	9.45	5.40
3.	1.274	4.48	4.44	1.89
4.	1.384	4.26	7.80	3.45
5.	1.170	4.68	9.85	2.20
6.	1.371	4.45	7.90	4.43
7.	1.274	3.85	8.28	4.24
8.	1.145	4.42	12.77	10.47
9.	1.202	4.63	5.05	5.65
10.	1.325	4.26	9.96	5.38
Japanese* Soy sauce	1.18*	4.72**	12.06**	11.57**

* Cited from Reference 5.

** Cited from Reference 6, average of 12 samples.

Composition of free amino acids in kecap is given in Table 4. Much lower contents of free amino acids were found in kecap than the Japanese soy sauce except one sample, as has already been expected from the result of the formol nitrogen analysis.

Table 4. Compositions of free amino acid in kecap.

Amino acid	Kecap sample No. (g/100 g)					Japanese* soy sauce g/100 g
	1	3	7	8	10	
Asp	0.008	0.030	0.076	0.425	0.028	0.58
Thr	0	0.009	0.044	0.212	0.015	0.23
Ser	0	0.013	0.054	0.290	0.022	0.50
Glu	0.005	0.100	0.196	0.626	0.049	1.45
Pro	0	0.010	0.051	0.162	0.020	0.63
Gly	0	0.005	0.023	0.149	0.009	0.24
Ala	0	0.019	0.072	0.301	0.076	0.35
Val	0	0.015	0.067	0.305	0.028	0.35
Met	0	0	0.017	0.080	0	0.06
Ileu	0	0.019	0.067	0.288	0.024	0.33
Leu	0	0.021	0.094	0.410	0.045	0.52
Tyr	0	0.022	0.065	0.152	0.054	0.07
Phe	0	0.016	0.064	0.240	0.032	0.25
Lys	0	0.010	0.063	0.272	0.030	0.42
His	0	0	0.018	0.090	0	0.07
Arg	0	0	0.048	0.269	0	0.13
Try	0	0	0	0	0	0.04
Cys	0	0	0	0	0	0.07
NH_3	0.003	0.010	0.032	0.126	0.075	—
Total Amino acid	0.013	0.289	1.019	4.271	0.432	6.29

* Cited from Reference 5.

Paper chromatogram of carbohydrate in kecap is represented in Fig. 4. The carbohydrate consist of glucose, fructose, sucrose and several minor additional components. The glucose spot may include galactose which might be derived from raffinose contained in soybean. Similarly, arabinose is presumed to be contained in the spot of fructose. In kecap, however, the carbohydrates introduced by the addition of palm sugar are usually much more dominant than those from soybean. Palm sugar is mainly composed of sucrose, glucose and fructose.

Analytical data on the three main sugars obtained by HPLC method are given in Table 5. The sugars were classified for convenience into sucrose, glucose and fructose, though fructose peak was overlapping with those of

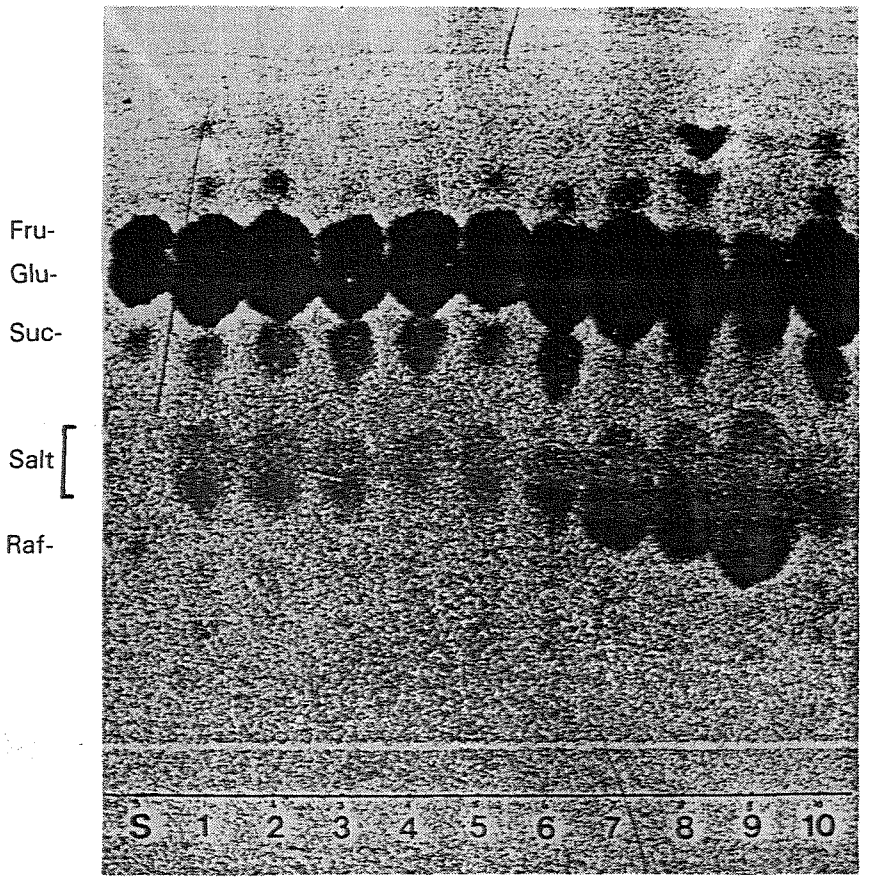

Fig. 4. Paper chromatogram of carbohydrates in kecap.
S; Standard Sugars, Fru; Fructose, Glu; Glucose, Suc; Sucrose, Raf; Raffinose, 1 — 10; No. of Kecap Samples.

other minor monosaccharides. The three sugars composed of 40% to 90% of the total carbohydrate in kecaps. The remaining part is composed of oligosaccharides.

Composition of organic acids in kecap measured by HPLC method is given in Table 6. Typical HPLC chromatogram is also presented in Fig. 5. Several components are overlapping and some peaks are remaining unidentified.

Lactic acid is the most dominant component in kecap as Japanese soy sauce[8], but some kecaps are also high in succinic, pyroglutamic or butyric acid content. Each type of kecap could not be well characterized by their organic acids composition. The organic acids in kecap are originated not only from

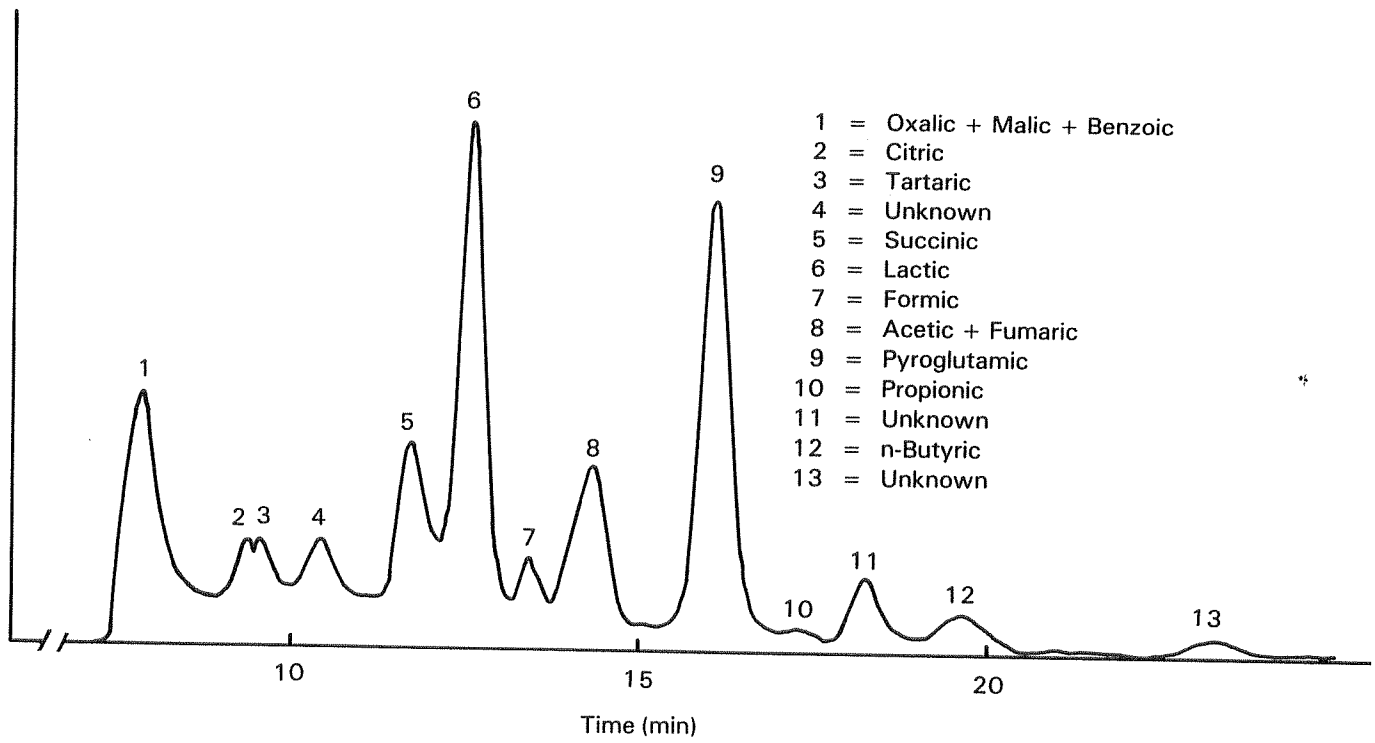

Fig. 5. HPLC chromatogram of organic acids in kecap.

Table 5. Major sugar composition in kecap.

Kecap Sample No.	Sucrose (%)	Glucose (%)	Fructose* (%)
1.	9.77	11.88	11.11
2.	18.26	11.08	12.06
3.	19.10	9.73	8.26
4.	26.76	16.12	16.40
5.	4.30	3.19	5.90
6.	28.05	13.24	11.93
7.	1.93	4.44	6.18
8.	1.79	2.68	1.43
9.	0.00	0.37	1.12
10.	14.85	8.45	9.81

* Containing other minor monosaccharides.

Table 6. Composition of organic acids in kecap (mg/100 g).

Kecap Sample No.	Citric	Tartaric	Succinic	Lactic	Formic	Pyroglu-tamic	Pro-pionic	Butyric
1.	57.7	6.4	295.8	803.8	20.9	58.2	0.0	8.0
2.	46.0	5.8	342.4	1179.9	50.3	120.9	0.0	17.0
3.	81.6	5.1	62.4	306.1	0.0	54.2	0.0	94.2
4.	78.0	40.5	43.4	780.3	13.0	57.8	0.0	190.8
7.	43.9	23.5	23.5	725.2	0.0	34.5	28.3	169.5
8.	104.7	3.5	0.0	43.6	7.0	194.6	0.0	3.5
10.	3.0	6.0	52.8	814.5	4.5	8.3	21.1	103.3

soybean fermentation but probably also from palm sugar and the latter is even dominant supplier of organic acids.

DISCUSSION

Kecap is fundamentally produced by fermentation of soybean. However, the composition of the final product varies depending on the mixed ingredient.

Palm sugar or sometimes cane sugar is added to give sweet taste in kecap. Palm sugar is produced by heat evaporation of sugar palm juice collected from palm trees. Fresh palm juice from the inflorescence of the palm trees consists mainly of sucrose, but a part of the sucrose is easily decomposed into glucose and fructose by microbial enzymes while juice is being collected on the tree or during storage before heat treatment. A part of sugars is further transformed into several converted sugars. Some additional organic

acids are also generated in this period. Such components are introduced into kecap by palm sugar and therefore, the composition of kecap is closely related to those of the palm sugar. This may also be the case if cane sugar or molases is used.

Low content of crude protein, formol nitrogen and free amino acid of kecap are implying a poor digestability of soybean protein during fermentation process. In addition, over extraction of moromi by brine and the subsequent addition of palm or cane sugar may result in a lowering of the relative concentration of nitrogen components. In some cases, the volume of the final kecap product multiplies 10 to 15 times from the volume of moromi. From the view point of fermentation technique, it is noted that, in comparison with Japanese soy sauce, the ratios of formol nitrogen to total nitrogen are lower. It would be possible to increase the ratios by the improvement of microbial strains and fermentation processes for kecap making.

Few analytical data have been presented on the composition of kecap[1,2]. Our data together with those are indicating wide variation of the composition of kecap from one product to the others due to several processing factors.

ACKNOWLEDGEMENT

The authors are greateful to the Research Center of Ajinomoto Co, Tokyo for the analysis of free amino acid, and Dr. K. Matsushima of Mie University, Dr. T. Yokotsuka of Kikkoman Corporation and Dr. A. Kuninaka of Yamasa Shoyu Co. Ltd. for their kind advices and suggestions.

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