Lipids in Japanese Noodle Flours[1]

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ABSTRACT

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Lipids in Japanese salt and alkaline noodle flours and in Australian soft white wheat (SWW) flours were extracted and compared. Nonstarch lipid (NSL) and free lipid (FL) levels ranges were 1.33–1.71% and 0.84–1.04%, respectively, for nine Japanese salt noodle flours compared to 1.43–1.50% and 0.97–1.00% for three Australian SWW flours used mainly to prepare salt noodle. The six Japanese alkaline noodle flours averaged ≈15% less NSL and 20% less FL than the Australian flours. The NSL was separated by column chromatography into nonpolar lipid (NL), glycolipid (GL), and phospholipid (PL) fractions. The NSL extracted from salt noodle and Australian flours contained ≈36% more NL than that from alkaline noodle flour. The composition of NSL was similar for salt noodle and Australian SWW flours but was different for alkaline noodle flour. Japanese salt noodle flour could be differentiated from alkaline noodle flour by the higher levels of NSL and FL, although those elevated levels may be caused in part to the somewhat higher extraction rate for the salt-noodle flours. However, two parameters independent of extraction rate, the ratios of NL/PL and NL/ash were 47 and 15% higher, respectively, in the salt vs. alkaline noodle flours.

Lipids from grains and their flours are named according to the methods of extraction. Free lipid (FL) is removed by extraction with hydrocarbon solvents, nonstarch lipid (NSL) with polar organic solvents plus water at room temperature, and total lipid including starch lipid by hot polar organic solvents plus water or by hot acid-hydrolysis or methanolysis to release bound lipids. The lipids and their components in bread flours have been extracted and investigated extensively (Daftary et al 1968, MacRitchie 1977, Chung 1986, Panozzo et al 1990) but not those in noodle flours.

According to Niihara et al (1982) and Niihara and Yonezawa (1990), the free fatty acids formed during storage of *somen*, a type of Japanese dry noodle, inhibited the swelling of starch during cooking and caused an increase in tensile strength of the cooked noodle and a decrease in cohesiveness. Rho et al (1989) found that wheat flour from which FL had been extracted gave salt noodles with decreased surface firmness after cooking, but that flour reconstituted with the FL or its nonpolar (NL) fraction restored noodle quality. Niihara and Harigai (1991) also extracted FL from flour and added it back at different levels. They observed that an increase in FL enhanced the firmness but decreased the cohesiveness of cooked noodles. Total lipid in Australian flours used for salt noodles measured ≈10% below that in U.S. soft and hard wheat flours, whereas the NSL occurred at approximately an equal level, suggesting that the Australian flours had reduced lipid in the starch (Wang and Seib 1996).

In this work, we compared the levels of FL and NSL in Japanese salt and alkaline noodle flours. We fractionated the NSL into NL-, glyco-, and phospholipids, and we compared the ratios in the two types of noodle flours. In another article (Jun et al 1998) on Japanese salt and alkaline noodle flours, we contrasted the protein quantity and quality, granulation, starch damage, and hot-water swelling power.

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MATERIALS AND METHODS

Materials

The 18 flours used included nine commercial salt noodle flours, six commercial alkaline noodle flours, and three Australian soft white wheat (SWW) flours. The 15 commercial noodle flours were obtained from two milling companies in Japan. The Australian SWW flours were milled from the cultivars Eradu, Gamenya, and Cadoux on a Buhler pilot mill to 60% extraction rate in Perth, Western Australia. All chemicals were reagent-grade unless otherwise noted. Silicic acid was Bio-Sil A (100–200 mesh) from Bio-Rad Laboratories (Richmond, CA) and nitrogen gas was ultrapure grade.

General Methods

Protein (N × 5.7) was measured by the Dumas method using a nitrogen determinator (Leco Corp., St. Joseph, MI). Flour ash (Method 08-01) and moisture (Method 44-15A) contents were determined by Approved Methods (AACC 1995). All assays were duplicated.

Extraction of FL and NSL

The FL was extracted from flour (10 g, db) with 200 mL of petroleum ether (bp 35–60°C) for 16 hr on a Soxhlet apparatus (Chung et al 1982). To isolate NSL, 5 g (db) of wheat flour was extracted successively with 200, 100, and 50 mL of a mixture of ethanol, ethyl ether, and water (2:2:1, v/v) (EEW) at 25°C as described by Wootton (1966) and Chung (1973) with modification. Each flour slurry was shaken vigorously by hand with 200 mL of EEW for 1 min in a glass-stoppered Erlenmeyer flask. The mixture was allowed to stand for 10 min and shaken again vigorously for 1 min. After filtering off the solids and rinsing, the second and third extractions were done for 12 min each (two 1-min extractions with 10-min rest). The solvents in the combined filtrates were evaporated on a rotary evaporator under reduced pressure at 30°C. Lipids were recovered from the crude extracts by dissolving in 100 mL of petroleum ether at 25°C and centrifuging in a capped centrifuge tube at 20,000 × *g* for 10 min at 4°C. After decanting, the residue was subjected to the dissolving and centrifuging procedure again. The supernatants were combined, and the solvents removed by a rotary evaporator under reduced pressure at 30°C until ≈1 mL remained. The concentrate was redissolved in 5 mL of petroleum ether at 25°C and transferred to a tared vial (16 × 50 mm). The solvent was evaporated under a gentle stream of nitrogen gas at 35°C, and the amount of lipids weighed. Lipid extraction was performed in duplicate.

Fractionation of NSL

The NSL from 5 g of flour was dissolved in 5 mL of chloroform and added to the top of a column (1.2 × 25 cm) of silicic acid (15 g) in chloroform. After the NL fraction was eluted with 150 mL of a mixture of chloroform and acetone (4:1, v/v), 150 mL of acetone was used to elute the glycolipid (GL) fraction. Lastly, the phospholipid (PL) fraction was eluted with 100 mL of methanol. The sum of GL and PL was polar lipid (PoL). The elution rate was 1.2 mL/min, and elution was monitored by spot tests on thin-layer plates coated with silica gel (Fisher Scientific, Pittsburgh, PA). The solvent in a fraction was evaporated on a rotary evaporator under reduced pressure at 30°C until ≈1 mL remained. The NL and GL concentrates were dissolved in 5 mL of petroleum ether, and PL concentrates were dissolved in 5 mL of a mixture of chloroform, methanol, and water (70:27:3, v/v). Each lipid fraction was transferred into a tared vial (16 × 50 mm), dried under a gentle stream of nitrogen gas in a water bath at 35°C, and weighed. Lipid fractionation was replicated twice. The recovery of the three fractions averaged >97% of the NSL.

Statistical Analysis

Data were analyzed with the SAS software system (release 6.04, SAS Institue, Cary, NC) using analysis of variance (ANOVA), Fisher's least significant difference (LSD), the Pearson correlation coefficient (r), and the general linear model (GLM).

RESULTS AND DISCUSSION

Flour Protein, Ash, and Lipid Levels

Protein levels of the Japanese salt noodle flours ranged from 8.5 to 10.4% with a mean of 9.0% (Table I). The mean protein level was similar to that of the Australian SWW flours (9.2%) but below that of the Japanese alkaline noodle flours (11.4%). Both Australian and salt noodle flours contained more ash than the alkaline noodle flours, indicating a low extraction rate for the latter. Generally, a low-extraction flour from soft wheat would be expected to have a somewhat lower ash content than a low-extraction hard wheat flour (Ziegler and Greer 1971).

The FL in salt noodle flours averaged 0.94%, and NSL averaged 1.51% (Table I). Alkaline noodle flours, on the other hand, contained decidedly lower levels of FL and NSL, with mean values of 0.77 and 1.26%, respectively. The levels of FL and NSL in the salt noodle flours were similar to the levels in the Australian SWW flours, indicating that the salt noodle flours may have been milled mostly from those wheats. If the extraction rate for the alkaline noodle flour was lower, this might have resulted in less contamination with aleurone and germ fragments, which would contribute to reductions in the FL and NSL.

One may speculate that the increased level of FL and NSL in salt noodle flour would contribute to the soft eating texture of salt versus alkaline noodles. In addition, Rho et al (1989) demonstrated the importance of FL to surface firmness of salt noodles.

NSL Fractions

The NL fraction was ≈34% higher in the salt noodle flour than in the alkaline noodle flour (Table II). The NL fractions in the three Australian SWW flours also were elevated compared to those in the alkaline noodle flour, again suggesting the use of those soft wheats for salt noodles (Jun et al 1998). The PL and PoL levels in the salt and alkaline noodle flours did not differ, and GL differed slightly. A significant correlation (r = 0.94, P < 0.01) was found between the levels of NSL and NL for all flours (Fig. 1), which indicates that an increase in the NSL level of the flour is caused mainly by an increase in the NL level. This is in agreement with the results of Kim and Seib (1993), who reported that the NL fraction contributed to the difference in the NSL level.

A flour with a high ash content usually contains more lipid from germ and aleurone (Morrison 1988) because the ash content reflects the extraction rate. The lipid level was divided by ash level to compensate for the proported difference in extraction rate (Table II). The salt noodle flour showed a higher NL-to-ash value (mean 1.51) than the alkaline noodle flour (mean 1.31), while the PoL-to-ash value of the alkaline noodle flour (1.74) was higher than that of

TABLE I
Protein, Ash, and Lipid Contents of Wheat Flours[a]

Flour Samples	Components (%)			
	Protein[b]	Ash[b]	Free Lipids[c]	Nonstarch Lipids[c]
Japanese salt noodle (n = 9)				
1	8.5	0.42	0.84	1.33
2	9.0	0.42	0.89	1.44
3	8.8	0.39	0.84	1.46
4	8.7	0.41	0.95	1.46
5	9.0	0.42	1.04	1.71
6	8.9	0.44	0.98	1.43
7	8.8	0.38	0.99	1.51
8	10.4	0.39	0.94	1.60
9	8.7	0.39	1.01	1.54
Mean	9.0a[d]	0.41a	0.94a	1.51a
Japanese alkaline noodle (n = 6)				
1	11.4	0.36	0.74	1.14
2	11.6	0.34	0.77	1.25
3	11.4	0.35	0.78	1.25
4	11.5	0.34	0.81	1.37
5	11.3	0.37	0.74	1.27
6	11.5	0.35	0.78	1.28
Mean	11.4b	0.35b	0.77b	1.26b
Australian soft white wheat				
Eradu	9.2	0.41	0.97	1.50
Gamenya	9.2	0.44	0.98	1.43
Cadoux	9.1	0.41	1.00	1.46
Mean	9.2a	0.42a	0.98a	1.46a
LSD[e]	0.3	0.03	0.05	0.07

[a] Data are averages of two replicates.
[b] Calculated on 14% mb.
[c] Calculated on dry basis.
[d] Means followed by different letters in the same column are significantly different (P < 0.01).
[e] Least significant difference for 18 samples (P < 0.05).

the salt noodle flour (1.58). The values of NL-to-ash and PoL-to-ash did not differ between the salt noodle and Australian flours. These results indicate that a salt noodle flour contains elevated NL as compared to an alkaline noodle flour, which probably softens the eating texture of the cooked noodles.

Composition of NSL

The salt noodle and Australian SWW flours displayed different lipid compositions in NSL when compared to the alkaline noodle flour (Table III). Both salt noodle and Australian flours were richer in the NL fraction, whereas the alkaline noodle flour was richer in

TABLE II
Nonstarch Lipid (NSL) Fractions and Ratios to Ash Levels of Wheat Flours[a]

	Lipid Fractions[b] (%, db)				Ratios	
Flour Samples	**NL**	**GL**	**PL**	**PoL**	**NL/Ash**	**PoL/Ash**
Japanese salt noodle						
1	0.59	0.46	0.25	0.71	1.20	1.45
2	0.69	0.43	0.20	0.63	1.41	1.30
3	0.70	0.51	0.20	0.70	1.55	1.55
4	0.70	0.53	0.23	0.76	1.47	1.59
5	0.78	0.57	0.25	0.82	1.60	1.68
6	0.68	0.49	0.25	0.73	1.33	1.43
7	0.74	0.49	0.28	0.77	1.68	1.73
8	0.78	0.50	0.31	0.81	1.71	1.79
9	0.75	0.48	0.28	0.76	1.65	1.68
Mean	0.71a[c]	0.50a	0.25a	0.75a	1.51a	1.58a
Japanese alkaline noodle						
1	0.49	0.41	0.24	0.65	1.17	1.55
2	0.52	0.45	0.26	0.71	1.32	1.80
3	0.53	0.43	0.27	0.70	1.30	1.72
4	0.60	0.45	0.32	0.77	1.51	1.94
5	0.53	0.44	0.27	0.71	1.23	1.66
6	0.54	0.44	0.27	0.71	1.33	1.74
Mean	0.53b	0.44b	0.27a	0.71a	1.31b	1.74b
Australian soft white wheat						
Eradu	0.71	0.51	0.28	0.79	1.48	1.65
Gamenya	0.74	0.44	0.23	0.67	1.45	1.30
Cadoux	0.71	0.47	0.27	0.75	1.49	1.57
Mean	0.72a	0.47ab	0.26a	0.73a	1.47a	1.51a
LSD[d]	0.04	0.04	0.03	0.05	0.11	0.12

[a] Data are averages of two replicates.
[b] NL = nonpolar lipids, GL = glycolipids, PL = phospholipids, and PoL = polar lipids (the sum of GL and PL).
[c] Means followed by different letters in the same column are significantly different ($P < 0.01$).
[d] Least significant difference for 18 samples ($P < 0.05$).

TABLE III
Nonstarch Lipid (NSL) Fractions and Ratios in Wheat Flours[a]

	Lipid Fractions[b] (% NSL)			Ratios	
Flour Samples	**NL**	**GL**	**PL**	**NL/PL**	**NL/PoL**
Japanese salt noodle					
1	45.4	35.7	18.9	2.40	0.83
2	52.0	32.8	15.2	3.42	1.08
3	50.0	36.1	13.9	3.60	0.96
4	47.9	36.4	15.8	3.04	0.93
5	48.6	35.5	16.0	3.05	0.94
6	48.4	34.6	17.0	2.85	0.95
7	49.3	32.1	18.6	2.65	0.97
8	49.0	31.7	19.3	2.54	0.97
9	49.7	31.6	18.7	2.65	0.99
Mean	48.9a[c]	34.1a	17.0a	2.91a	0.96a
Japanese alkaline noodle					
1	43.1	35.9	21.1	2.04	0.76
2	42.7	36.4	20.9	2.04	0.75
3	43.1	35.0	21.8	1.97	0.76
4	43.7	33.1	23.2	1.88	0.78
5	42.6	35.5	21.9	1.95	0.74
6	43.2	35.4	21.4	2.02	0.76
Mean	43.0b	35.2a	21.7b	1.98b	0.76b
Australian soft white wheat					
Eradu	47.2a	33.9	18.9	2.50	0.89
Gamenya	52.5	31.0	16.4	3.20	1.11
Cadoux	48.8	32.5	18.7	2.61	0.95
Mean	49.5a	32.5a	18.0a	2.77a	0.98a
LSD[d]	2.8	2.7	2.5	0.45	0.11

[a] Data are averages of two replicates.
[b] NL = nonpolar lipids, GL = glycolipids, PL = phospholipids, and PoL = polar lipids.
[c] Means followed by different letters in the same column are significantly different ($P < 0.01$).
[d] Least significant difference for 18 samples ($P < 0.05$).

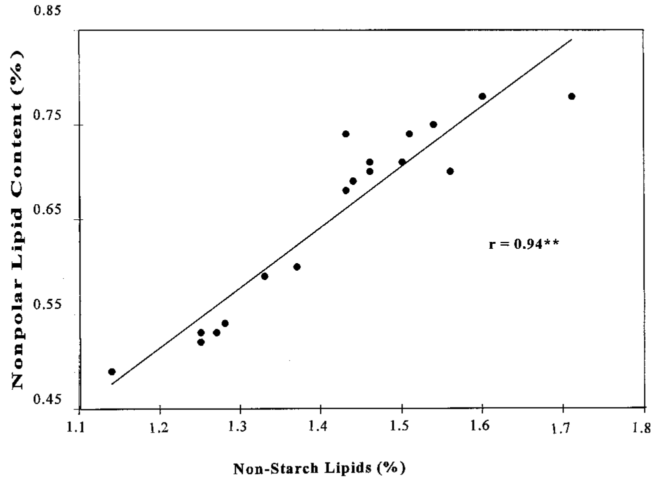

Fig. 1. Relationship between the levels (% flour weight, db) of nonstarch lipid and nonpolar lipid fraction in 18 wheat flours.

the PL fraction, while the GL fraction in the NSL was the same in salt and alkaline noodle flours. In contrast, FL from soft wheat endosperm has been reported to contain more PoL than that from hard wheat (Morrison et al 1989). However, Hargin and Morrison (1980) reported that the NL fraction in the NSL of an English soft wheat (Atou) flour was higher than that in the NSL of an English hard wheat (Flinor) flour, but the PoL fraction of Atou was lower. The ratio of NL to PL or NL to PoL may provide another index to differentiate a salt noodle flour from an alkaline noodle flour (Table III). The average ratio of NL to PL in the NSL from salt noodle flour was 2.91, which was higher than the 1.98 in the NSL from alkaline noodle flour. The Australian SWW flour showed a mean ratio of NL to PL in NSL that was similar to that of the salt noodle flour.

CONCLUSIONS

Japanese salt noodle flour contained elevated levels of FL and NSL as compared to alkaline noodle flour. The neutral lipid fraction in the nonstarch lipids was responsible for the elevated lipids in the salt noodle flour. Those differences in lipid levels may be added to other characteristics of Japanese salt noodle flour to distinguish it from alkaline noodle flour, namely, higher hot-water swelling power, lower starch damage, brighter color, and 2–3 percentage points less protein but of higher inherent strength (Jun et al 1998).

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