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Changes in the Nutrient Values of Sardines and Pink Salmon after High-pressure-high-temperature Processing

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Abstract

To promote daily fish and shellfish consumption in schools, hospitals, and care facilities, as well as ordinary households, we analyzed the nutritional components of sardines and pink salmon processed by the high-pressure-high-temperature (HPHT) method.

We performed the nutrition analysis, adopting the methods used to create the [Food Composition Tables (Seventh Revised Edition)]. On comparing the nutrient values of HPHT-processed sardines and pink salmon with those of raw/water-boiled/water-boiled and canned sardines[1] and raw/water-boiled and canned pink salmons[2] shown in the Standard Tables of Food Composition in Japan 2015 - (Seventh Revised Version), we obtained the following findings:

1) The amount of proteins did not decrease after HPHT processing in either case. With the protein content accounting for approximately 20%, these products may be useful as convenient sources of proteins.

2) Although HPHT-processed sardines and pink salmon are seasoned, they may contribute to salt reduction, as the amount of sodium was as low as about 0.2-0.5 g.

3) Both HPHT-processed sardines and pink salmon had markedly higher iron and calcium contents than raw and water-boiled controls. Therefore, they may also contribute to the intake of calcium and iron, the 2 nutrients Japanese people tend to lack.

キーワード： high-pressure-high-temperature (HPHT) processing, sardines, pink salmon, nutrient values

Introduction

Being rich in aquatic resources, Japan has been a country with a thriving fishing industry and a variety of fish and shellfish dishes consumed since ancient times.

According to the Annual Report on the Developments in Japan's Fisheries in FY2018[3], the amount of fish and shellfish consumption is markedly decreasing, revealing consumers' reduced preference for fish, and changes in consumers' attitudes toward food may be a cause. A consumer confidence survey conducted by Japan Finance Corporation in July 2020 reported that today's consumers place importance on health, economy, and convenience, rather than safety and homemade tastes[4]. Many people find fish dishes burdensome to cook and eat. On the other hand, in an awareness survey on fish dishes involving married females, respondents, mainly younger groups, wishing to increasingly cook and consume fish dishes accounted for more than 50%, suggesting a high potential demand for fish and shellfish[5]. Furthermore, more than 90% of all parents recognize the importance of conveying techniques to eat fish and the culture of its consumption to their children. Thus, many parents are aware of the necessity of showing how to eat fish[6].

Under these circumstances, it may be necessary to convey the palatability of fish and shellfish by providing easy-to-eat fish dishes, including appropriately teaching how to eat fish with bones in school lunch services, where a certain degree of convenience is also required, in addition to safety assurance, as large quantities of food should be cooked in a short time.

Nowadays, an increasing number of processed, already-cooked foods, such as those with bones completely removed and those that are ready only after heating up in the microwave, are available for ordinary households to prepare meals, skipping conventional cooking processes. In this modern society facing aging, the processing of fish and shellfish to make them easy for everyone to eat may also allow hospitals and care facilities to provide richer meals.

To promote daily fish and shellfish consumption in schools, hospitals, and care facilities, as well as ordinary households, we measured the nutrient values (energy, Water, protein, lipid, carbohydrate, total dietary fiber, ash, calcium, and iron contents, and sodium chloride equivalent) of sardines and pink salmon processed by the high-pressure-high-temperature (HPHT) method.

Materials and Methods

1. Materials

We used HPHT-processed and seasoned sardines and pink salmon as samples.

1) Sardines

We used sardines processed by Kishimoto Co., Ltd. (Ehime Prefecture); sardines (head and viscera removed) landed at Kushiro Port in Hokkaido were placed in a vacuum with a seasoning solution (10 g of sugar, 7 g of plum paste, 4.9 g of dark soy sauce, 2.4 g of mirin, and 0.62 g of salt per 100 g), and processed by the HPHT method (Photograph 1). We adopted these sardines as a sample for measurement after wiping the seasoning solution on the surface off and mixing using a food processor.

2) Pink salmon

We used pink salmon processed by Kishimoto Co., Ltd. (Ehime Prefecture); pink salmon (head and viscera removed) from Hokkaido was cut at the center, with the backbone included, soaked it in a saline solution of 0.5% for 1 night, cold air-dried, placed in a vacuum, and processed by the HPHT method (Photograph 2). We adopted this pink salmon as a sample for measurement after wiping the Water content on the surface off and mixing using a food processor.

2. Component analysis

We analyzed general components, adopting the official analytical methods specified in the Standard Tables of Food Composition in Japan 2015 - (Seventh Revised Version)[7]. As for inorganic components, we determined the amount of iron by the spectrophotometric method using phenanthroline[8], and that of calcium by the chelatometric titration method[9].

1) Energy

To calculate the energy content, we multiplied the analytical protein, lipid, and carbohydrate values per the edible part of 100 g by the energy conversion factors for fish and shellfish (proteins: 4.22 kcal/g, lipids: 9.41 kcal/g, and carbohydrates: 4.11 kcal/g).

Photograph 1: A sample of HPHT-processed sardines
Photograph 2: A sample of HPHT-processed pink salmon

2) Water

We calculated the Water contents of homogenized samples (1-3 g) by heating them to 105℃ under atmospheric pressure for drying and measuring the difference in the weight.

3) Proteins

We calculated the protein content by measuring the total amount of nitrogen in homogenized samples (approximately 1 g) using the Kjeldahl method and multiplying this by a nitrogen-protein conversion factor of 6.25.

4) Lipids

To calculate the lipid content, we extracted lipids from homogenized sample sardines (approximately 0.5 g) by the chloroform-methanol (Folch) method and from homogenized sample pink salmon (approximately 5 g) by the Soxhlet extraction method. In both cases, we isolated the lipid extraction solvent, volatilized the solvent, and calculated the lipid content based on the weight of the remnants.

5) Carbohydrates (Total sugar)

We calculated the carbohydrate contents of the homogenized samples (approximately 5 g) by colorimetry, adopting the anthrone-sulfuric acid method.

6) Dietary fiber

We analyzed dietary fiber in the homogenized samples (5 g) by the modified Prosky method.

7) Ashes

We calculated the ash contents of the homogenized samples (sardines: approximately 2-3 g; pink salmon: approximately 5 g) by heating them at 550℃ for 5-6 hours for incineration and measuring the weight of the remnants.

8) Sodium chloride equivalent

We measured the sodium chloride equivalent by dissolving samples in distilled water after incineration to determine the constant volume, adopting the Mohr method for precipitation titration.

9) Calcium

We calculated the calcium content by dissolving samples with dilute hydrochloric acid after incineration, determining the constant volume in distilled water, and determining the amount using the chelatometric titration method.

10) Iron

We calculated the iron content by dissolving samples with dilute hydrochloric acid after incineration, determining the constant volume in distilled water, and determining the amount, adopting the spectrophotometric method using phenanthroline.

Results and Discussion

1. Energy and carbohydrates

As shown in Table 1, the carbohydrate and energy values of the HPHT-processed sardines were higher than those of the controls (raw/water-boiled/water-boiled and canned sardines) in the Standard Tables of Food Composition in Japan 2015-(Seventh Revised Version), possibly due to the use of a seasoning solution containing sugar and mirin.

Similarly, as shown in Table 2, the carbohydrate and energy values of the HPHT-processed pink salmon were slightly lower than those of the controls (raw/water-boiled and canned), possibly due to a lower lipid content of individuals caught during this period, which resulted in a lower energy value.

2. Water

As shown in Table 1, the Water content of the HPHT-processed sardines was lower than those of the controls (raw/water-boiled/water-boiled and canned). Similarly, as shown in Table 2, the Water content of the HPHT-processed pink salmon was slightly lower than those of the controls (raw/water-boiled and canned). This may be explained by an outflow of Water during HPHT processing, as salt and a seasoning containing it were used.

Table 1 Nutrient Values of Sardines (per 100 g)

Component (Unit)	Raw sardine[1)]	HPHT-processed sardine	Water-boiled sardine[1)]	Water-boiled and canned sardine[1)]
Energy (kcal)	169	193±9.6	178	188
Water (g)	68.9	58.2±0.9	61.7	66.3
Proteins (g)	19.2	18.7±2.4	22.4	20.7
Lipids (g)	9.2	11.6±0.7	8.7	10.6
Carbohydrates (g)	0.2*	1.2±0.07	0.2*	0.1*
Dietary fiber (g)	(0)	0	(0)	(0)
Ashes (g)	1.2	2.3±0.06	1.3	2.3
Sodium chloride equivalent (g)	0.2	0.24±0.05	0.2	0.8
Calcium (mg)	74	380±30	82	320
Iron (mg)	2.1	17.7±2.7	2.3	2.6

*Total sugar

Table 2 Nutrient Values of Pink Salmon (per 100 g)

Component (Unit)	Raw pink salmon[2)]	HPHT-processed pink salmon	Water-boiled and canned pink salmon[2)]
Energy (kcal)	154	141±18	156
Water (g)	70.1	65.9±0.8	69.7
Proteins (g)	21.7	24.5±4.0	20.7
Lipids (g)	6.6	4.0±2.8	7.2
Carbohydrates (g)	0.1*	0.05±0.01	0.1*
Dietary fiber (g)	(0)	0	(0)
Ashes (g)	1.5	2.7±0.15	2.3
Sodium chloride equivalent (g)	0.2	0.5±0.07	0.9
Calcium (mg)	13	292±41	110
Iron (mg)	0.4	4.0±0.6	1.5

*Total sugar

3. Proteins

As shown in Table 1, the protein content of the HPHT-processed sardines was similar to those of the controls (raw/water-boiled/water-boiled and canned). Similarly, as shown in Table 2, the protein content of the HPHT-processed pink salmon was slightly higher than those of the controls (raw/water-boiled and canned).

The results clarified that there is no decrease in the amount of proteins after HPHT processing in either case. The protein contents of both the HPHT-processed sardines and pink salmon were approximately 20%, supporting the usefulness of these products as convenient sources of proteins.

4. Lipids

We initially adopted the Soxhlet extraction method to determine the lipid content of the HPHT-processed sardines, but measurement values markedly varied, possibly due to incomplete lipid extraction resulting from an excessive sample amount for filtration, a high fat level of sardines, which made it difficult to sufficiently dry samples, and their solidifying when mixed with diatomaceous earth and dried. Therefore, we changed to the chloroform-methanol method, and performed the measurement again. Tables 1 and 2 show the lipid contents of the HPHT-processed sardines and pink salmon, respectively.

The lipid content of each control sardine is as follows: raw: 9.2 g; water-boiled: 8.7 g; and water-boiled and canned: 10.6 g. The lipid content of water-boiled and canned pink salmon is 7.2 g. Compared with these values, the lipid content of the HPHT-processed sardines was slightly higher, 11.6 ± 0.7 g, whereas that of the HPHT-processed pink salmon was slightly lower, 4.0 ± 2.8 g.

As no high-fat seasonings are used to process sardines by the HPHT method, the former may have been due to the period of catching or individual differences associated with other factors. The latter may be explained by a decrease in the amount of lipids through HPHT processing or a lower lipid content of individuals caught during this period.

5. Ashes and dietary fiber

The ash content of the HPHT-processed sardines was higher than those of raw/water-boiled sardines, but it was similar to that of water-boiled and canned sardines, revealing that canned and HPHT-processed sardines contain a larger amount of ashes than raw and water-boiled sardines.

As shown in Table 1, the dietary fiber content of the controls (raw/water-boiled/water-boiled and canned) is estimated at 0. Our measurement confirmed that HPHT-processed sardines also contain 0 g of dietary fiber. The Standard Tables of Food Composition in Japan 2015-(Seventh Revised Version) show analytical values only for the edible parts of raw/water-boiled sardines, with bones, viscera, head, and fins removed. Therefore, they may also be estimating the ash contents low.

HPHT-processed pink salmon had a markedly higher ash content than raw pink salmon and slightly higher than water-boiled and canned pink salmon. As the Standard Tables of Food Composition in Japan 2015-(Seventh Revised Version) show analytical values only for slices of raw pink salmon, they may also be estimating the ash content low. On the other hand, as shown in Table 2, the dietary fiber content of HPHT-processed pink salmon was 0, similarly to the case of HPHT-processed sardines, and there were no differences from the controls (raw/water-boiled and canned).

6. Sodium chloride equivalent

As shown in Table 1, the sodium chloride equivalent of the HPHT-processed sardines was almost the same as those of raw/water-boiled sardines, but it was lower than that of water-boiled and canned sardines.

Similarly, as show in Table 2, the sodium chloride equivalent of HPHT-processed pink salmon with salt added was higher than that of raw pink salmon, but it was lower than that of water-boiled and canned pink salmon.

Both HPHT-processed sardines and pink salmon are already seasoned to be ready to eat, but they may contribute to salt reduction, as the amounts of sodium in them are low.

7. Calcium

As shown in Table 1, the calcium content of HPHT-processed sardines was approximately 5 times higher than those of raw/water-boiled sardines, and it was also higher than that of water-boiled and canned sardines. Similarly to the case of the ash content, the [Food Composition Tables] show analytical values only for the edible parts of raw/water-boiled sardines, with bones, viscera, head, and fins removed, and, therefore, it may also be estimating the calcium contents low.

Furthermore, as shown in Table 2, the calcium content of the HPHT-processed pink salmon was more than 20 times higher than that of raw pink salmon and more than double that of water-boiled and canned pink salmon. As the Standard Tables of Food Composition in Japan 2015-(Seventh Revised Version) show analytical values only for slices of raw pink salmon, it may also be estimating the calcium content low.

When processed by the HPHT method, bones also soften, and become edible. HPHT-processed sardines and pink salmon may become useful sources of calcium for Japanese people, who tend to lack this nutrient.

8. Iron

The iron content of the HPHT-processed sardines was about 7-8 times higher than those of raw, water-boiled, and water-boiled and canned sardines.

The iron content of the HPHT-processed pink salmon was approximately 10 times higher than that of raw pink salmon and approximately 3 times higher than that of water-boiled and canned pink salmon.

In the HPHT method, sardines are entirely processed without any part removed, and pink salmon, processed with only the head and viscera removed, become entirely edible, including bones. This explains the high iron content in both cases, and it also suggests that HPHT-processed sardines and pink salmon promote iron intake.

Conclusion

This study examined sardines and pink salmon processed by the high-pressure-high-temperature (HPHT) method. In this method, sardines are processed whole, without any part removed, whereas pink salmon, with the head and viscera removed, is processed until it becomes entirely edible, including bones, as they soften. We analyzed the nutritional components of HPHT-processed sardines and pink salmon, adopting the methods used to create the Standard Tables of Food Composition in Japan 2015-(Seventh Revised Edition)], and obtained the following findings:

1) The amount of proteins did not decrease after HPHT processing in either case. With the protein content accounting for approximately 20%, these products may be useful as convenient sources of proteins.

2) Although HPHT-processed sardines and pink salmon are seasoned, they may contribute to salt reduction, as the amount of sodium was as low as about 0.2-0.5 g.

3) Both HPHT-processed sardines and pink salmon had markedly higher iron and calcium contents than raw and water-boiled controls. Therefore, they may also contribute to the intake of calcium and iron, the 2 nutrients Japanese people tend to lack.

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References

1) Women's Nutrition College Publishing Department, Standard Tables of Food Composition in Japan 2015 (Seventh Revised Edition), 2020, 122-123
2) Women's Nutrition College Publishing Department, Standard Tables of Food Composition in Japan 2015 (Seventh Revised Edition), 2020, 130-131
3) Annual Report on the Developments in Japan's Fisheries in FY2018. Fisheries Agency
4) Consumer Confidence Survey, August 2020, Japan Finance Corporation, https://www.jfc.go.jp/n/findings/pdf/topic s_200805a.pdf Accessed on October 9, 2020
5) Annual Report on the Developments in Japan's Fisheries in FY2013. 119-121, Fisheries Agency

6) Annual Report on the Developments in Japan's Fisheries in FY2013. 123-124, Fisheries Agency
7) Akemi Yasui, Tomoko Watanabe, Takashi Nakazato, Kenichi Fuchigami, Analytical Manual and Commentary for the Standard Tables of Food Composition in Japan 2015 (Seventh Revised Edition), KENPAKUSHA, 2016, 11-13, 25-42, 51-59
8) Akemi Yasui, Tomoko Watanabe, Takashi Nakazato, Kenichi Fuchigami, Analytical Manual and Commentary for the Standard Tables of Food Composition in Japan 2015 (Seventh Revised Edition), KENPAKUSHA, 2016, 88
9) Basic Knowledge of Food Science and Experiment of Food Chemistry (Revised Version), Toshio Murakami, Masumi Ikeuchi, Yoshiaki Inada, Makoto Kotaru, Atsumi Shimada, Keiko Tanaka, Satoko Tanaka, Satsuki Miura, Hideki Yoshikawa, KENPAKUSHA, 2017, 32-33