INTRODUCTION

Hanpen is a traditional type of fish paste product made from minced fish (surimi) in Japan like imitation crab and kamaboko (fish cake). Hanpen is prepared from many kinds of fish species such as pollack, threadfin beam, white croaker, red bigeye, blue shark, and pike eel (Kuronuma & Shimomura, 2019). In addition to minced fish, Japanese yam, egg white, starch, and salt are also key ingredients of hanpen, and it contains a lot of air by trapping large amounts of fine foam inside. Therefore, one major characteristic of hanpen is its marshmallow-like, soft texture unlike imitation crab and kamaboko (Wakamatsu, Numata, & Nakamura, 1997). Generally in Japan, hanpen is known as a high-protein and low-fat food. However, very little research is available in the literature on health benefits of hanpen. Some fishes and fish paste products have bioactive compounds such as eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA),...
and fish protein beneficial for human health. Arai, Kim, Chiba, and Matsumoto (2009) showed that fish oils containing EPA and DHA inhibited body weight gain and exhibited an anti-obesity effect in female KK mice. Hung et al. (2000) reported that serum cholesterol (CHO), triglyceride (TG), and phospholipid levels of Sprague-Dawley rats fed EPA or DHA for 3 weeks were significantly lower than those in the rats fed safflower oil. In addition, one study demonstrated that fish protein hydrolysate reduced plasma T-CHO and increased the proportion of HDL-C in male Wistar rats (Wergedahl et al., 2004). Moreover, Mizushige et al. (2010) investigated the effect of Alaska pollack protein (APP) intake with high-fat diet on rats for 4 weeks and reported that intake of APP decreased serum TG and inhibited visceral body fat accumulation in rats. However, there are no experimental data on the effect of fish paste product, hanpen (Figure 1) intake in rats for 3 months.

In this study, we demonstrated the effect of hanpen intake on organ weight and biomarker levels in Sprague-Dawley rats fed a diet comprising hanpen for 84 days for the first time.

2 | MATERIALS AND METHODS

2.1 | Materials

The commercial KIBUN hanpen (Figure 1) was lyophilized. In brief, minced fish, surimi (pollack, red bigeye, and shortfin shark), were ground with Japanese yam, egg white, starch, salt, and other ingredients; trapped large amounts of fine foam inside; and then boiled.

2.2 | Animal experiments

Male, 6-week-old Sprague-Dawley rats purchased from SLC Japan, Inc. (Shizuoka, Japan) were individually housed under a 12-hr light/dark cycle (light phase; 8 a.m.-8 p.m., dark phase; 8 p.m.-8 a.m.) at a temperature of 23 ± 2°C, relative humidity of 50 ± 20% with aseptic food and tap water ad libitum, and divided into two groups: group I, fed AIN-93G (n = 8), and group II, fed AIN-93G with 5% dried hanpen (n = 8). Subjects had free access to food for 84 days. Body weight and food intake were measured once a week for each rat. After 84 days of administration, all rats were sacrificed under isoflurane inhalation anesthesia (concentration for induction of anesthesia: 4%, concentration for maintenance: 2%), and blood corresponding to a nonfasting state was collected. The blood was centrifuged at 1,657 g at 4°C for 10 min and stored at −80°C until the analysis. The weight of liver, spleen, kidney, white adipose tissue, interscapular brown adipose tissue, and skeletal muscle of each rat were measured. The experiments were performed at LA Centre in Oriental Yeast Co., Ltd. and authorized by the Japanese Government. The present study was conducted according to the ethical guidelines for laboratory animals and the standard operating procedures of the laboratory. The experimental protocol was approved by the animal experiment ethics committee of the laboratory (approval no. 19,003).

2.3 | Diets

Rats in group I were fed the AIN-93G (Oriental Yeast Co., Ltd.) as control diet. Rats in group II were given a diet in which dried hanpen replaced casein, L-cystine, and β-cornstarch. Formulation and nutrients of experimental diets in this study are shown in Tables 1 and 2.

2.4 | Statistical analysis

The results are presented as mean ± standard error. Statistical significance was evaluated by Student’s t test. A p-value of less than .05 was considered statistically significant.

| TABLE 1 Composition of the experimental diet |
|---------------------------------------------|
|                Group I (without hanpen) | Group II (with hanpen) |
|-----------------|-----------------|
| Casein          | 20.0            | 18.0            |
| L-Cystine       | 0.30            | 0.27            |
| β-Cornstarch    | 39.7486         | 36.0786         |
| α-Cornstarch    | 13.2            | 13.2            |
| Sucrose         | 10.0            | 10.0            |
| Soybean oil     | 7.0             | 7.0             |
| Cellulose       | 5.0             | 5.0             |
| Mineral mix, AIN-93G-MX | 3.5 | –               |
| Modified mineral mix | – | 3.5            |
| Tripotassium citrate | – | 0.7            |
| Vitamin mix, AIN-93G-VX | 1.0 | 1.0            |
| Choline bitartrate | 0.25         | 0.25            |
| Butylhydroquinone | 0.0014       | 0.0014          |
| Hanpen dry powder | –              | 5.0             |
| Total (%)       | 100             | 100             |

FIGURE 1 Fish paste product, KIBUN hanpen
3 | RESULTS

3.1 | Effect of hanpen on body weight, organ weight, adipose tissue weight, and muscle weight in Sprague-Dawley rats

The effects of oral administration of AIN-93G with 5% hanpen on body weight, organ weight, adipose tissue weight, and muscle weight in Sprague-Dawley rats are shown in Table 3. Total food intake of group II (1,906 ± 41 g for 84 days) tended to be higher than those of group I (1,765 ± 53 g for 84 days), but no significant differences were observed. Differences in body weight, spleen weight, adipose tissue weight, and muscle weight between group I and group II were not significant after administration for 84 days. On the contrary, liver and kidney weights of group II (liver: 22 ± 0.9 g, kidney: 3.5 ± 0.1 g) were higher than those of group I (liver: 19 ± 0.9 g, kidney: 3.1 ± 0.1 g) after 84 days, respectively.

3.2 | Effect of hanpen on biochemical parameters in Sprague-Dawley rats

Table 4 shows the analysis of blood biochemical parameters of rats after diets containing 5% dried hanpen administration. No marked differences were seen in almost all the biochemical parameters between group I and group II. The inorganic phosphorus (IP) level of group II (5.8 ± 0.1 mg/dl) was higher than that of group I (4.8 ± 0.1 mg/dl). The T-CHO and HDL-C levels of group II (T-CHO: 104 ± 5.4 mg/dl, HDL-C: 27 ± 1.6 mg/dl) were higher than those of group I (T-CHO: 83 ± 5.4 mg/dl, HDL-C: 27 ± 1.6 mg/dl) after 84 days, respectively. Moreover, interestingly, the LDH level of group II (492 ± 69 IU/L) was significantly lower than that of group I (700 ± 46 IU/L).

4 | DISCUSSION

A traditional Japanese diet and Japanese food products are widely known to be healthy, contributing to longevity and preventing various noncommunicable diseases (Gabriel, Ninomiya, & Uneyama, 2018; Ueshima, 2007). The traditional Japanese diets include rice, miso soup, soybean products, vegetables, fruits, Japanese pickles, seaweed, mushrooms, green tea, and fish (Kanauchi & Kanauchi, 2019). In addition to these products, fish paste products including kamaboko, imitation crab, and hanpen are also traditional Japanese foods. These products are made from minced fish, starch, and salt, and are easy to eat in comparison with raw fish containing skeletal bone and fish guts. Among them, hanpen, which contains Japanese yam and egg white as well as minced fish, starch, and salt, has a marshmallow-like, soft texture by trapping large amounts of fine foam inside (Figure 1). Raw hanpen (KIBUN hanpen) contains approximately 10.3% protein and 0.2% fat, and it is known as a high-protein and low-fat food. However, few studies have been conducted on its health benefits.

---

**TABLE 2** Composition of the nutritional analysis of the experimental diet

| Component       | Group I (without hanpen) | Group II (with hanpen) |
|-----------------|--------------------------|------------------------|
| Water g         | 9.00                     | 9.00                   |
| Energy kcal     | 368.00                   | 368.70                 |
| Crude protein g | 18.10                    | 18.10                  |
| Crude fat g     | 7.30                     | 7.20                   |
| Crude ash g     | 3.10                     | 2.90                   |
| Crude fiber g   | 5.00                     | 5.00                   |
| Nitrogen-free extract g | 57.60                  | 57.80                  |
| Ca g            | 0.52                     | 0.52                   |
| P g             | 0.32                     | 0.32                   |
| Mg g            | 0.05                     | 0.05                   |
| Na g            | 0.10                     | 0.11                   |
| K g             | 0.36                     | 0.35                   |

Abbreviations: Ca, calcium; K, potassium; Mg, magnesium; Na, sodium; P, phosphorus.

**TABLE 3** Effect of hanpen on body weight, organ weight, adipose tissue weight, and muscle weight in Sprague-Dawley rats (n = 8)

| Component            | Group I (without hanpen) | Group II (with hanpen) |
|----------------------|--------------------------|------------------------|
| Total food intake g  | 1765.230 ± 53.057        | 1906.075 ± 41.148      |
| Initial body weight g| 193.788 ± 1.687          | 193.663 ± 2.651        |
| Final body weight g  | 559.138 ± 18.433         | 589.038 ± 12.179       |
| Liver g              | 19.335 ± 0.869           | 22.245 ± 0.851*        |
| Kidney g             | 3.119 ± 0.088            | 3.480 ± 0.160*         |
| Spleen g             | 0.902 ± 0.048            | 0.908 ± 0.040          |
| White adipose tissue g| 27.660 ± 2.190          | 30.299 ± 1.065         |
| Brown adipose tissue g| 0.291 ± 0.020            | 0.285 ± 0.021          |
| Muscle g             | 6.960 ± 0.217            | 6.556 ± 0.066          |

Note: Results are expressed as mean ± standard error. Statistical significance was evaluated by Student’s t test. *p < .05 versus group I.

In this study, we aimed to investigate the effects of hanpen intake on organ weight and biomarker levels in Sprague-Dawley rats for the first time. Male, 6-week-old Sprague-Dawley rats were divided into two groups: group I, fed AIN-93G, and group II, fed AIN-93G with 5% dried hanpen.

No deaths or abnormalities in food consumption and coat condition were noted in the hanpen-administered rats in this study. From
the study results, we confirmed that the hanpen did not induce any adverse reaction in rats after 84 days of administration. No significant differences were found in body weight, organ weight, and most biochemical parameters between group I and group II because nutrition levels of group II diets were almost equal to those of group I diets (Table 2).

No significant differences in total food intake were found, although that of group II tended to be higher than that of group I.

### Table 4: Effect of hanpen on blood biochemical parameters in Sprague-Dawley rats after 84 days of administration

| Parameter | 0-day administration (n = 3) | Group I (without hanpen) | Group II (with hanpen) |
|-----------|-------------------------------|--------------------------|------------------------|
| TP g/dL   | 5.533 ± 0.027                 | 6.838 ± 0.025            | 6.975 ± 0.093          |
| ALB g/dL  | 4.000 ± 0.000                 | 4.250 ± 0.050            | 4.363 ± 0.081          |
| A/G       | -                             | 1.663 ± 0.053            | 1.675 ± 0.039          |
| BUN mg/dL | 7.933 ± 0.307                 | 17.463 ± 0.683           | 15.888 ± 0.421         |
| CRE mg/dL | 0.210 ± 0.009                 | 0.336 ± 0.012            | 0.350 ± 0.009          |
| Na mEq/L  | 141.667 ± 0.272               | 142.375 ± 0.246          | 142.750 ± 0.293        |
| K mEq/L   | 4.967 ± 0.191                 | 4.238 ± 0.050            | 4.263 ± 0.043          |
| Cl mEq/L  | 97.333 ± 0.272                | 100.750 ± 0.342          | 100.250 ± 0.293        |
| Ca mg/dL  | 11.000 ± 0.082                | 10.625 ± 0.061           | 10.613 ± 0.054         |
| IP mg/dL  | 9.667 ± 0.136                 | 4.763 ± 0.137            | 5.800 ± 0.113**        |
| Fe µg/dL  | 120.333 ± 3.193               | 158.375 ± 5.282          | 157.750 ± 3.896        |
| AST IU/L  | 67.000 ± 8.340                | 85.750 ± 7.271           | 70.250 ± 4.137         |
| ALT IU/L  | 30.333 ± 2.126                | 32.375 ± 2.744           | 31.875 ± 3.891         |
| ALP IU/L  | 1071.333 ± 80.656             | 469.375 ± 34.741         | 461.850 ± 25.766       |
| LDH IU/L  | 139.667 ± 5.041               | 699.500 ± 45.934         | 491.625 ± 69.099*      |
| LAP IU/L  | 47.000 ± 2.160                | 47.875 ± 0.648           | 46.375 ± 0.951         |
| AMY IU/L  | 2119.333 ± 81.198             | 2097.750 ± 68.254        | 2046.125 ± 60.536      |
| γ-GT IU/L | 3.000>                        | 3.000>                   | 3.000>                 |
| ChE IU/L  | 5.000>                        | 5.000>                   | 5.000>                 |
| T-CHO mg/dL | 70.375 ± 2.778               | 83.250 ± 5.431           | 103.750 ± 5.367**      |
| F-CHO mg/dL | 18.000 ± 0.471               | 20.875 ± 1.473           | 23.875 ± 1.634         |
| E-CHO mg/dL | 64.667 ± 3.538               | 77.000 ± 4.953           | 85.750 ± 4.670         |
| E/T %     | 78.000 ± 0.471                | 78.625 ± 0.660           | 78.375 ± 0.585         |
| TG mg/dL  | 74.125 ± 7.330                | 155.375 ± 24.576         | 132.500 ± 16.717       |
| LDL-C mg/dL | 7.667 ± 0.272                | 9.875 ± 0.799            | 9.125 ± 0.571          |
| HDL-C mg/dL | 29.750 ± 0.964               | 26.500 ± 1.649           | 34.000 ± 1.173*        |
| AIPa       | -                             | 0.022 ± 0.050            | 0.381 ± 0.065          |
| GLU mg/dL  | 242.000 ± 10.677              | 176.250 ± 3.944          | 179.875 ± 5.357        |
| T-BIL mg/dL | 0.030 ± 0.005                | 0.046 ± 0.005            | 0.060 ± 0.004          |
| D-BIL mg/dL | 0.000 ± 0.000                | 0.004 ± 0.002            | 0.004 ± 0.004          |
| I-BIL mg/dL | 0.030 ± 0.005                | 0.043 ± 0.005            | 0.056 ± 0.004          |
| TBA µmol/L | 12.667 ± 0.981               | 14.125 ± 2.281           | 9.625 ± 1.648          |

Note: Results are expressed as mean ± standard error. Statistical significance was evaluated by Student’s t test.

Abbreviations: AIP, atherogenic index of plasma; ALB, albumin; ALP, alkaline phosphatase; ALT, alanine transaminase; AMY, amylase; AST, aspartate aminotransferase; BUN, blood urea nitrogen; Ca, calcium; ChE, cholinesterase; Cl, chloride; CRE, creatinine; D-BIL, direct bilirubin; E-CHO, esterified cholesterol; F-CHO, free cholesterol; Fe, iron; GLU, glucose; HDL-C, high-density lipoprotein-cholesterol; I-BIL, indirect bilirubin; IP, inorganic phosphorus; K, potassium; LAP, leucine aminopeptidase; LDH, lactate dehydrogenase; LDL-C, low-density lipoprotein-cholesterol; Na, sodium; TBA, total bile acids; T-BIL, total bilirubin; T-CHO, total cholesterol; TG, triglyceride; TP, total protein; γ-GT, γ-glutamyl transpeptidase.

*aAIP: log (TG/HDL-C) with TG (mg/dL/88.57) and HDL-C (mg/dL/38.67) expressed in mmol/L (Edwards, Blaha, & Loprinzi, 2017).

**p < .01 versus group I.

*p < .05 versus group I.
The taste of hanpen might be suitable to Sprague-Dawley rats in comparison with normal diets. Liver and kidney weight gains in group II were observed unlike those of group I (p < .05) after administration for 84 days. Therefore, we calculated the relative organ weight to body weight (%) using formulae described by Vani and Reddy (2000).

Relative organ to body weight (%) = Actual weight of the organ (g)/Body weight (g) × 100

Relative organ to body weight of liver and kidney in group II was 3.77% and 0.59%, respectively, and no significant differences in those values were obtained when compared with group I (liver, 3.45%; kidney, 0.55%). There were no significant differences in the final body weight, spleen weight, and adipose tissue weight between group I and group II. Moreover, there were no differences in muscle weight between groups. The diets of group I, AIN-93G, had 20% casein as main protein source, and the diets of group II contained 5% dried hanpen instead of mainly casein. Generally, protein ingestion in the form of casein and whey increases the amino acid supply to muscles, which further promotes muscle protein synthesis Reidy et al. (2013). Dort et al. (2013), reported that cod protein induced anti-inflammatory activity and had an effect on skeletal muscle repair after an injury in male Wistar rats. These studies and our findings indicate that the fish paste product, hanpen, may be a protein source for skeletal muscle synthesis as well as casein.

In the biomarker analysis, the IP level of group II was higher than that of group I (p < .01). Hatayama et al. (2002) investigated the background data of blood chemistry parameters in Crj:CD(SD) IGS rats and reported that standard value of IP in 10-week-old, 19-week-old, and 32-week-old rats is range of 7.7 ± 0.6, 6.5 ± 0.8, and 6.0 ± 0.9 mg/dl, respectively. From this study, we assumed that the IP level of group II is almost in range of this standard value.

Hyperlipidemia is characterized by an increase in plasma T-CHO, TG, low-density lipoprotein cholesterol (LDL-C), and/or decrease in HDL-C (Wu et al., 2014). T-CHO and HDL-C levels of group II were significantly higher than that of group I after 84 days of administration. On the other hand, the TG and LDL-C levels of group II tended to be lower than that of group I. Therefore, it was assumed that high T-CHO levels of group II were predominantly related to HDL-C levels increasing. From this result, it was considered that hanpen intake was effective in protecting hyperlipidemia. Further, the atherogenic index of plasma (AIP) in group II (0.205 ± 0.054, p = .07 vs. group I) was inclined to decrease in comparison with group I (0.381 ± 0.065). The serum TG levels and AIP are risk factors for coronary heart disease (NIH Consensus conference, 1993; Wu, Gao, Zheng, Ma, & Xie, 2018), and hanpen intake may be an effective protection against coronary heart disease. Dried KIBUN hanpen contains approximately 0.08% EPA and 0.22% DHA, and levels of omega-3 fatty acids and omega-6 fatty acids in dried hanpen are 0.33% and 0.07%, respectively. EPA and DHA are very long chains of omega-3 fatty acids, and their daily intake is recommended by many global dietary guidelines (Sioen et al., 2017). Some studies reported the effect of EPA and/or DHA on lipid metabolism. For instance, there are reports that the intake of EPA lowers plasma TG in animal studies (Ding et al., 2016; Shang et al., 2017). Clinical studies that investigated EPA also demonstrated that it lowers TG and non-HDL-C levels (Ballantyne et al., 2012; Bays et al., 2011). In addition, Abdelhamid et al. (2018) reported in their review articles that EPA and DHA slightly reduced serum TG and raised HDL-C. From these reports, it was presumed that the effects of group II including hanpen on lipid metabolism may be related to EPA and DHA.

Interestingly, LDH level of group II was significantly lower than that of group I and the AST level of group II tended to be lower than that of group I. In addition to LDH and AST levels, the values related to liver function such as ALT, ALP, and LAP of group II were likely to decrease compared with that of group I. These data indicated that hanpen intake might be effective for preventing liver function deterioration. The polyunsaturated fatty acids including EPA and DHA have been recommended as the dietary strategy to protect against nonalcoholic fatty liver disease, because EPA and DHA induced high antioxidant, anti-inflammatory, and hypolipidemic effects (Bays, Ballantyne, Braeckman, Stirtan, & Soni, 2013; Dangardt et al., 2010). One ingredient in hanpen is Japanese yam which contains diosgenin, a steroid saponin which has reduced doxorubicin (DOX)-induced cardiotoxicity in mice (Kusano, Tsujihara, Masui, Kozi, & Takeuchi, 2016; Patel, Gadewar, Tahilyani, & Patel, 2012). Chen, Wang, Hsu, Lin, and Chen (2017) reported that yam (Dioscorea japonica Thunb.) extracts including diosgenin had an antioxidant and anti-inflammatory effect, and contributed to increasing glutathione peroxidase and superoxide dismutase activities in DOX-treated mice. We assumed that the values related to liver function of group II were lower than that of group I, because EPA, DHA, and Japanese yam including diosgenin were contained in KIBUN hanpen.

5 CONCLUSION

In summary, the Japanese traditional food, KIBUN hanpen, facilitated skeletal muscle synthesis as well as casein, raising plasma HDL-C level, and prevention of liver function deterioration after 84 days of administration in Sprague-Dawley rats. Hanpen is easy to eat in comparison with raw fish, which contains skeletal bone and fish guts, and is beneficial to human health. This study is a preliminary investigation of the effects of hanpen intake on organ weight and biomarker levels in rats. Thus, the mechanisms of hanpen on raising plasma HDL-C level and prevention of liver function deterioration remain unclear. However, hanpen could be effective as a functional food for human health management worldwide.

ACKNOWLEDGMENT

We are grateful to the Chairman and C.E.O. Masahito Hoashi, Kibun Foods Inc., for supporting this study.
CONFLICT OF INTERESTS
The authors have no conflict of interest to report.

AUTHOR CONTRIBUTION
KK, TT, and KS designed the study and conducted the experiments. KK, MK, TM, and KS prepared fish paste products hanpen. KK, TT, and KS analyzed the data and wrote the manuscript.

ETHICAL STATEMENTS
The experiments were performed at LA Centre in Oriental Yeast Co., Ltd. and authorized by the Japanese Government. The present study was conducted according to the ethical guidelines for laboratory animals and the standard operating procedures of the laboratory. The experimental protocol was approved by the animal experiment ethics committee of the laboratory (approval no. 19003).

ORCID
Kohei Suruga https://orcid.org/0000-0001-9430-9620

REFERENCES
Abdelhamid, A. S., Brown, T. J., Brainard, J. S., Biswas, P., Thorpe, G. C., Moore, H. J., ... Hooper, L. (2018). Omega-3 fatty acids for the primary and secondary prevention of cardiovascular disease (Review). Cochrane Database of Systematic Reviews, 18, 7. https://doi.org/10.1002/14651858.CD003177.pub3
Arai, T., Kim, H., Chiba, H., & Matsumoto, A. (2009). Anti-obesity effect of fish oil and fish oil-fenofibrate combination in female KK mice. Journal of Atherosclerosis and Thrombosis, 16, 674–683. https://doi.org/10.5551/jat.1313
Ballantyne, C. M., Bays, H. E., Kastelein, J. J., Stein, E., Isaacoohn, J. L., Braeckman, R. A., & Soni, P. N. (2012). Efficacy and safety of eicosapentaenoic acid ethyl ester (AMR101) therapy in statin-treated patients with persistent high triglycerides (from the ANCHOR study). The American Journal of Cardiology, 110, 984–992. https://doi.org/10.1016/j.amjcard.2012.05.031
Bays, H. E., Ballantyne, C. M., Braeckman, R. A., Stirtan, W. G., & Soni, P. N. (2013). Icosapent ethyl, a pure ethyl ester of eicosapentaenoic acid: Effects on circulating markers of inflammation from the MARINE and ANCHOR studies. American Journal of Cardiovascular Drugs, 13, 37–46. https://doi.org/10.1007/s40256-012-0002-3
Bays, H. E., Ballantyne, C. M., Kastelein, J. J., Isaacoohn, J. L., Braeckman, R. A., & Soni, P. N. (2011). Eicosapentaenoic acid ethyl ester (AMR101) therapy in patients with very high triglyceride levels (from the Multi-center, placebo-controlled, randomized, double-blind, 12-week study with an open-label extension [MARINE] trial). The American Journal of Cardiology, 108, 682–690. https://doi.org/10.1016/j.amjcard.2011.04.015
Chen, C. T., Wang, Z. H., Hsu, C. C., Lin, H. H., & Chen, J. H. (2017). Taiwanese and Japanese Yam ( Dioscorea spp.) extracts attenuate doxorubicin-induced cardiotoxicity in mice. Journal of Food and Drug Analysis, 25, 872–880. https://doi.org/10.1016/j.jfda.2016.09.002
Dangardt, F., Osika, W., Chen, Y., Nilsson, U., Gan, L. M., Gronowitz, E., ... Friberg, P. (2010). Omega-3 fatty acid supplementation improves vascular function and reduces inflammation in obese adolescents. Atherosclerosis, 212, 580–585. https://doi.org/10.1016/j.atherosclerosis.2010.06.046
Ding, L., Wang, D., Zhou, M., Du, L., Xu, J., Xue, C., & Wang, Y. (2016). Comparative study of EPA-enriched phosphatidylcholine and EPA-enriched phosphatidylserine on lipid metabolism in mice. Journal of Oleo Science, 65, 593–602. https://doi.org/10.5650/jos.ess16005
Dort, J., Leblanc, N., Maltais-Giguère, J., Li, B., Li, C., H., & Jacques, H. (2013). Beneficial effects of cod protein on inflammatory cell accumulation in rat skeletal muscle after injury are driven by its high levels of arginine, glycine, taurine, and lysine. PLoS ONE, 8, e77274. https://doi.org/10.1371/journal.pone.0077274
Edwards, M. K., Blaha, M. J., & Loprinzi, P. D. (2017). Atherogenic index of plasma and triglyceride/high-density lipoprotein cholesterol ratio predict mortality risk better than individual cholesterol risk factors, among an older adult population. Mayo Clinic Proceedings, 92, 680–681. https://doi.org/10.1016/j.mayocp.2016.12.018
Gabriel, A. S., Ninomiya, K., & Uneyama, H. (2018). The role of the Japanese traditional diet in healthy and sustainable dietary patterns around the world. Nutrients, 10, 173. https://doi.org/10.3390/nu10020173
Hatayama, K., Kobayashi, J., Ishii, T., Kinoshita, Y., Ichikawa, Y., & Okazaki, S. (2002). Background data of blood chemistry parameters in toxicity studies using Crj-CD(SD)IGS rats at 10, 19 and 32 weeks of age. Biological reference data on CD (SD) Rats (CD (SD)) IGS study group. pp 53–60
Hung, P., Gu, J. Y., Kaku, S., Yunoki, S., Ohkura, K., Ikeda, I., ... Yamada, K. (2000). Dietary effects of eicosapentaenoic and docosahexaenoic acid esters on lipid metabolism and immune parameters in sprague-dawley rats. Bioscience, Biotechnology, and Biochemistry, 64, 2588–2593. https://doi.org/10.1271/bbb.64.2588
Kanauchi, M., & Kanauchi, K. (2019). Proposal for an empirical Japanese diet score and the Japanese diet pyramid. Nutrients, 11, 2741. https://doi.org/10.3390/nu11122741
Kuronuma, Y., & Shimomura, M. (2019). Effects of egg white, yam, and additives on the physical properties of hanpen. Journal of Cookery Science of Japan, 52, 169–175. https://doi.org/10.11402/cookeryscience.52.169
Kusano, Y., Tsujihara, N., Masui, H., Kozai, H., & Takeuchi, W. (2016). Consumption of Japanese yam improves lipid metabolism in high-cholesterol diet-fed rats. Journal of Nutritional Science and Vitaminology, 62, 350–360. https://doi.org/10.3177/jnsv.62.350
Mizushima, T., Kawanoto, F., Uozumi, K., Tsuji, T., Kishida, T., & Ebihara, K. (2010). Fast-twitch muscle hypertrophy partly induces lipid accumulation inhibition with Alaska pollack protein intake in rats. Biomedical Research, 31, 347–352. https://doi.org/10.2220/biometres.31.347
NIH Consensus conference (1993). Triglyceride, high-density lipoprotein, and coronary heart disease. NIH consensus development panel on triglyceride, high-density lipoprotein, and coronary heart disease. JAMA, 269, 505–510. https://doi.org/10.1001/jama.1993.0350040071040
Patel, K., Gadewar, M., Tahiliani, V., & Patel, D. K. (2012). A review on pharmacological and analytical aspects of disogenin: A concise report. Natural Products and Bioprospecting, 2, 46–52. https://doi.org/10.1007/s13659-012-0014-3
Reidy, P. T., Walker, D. K., Dickinson, J. M., Gundermann, D. M., Drummond, M. M., Timmerman, K. L., ... Rasmussen, B. B. (2013). Protein blend ingestion following resistance exercise promotes human muscle protein synthesis. Journal of Nutrition, 143, 410–416. https://doi.org/10.3945/jn.112.168021
Shang, T., Liu, L., Zhou, J., Zhang, M., Hu, Q., Fang, M., ... Gong, Z. (2017). Protective effects of various ratios of DHA/EPA supplementation on high-fat diet-induced liver damage in mice. Lipids in Health and Disease, 16, 65. https://doi.org/10.1186/s12944-017-0461-2
Sioen, I., Lieshout, L., Elander, A., Fleeth, M., Lohner, S., Szommer, A., ... Mensink, R. (2017). Systematic review on N-3 and N-6 polyunsaturated fatty acid intake in European countries in light of the current recommendations- focus on specific population groups. Annals of Nutrition and Metabolism, 70, 39–50. https://doi.org/10.1159/000456723
Ueshima, H. (2007). Explanation for the Japanese paradox: Prevention of increase in coronary heart disease and reduction in stroke. Journal
of Atherosclerosis Thrombosis, 14, 278–286. https://doi.org/10.5551/jat.e529

Vani, M. L., & Reddy, K. P. (2000). Effects of fluoride accumulation on some enzyme of brain and gastrocnemius muscle of mice. Fluoride, 33, 17–26.

Wakamatsu, J., Numata, M., & Nakamura, T. (1997). Hanpen-like whipped sausage: Its sensory evaluation and texture. Nippon Shokuhin Kagaku Kagaku Kaishi, 44, 516–521. https://doi.org/10.3136/nskkk.44.516

Wergedahl, H., Liaset, B., Gudbrandsen, O. A., Lied, E., Espe, M., Muna, Z., … Berge, R. K. (2004). Fish protein hydrolysate reduces plasma total cholesterol, increases the proportion of HDL cholesterol, and lowers acyl-CoA: Cholesterol acyltransferase activity in liver of Zucker rats. Journal of Nutrition, 134, 1320–1327. https://doi.org/10.1093/jn/134.6.1320

Wu, Q., Zhang, H., Dong, X., Chen, X. F., Zhu, Z. Y., Hong, Z. Y., & Chai, Y. F. (2014). UPLC-Q-TOF/MS based metabolomics profiling of serum and urine of hyperlipidemic rats induced by high fat diet. Journal of Pharmaceutical Analysis, 4, 360–367. https://doi.org/10.1016/j.jpha.2014.04.002

Wu, T. T., Gao, Y., Zheng, Y. Y., Ma, Y. T., & Xie, X. (2018). Atherogenic index of plasma (AIP): A novel predictive indicator for the coronary artery disease in postmenopausal woman. Lipids in Health and Disease, 17, 197. https://doi.org/10.1186/s12944-018-0828-z

How to cite this article: Kadokura K, Tomita T, Kobayashi M, Mitsui T, Suruga K. Effect of fish paste products “Hanpen” intake in Sprague-Dawley rats. Food Sci Nutr. 2020;8:2773–2779. https://doi.org/10.1002/fsn3.1569