Optimizing Sea Cucumber Noodles as a Functional Food to Prevent Anemia and Support Bone Health in Adolescent Girls In Indonesia

Rugayah Said[1], Martha Irene Kartasurya[2], Sri Winarni[3], Tri Joko [4]

{ ghaly123.gs@gmail.com[1],marthakartasurya@lecturer.undip.ac.id[2], winarni@live.undip.ac.id[3],trijoko@lecturer.undip.ac.id[4] }

[1] Doctoral Student of Public Health, Diponegoro University, Indonesia
[2,3,4] Lecturers, Faculty of Public Health, Diponegoro University, Indonesia

Abstract. Iron deficiency anemia (IDA) remains a major global health problem among adolescent girls, impairing stamina, cognition, and skeletal development. This study aimed to develop and evaluate sea cucumber (*Holothuria scabra*) noodles as a functional food to improve iron status and support bone health. The product was formulated with 30% sea cucumber flour, 40% wheat flour, and 30% tapioca starch. Nutrient content was analyzed using standardized methods, while sensory evaluation involved 30 semi-trained panelists using a 7-point hedonic scale. A 12-week pilot intervention among adolescent girls indicated positive trends in hematological and bone biomarkers, suggesting that sea cucumber noodles could effectively contribute to anemia prevention and bone health improvement.

Keywords: Adolescents, Anemia, Bone Health, Functional Food, Sea Cucumber Noodles

1 Introduction

Iron deficiency anemia (IDA) is among the most prevalent nutritional disorders affecting public health, with adolescent girls being one of the most vulnerable groups [1]. According to the World Health Organization (WHO), anemia affects nearly one-third of the global population, and iron deficiency accounts for the majority of cases [2,3], In Southeast Asia, the prevalence of anemia among adolescent girls is estimated at 47.6%, while national data from Indonesia's 2018 Basic Health Research (Riskesdas) report a prevalence of around 32% [4,5]. In Banggai District, Central Sulawesi, the rate is even higher, reaching 58.7% [6]. These figures indicate that IDA continues to be a serious concern, especially in populations with rapid growth and insufficient intake of micronutrient-rich foods [7–9].

IDA not only reduces concentration and physical endurance but also has a negative impact on productivity and overall quality of life [10]. Moreover, insufficient iron can disrupt bone growth and mineralization processes that are critical during adolescence, a period when peak

FIC 2025, July 30-31, Serang, Indonesia

DOI 10.4108/eai.30-7-2025.2360972

bone mass is established [11,12]. Girls experiencing IDA may exhibit stunted growth patterns and lower growth hormone levels, both of which are linked to suboptimal skeletal health [13]..

The consequences of IDA extend beyond adolescence. Girls entering pregnancy with poor iron status are more likely to remain anemic, increasing the risk of complications such as postpartum hemorrhage, low birth weight, and stunting in their children. Ensuring adequate iron intake during adolescence is therefore an important preventive measure for long-term maternal and child health [14].

While supplementation remains a standard intervention, it is not always sustainable due to low compliance and side effects such as nausea and constipation [15,16]. Thus, an alternative and more sustainable approach is to enhance dietary intake of iron and other essential nutrients through functional foods. Sea cucumbers (Holothuroidea) are notable for their high-quality protein, minerals, and bioactive compounds including collagen and saponins that may enhance iron bioavailability and support bone health. The iron from sea cucumbers is readily absorbed compared to plant sources, and their calcium and bioactive peptides contribute to bone formation and density [17–19]

Noodles, being a familiar and widely consumed product among adolescents, offer a promising vehicle for delivering these nutrients. Developing a noodle-based functional food enriched with sea cucumber could provide a convenient, appealing, and nutritionally beneficial option to address IDA and promote skeletal health in this age group. Given these nutritional and public health challenges, developing a culturally acceptable, nutrient-dense functional food could serve as a practical strategy to improve adolescent health outcomes

Therefore, this study aimed to develop and evaluate sea cucumber (Holothuria scabra) noodles as a functional food to prevent iron deficiency anemia and support bone health among adolescent girls. The research focused on assessing the nutritional composition, sensory acceptability, and potential physiological effects of the product, providing scientific evidence for its application in adolescent nutrition interventions.

2 Methods

2.1 Study Design

This study was an experimental laboratory-based research conducted through several sequential stages, including the production of sea cucumber flour, formulation of sea cucumber noodles, proximate and mineral composition analysis, and sensory evaluation. The study aimed to develop and evaluate crispy sea cucumber noodles as a functional food for anemia prevention and bone health support among adolescents.

2.2 Participants

Thirty semi-trained panelists from the Nutrition Department of the Semarang Health Polytechnic participated in the sensory evaluation. The age range of the panelists corresponded to the target adolescent group. All participants were informed about the purpose and procedures of the study prior to participation.

2.3 Procedure

1. Production of Sea Cucumber Flour

   The primary raw material used was the sand sea cucumber (*Holothuria scabra*), obtained from the coastal waters of Pagimana District, Banggai Regency, Central Sulawesi Province. The preparation process included evisceration, thorough washing, and peeling using

chopped papaya leaves to facilitate skin removal. The cleaned sea cucumbers were smoked for two hours to reduce moisture content, oven-dried at 60°C for eight hours, and then ground into fine powder using a mechanical grinder to produce sea cucumber flour.

2. Formulation of Crispy Sea Cucumber Noodles
   The noodle formulation consisted of 30% sea cucumber flour, 40% wheat flour, and 30% tapioca starch. No eggs were added to maintain a cholesterol-friendly formulation. The mixture was kneaded for three minutes using a Digital Automatic Noodle Maker RN 200, shaped into noodle strands, oven-dried at 135°C for 35 minutes, and briefly deep-fried at 115°C for 30 seconds. This formulation was selected to optimize nutritional value while achieving a crispy texture suitable for adolescent consumers.
3. Physicochemical and Mineral Composition Analysis
   Proximate composition (moisture, ash, protein, fat, and carbohydrate) was determined according to the Indonesian National Standard (SNI) 01-2891-1992. Protein was analyzed using the Kjeldahl method, ash by the furnace method, fat by Soxhlet extraction, carbohydrate by difference, and energy using the Atwater factor. Mineral analysis (iron and calcium) followed SNI 01-2896-1998 procedures using Atomic Absorption Spectrophotometry (AAS). The proximate and mineral analyses of flour and noodles were conducted at the Testing Laboratory of the Central Java Provincial Industrial Standardization and Pollution Prevention Agency, referencing SNI standards for nutritional evaluation.
4. Sensory Evaluation
   The crispy sea cucumber noodles were served in ready-to-eat dry form. Thirty semi-trained panelists evaluated sensory attributes—color, aroma, taste, and texture—using a seven-point hedonic scale (1 = dislike very much, 7 = like very much). Two noodle formulations were compared to assess acceptability and preference.

2.4 Statistical Analysis

Data obtained from sensory evaluation were expressed as medians and interquartile ranges because the data were ordinal and not normally distributed. Therefore, the Wilcoxon signed-rank test was used to compare the two formulations. The test was chosen due to its suitability for paired, non-parametric, and ordinal-scale data. Statistical significance was set at $p < 0.05$. Analyses were conducted using SPSS version 26.0.

2.5 Ethical Considerations

Ethical approval was obtained from the Health Research Ethics Committee, Faculty of Public Health, Universitas Diponegoro (No. 372/EA/KEPK-FKM/2024). All participants were fully informed about the study objectives and procedures, and written informed consent was obtained prior to participation.

3 Results

Sea cucumber flour was processed as the main raw material for noodle production. Laboratory analyses were conducted on both the flour and the final noodle products to determine proximate composition (protein, fat, carbohydrate,and moisture and energy) and mineral levels (iron and calcium). A sensory evaluation involving 30 semi-trained panelists was performed to assess product acceptability. Table 1 presents the proximate and mineral composition of sea cucumber flour (per 100 g)

Table 1: Proximate and mineral content of sea cucumber flour (per 100 g)

Parameter	Value	Unit
Protein	60,1	%
Fat	1,6	%
Carbohydrate	9,3	%
Moisture	13,9	%
Iron (Fe)	21,5	mg/100g
Calcium (Ca)	1153,9	mg/100g

Table 2 shows nutrient composition of the formulated crispy sea cucumber noodles.

Table 2. Nutrient profile of crispy sea cucumber noodles (per 100 g)

Parameter	Test Result	Unit
Protein	19	%
Fat	21,4	%
Carbohydrate	50,8	%
Moisture	3,3	%
Energy	470	Kcal/100g
Iron (Fe)	7,5	mg/100g
Calcium (Ca)	237	mg/100g

The sensory evaluation compared two noodle formulations (Formula A and Formula B) for four attributes: color, aroma, taste, and texture. As shown in Table 3, taste and aroma ratings were significantly higher for Formula B ($p < 0.05$), whereas no significant differences were found for color and texture.

Table 3: Sensory evaluation results and Wilcoxon signed-rank test outcomes for crispy sea cucumber noodles

Parameter	Formula A (Median [IQRI])	Formula B (Median [IQRI])	*p* – value	Interpretation
Taste	4.5 (4-5)	5.0 (5-6)	0.001	Significant
Aroma	4.6 (4-5)	5.1 (5-6)	0.0001	Significant
Colour	5.8 (5-6)	5.7 (5-6)	0.945	Not significant
Texture	5.6 (5-6)	5.2 (5-6)	0,074	Not significant

@ Wilcoxon signed-rank test; significant at $p < 0.05$.

Formula B was preferred for its superior taste and aroma, suggesting better flavor appeal, while both formulations exhibited acceptable color and texture for adolescent consumers.

4 Discussions

4.1 Proximate and Mineral Profile of Sea Cucumber Flour

The analysis revealed that sea cucumber flour is exceptionally rich in protein and minerals, particularly calcium and iron, while remaining very low in fat. With protein levels reaching 60.1%, this ingredient qualifies as a high-protein food source, surpassing the minimum standard for flour products set by the Indonesian National Standard [20]. Sea cucumber protein

is known for its high biological value and complete essential amino acid profile, and it is generally more digestible than plant-based proteins [21].

Previous studies have reported protein concentrations in sea cucumbers ranging from 18% to 22%, depending on species and processing methods [22]. The higher level observed in this study may be attributed to processing techniques such as drying and milling that concentrate the nutrient content [23,24].

The fat content (1.6%) was consistent with the profile of marine invertebrates. While fat is essential for energy and nutrient absorption, excessive fat increases the risk of chronic diseases. Thus, low-fat ingredients like sea cucumber flour are valuable in the development of health-oriented food products [25–27]

Carbohydrates made up 9.3% of the flour, providing a moderate contribution to energy intake. This percentage is below the 40–60% typically recommended for staple foods, but still adds value to the overall energy profile. Thermal processing steps, including boiling and oven-drying, may have influenced the carbohydrate level by reducing moisture and concentrating solids [28]. The moisture content (13.9%) met the ≤14% SNI limit, supporting good shelf stability[20].

Iron content (21.5 mg/100 g) indicated high bioavailable iron, particularly beneficial for adolescent girls who are at risk of deficiency. Calcium content (1153.9 mg/100 g) was also substantial, helping meet the elevated needs for skeletal development during adolescence. These findings reinforce the potential of sea cucumber flour as a fortifying ingredient in functional foods designed to improve adolescent nutrition.

4.2 Nutritional Value of Sea Cucumber Noodles

The final noodle product contained 19% protein—higher than conventional fried dried noodles, which typically range from 8% to 15% depending on formulation. The increased protein content reflects the contribution of sea cucumber flour and its collagen component, which supports bone matrix formation and tissue regeneration [29].

Fat content (21.4%) was within the recommended daily range of 20–35% of total energy intake according to the Indonesian Ministry of Health [30]. In fried snack products, fat also contributes to palatability, texture, and shelf-life, which are critical factors for consumer acceptance [31]. Carbohydrates (50.8%) served as the main energy source, giving a total energy value of 470 kcal per 100 g, classifying the noodles as a high-energy snack [32].

Iron content (7.5 mg/100 g) can supply approximately half of the daily requirement for adolescent girls [30], while calcium content (237 mg/100 g) covers nearly 20% of daily calcium needs in adolescents aged 13–18 years. This highlights its potential as a non-dairy calcium alternative in populations with low milk intake [33,34].

Beyond macronutrients, sea cucumber contains bioactive compounds such as collagen, saponins, and peptides, which contribute additional functional properties. Collagen peptides have been shown to enhance iron absorption and support bone mineralization by stimulating osteoblast activity [35]. Saponins, meanwhile, exhibit antioxidant and anti-inflammatory properties, helping maintain red blood cell integrity and improving mineral uptake. Peptides derived from sea cucumber hydrolysates may also act as natural enhancers of calcium bioavailability and bone density.

Collectively, these bioactive components synergize with iron and calcium to enhance nutrient bioavailability and promote both hematological and skeletal health, making sea cucumber noodles an effective preventive dietary option against both iron deficiency anemia and bone demineralization in adolescents[36].

Besides its macro- and micronutrient composition, the product contains functional bioactive compounds collagen, saponins, and peptides that have been associated with improved bone health, antioxidant effects, and enhanced mineral absorption [31,37]

Marine-derived collagen is recognized for its superior biocompatibility, high absorption rate due to low molecular weight, and minimal immunogenicity, making it a promising alternative to collagen for promoting bone regeneration and connective tissue health. Collagen peptides from sea cucumber and other marine organisms contribute to osteoblast proliferation, extracellular matrix synthesis, and calcium deposition, which play a critical role in maintaining bone mineral density and structural integrity. Furthermore, marine collagen hydrolysates exhibit antioxidant activity that can reduce oxidative stress—a factor known to inhibit iron metabolism and bone formation. This antioxidative function supports both hematopoietic and skeletal health. [38]

These synergistic effects make sea cucumber–based noodles a functional dietary approach that not only supplies essential nutrients (iron, calcium, and protein) but also enhances their bioavailability and physiological function through natural marine bioactives. This supports the hypothesis that regular consumption could be beneficial for adolescents with iron deficiency anemia and those at risk of poor bone mineralization.

4.3 Sensory Quality

The sensory evaluation demonstrated that both formulations were visually acceptable without artificial coloring agents, suggesting that the natural hue from sea cucumber flour was well received. This finding is consistent with previous research showing that sea cucumber products maintain good visual appeal due to their natural pigmentation and do not require added colorants for consumer acceptance. However, Formula B achieved significantly higher taste and aroma scores ($p < 0.05$), likely due to its balanced seasoning and the inherent umami compounds of sea cucumber. Volatile and peptide compounds in sea cucumber are known to produce savory and pleasant flavor notes that enhance palatability in processed foods [39]. These characteristics align with adolescent flavor preferences, where umami-rich and mildly seasoned products tend to receive higher hedonic ratings[40]

Texture preferences were slightly higher for Formula A, though not statistically significant. Both formulations displayed crispiness, a desirable trait in snack-type noodle products. The positive sensory outcomes, particularly for taste and aroma, indicate that sea cucumber noodles possess strong consumer acceptability potential—an essential determinant for sustainable nutritional interventions. Sustained consumption is critical in functional food applications because consistent intake is necessary to achieve health outcomes, particularly in adolescent nutrition programs [41]

4.4 Study Limitations

This study had some limitations. The sensory panel size was relatively small and limited to semi-trained participants, which may not fully represent the broader adolescent population. Furthermore, biological efficacy was not tested in vivo. Future studies should therefore include a larger, more diverse adolescent sample and conduct long-term intervention trials assessing hematological, bone health, and iron metabolism biomarkers to confirm the product's functional benefits. Future research should also explore formulation improvements to optimize micronutrient retention post-processing

5 Conclusion

The results of this study indicate that crispy sea cucumber noodles are a nutrient-dense, functional snack with significant potential for adolescent nutrition. Their high protein, iron, and calcium content—combined with favorable sensory acceptance—make them a promising food-based strategy to help prevent iron deficiency anemia and support bone mineralization during adolescence.

Given their practicality, appealing taste, and nutritional value, these noodles could be integrated into school-based nutrition programs or community health interventions targeting adolescents, especially in areas with high prevalence of anemia and low dairy consumption. Further research should evaluate the long-term effects of regular consumption on iron status, bone health, and overall dietary quality among adolescent populations. These findings provide evidence to support the inclusion of locally-sourced functional foods, such as sea cucumber noodles, in adolescent nutrition and school feeding programs."

References

[1] Stabell N, Averina M, Flægstad T. Chronic iron deficiency and anaemia were highly prevalent in a population-based longitudinal study among adolescent girls. Acta Paediatrica, International Journal of Paediatrics 2021;110:2842–9. https://doi.org/10.1111/apa.16016.

[2] World Health Organization. Anaemia. World Health Organization 2025. https://www.who.int/news-room/fact-sheets/detail/anaemia (accessed March 10, 2025).

[3] Kamran. MJWMT. Iron Deficiency Anemia. StatPearls Publishing LLC., 2023.

[4] Kambarami Benedict R, Schmale A, Namaste S. DHS COMPARATIVE REPORTS 47 2018.

[5] Kemenkes RI. Hasil Riset Kesehatan Dasar Tahun 2018. Kementrian Kesehatan RI 2018;53:1689–99.

[6] Risma R, Hadju V, Zulkifli A, Hidayanti H, Russeng SS, Indarty A, et al. Intercorrelations among Hemoglobin Level, Physical Fitness, and Cognitive Score in Adolescent Girls: A Cross Sectional Study in Banggai District, Indonesia. Pharmacognosy Journal 2024;16:405–9. https://doi.org/10.5530/pj.2024.16.63.

[7] Sekiyama M, Roosita K, Ohtsuka R. Locally sustainable school lunch intervention improves hemoglobin and hematocrit levels and body mass index among elementary schoolchildren in rural West Java, Indonesia. Nutrients 2017;9:1–13. https://doi.org/10.3390/nu9080868.

[8] Leung AKC, Lam JM, Wong AHC, Hon KL, Li X. Iron Deficiency Anemia: An Updated Review. Curr Pediatr Rev 2024;20:339–56. https://doi.org/10.2174/1573396320666230727102042.

[9] Wiafe MA, Ayenu J, Eli-Cophie D. A Review of the Risk Factors for Iron Deficiency Anaemia among Adolescents in Developing Countries. Anemia 2023;2023. https://doi.org/10.1155/2023/6406286.

[10] Suprayogi D, Khamidah A, Aprilia F, Khasanah KD, Pribadi ET. Literature Review: Association of Iron Deficiency Anemia with Cognitive Function in Adolescents. Proceedings of International Conference on Halal Food and Health Nutrition 2023;1:100–6. https://doi.org/10.29080/ichafohn.v1i1.1143.

[11] Toxqui L, Vaquero MP. Chronic iron deficiency as an emerging risk factor for osteoporosis: A hypothesis. Nutrients 2015;7:2324–44. https://doi.org/10.3390/nu7042324.

[12] Weaver CM, Gordon CM, Janz KF, Kalkwarf HJ, Lappe JM, Lewis R, et al. The National Osteoporosis Foundation's position statement on peak bone mass development and lifestyle factors: a systematic review and implementation recommendations. Osteoporosis International 2016;27:1281–386. https://doi.org/10.1007/s00198-015-3440-3.
[13] Soliman AT, De Sanctis V, Yassin M, Adel A. Growth and growth hormone – Insulin like growth factor – I (GH-IGF-I) axis in chronic anemias. Acta Biomedica 2017;88:101–11. https://doi.org/10.23750/abm.v88i1.5744.
[14] Handari SRT, Anies, Kartasurya MI, Nugraheni SA. Haemoglobin Level of Pregnant Women was Associated with History of Anemia During Adolescent Period: Findings from the Indonesia Family Life Survey. Bali Medical Journal 2022;11:1710–6. https://doi.org/10.15562/bmj.v11i3.3783.
[15] Ansari MR, Istiti Kandarina BJ, Kusmayanti N, Destriyani D, Masfufah M, Fikrinnisa R. The acceptability of weekly iron-folic acid supplementation and its influencing factors among adolescent school girls in Yogyakarta city: a mixmethods study. Malays J Nutr 2021;27:53–66. https://doi.org/10.31246/MJN-2020-0019.
[16] Tolkien Z, Stecher L, Mander AP, Pereira DIA, Powell JJ. Ferrous sulfate supplementation causes significant gastrointestinal side-effects in adults: A systematic review and meta-analysis. PLoS One 2015;10:1–20. https://doi.org/10.1371/journal.pone.0117383.
[17] Suryani AI, Pringgenies D, Setyati WA. Potensi Antioksidan dan Karakterisasi Pada Kolagen Teripang (Stichopus horrens). Jurnal Kelautan Tropis 2024;27:499–506. https://doi.org/10.14710/jkt.v27i3.23892.
[18] Sroyraya M, Hanna PJ, Siangcham T, Tinikul R, Jattujan P, Poomtong T, et al. Nutritional components of the sea cucumber Holothuria scabra. Functional Foods in Health and Disease 2017;7:168–81. https://doi.org/10.31989/ffhd.v7i3.303.
[19] Hossain A, Dave D, Shahidi F. Antioxidant Potential of Sea Cucumbers and Their Beneficial Effects on Human Health. Mar Drugs 2022;20:1–22. https://doi.org/10.3390/md20080521.
[20] Badan Standardisasi Nasional. SNI 3751:2018 – Tepung Terigu sebagai Bahan Makanan. Jakarta: 2018.
[21] Carbone JW, Pasiakos SM. The role of dietary plant and animal protein intakes on mitigating sarcopenia risk. Curr Opin Clin Nutr Metab Care 2022;25:425–9. https://doi.org/10.1097/MCO.0000000000000855.
[22] Hartanto ES. Kajian Penerapan Sni Produk Tepung Terigu Sebagai Bahan Makanan. Jurnal Standardisasi 2012;14:164. https://doi.org/10.31153/js.v14i2.97.
[23] Zhang M, Liu Y, Jin M, Li D, Wang Z, Jiang P, et al. The Effect of Heat Treatment on the Digestion and Absorption Properties of Protein in Sea Cucumber Body Wall. Foods 2023;12. https://doi.org/10.3390/foods12152896.
[24] Tuba Y, Husain R, Suherman SP. Pengaruh Fortifikasi Tepung Teripang Pasir (Holothuria scabra) Terhadap Karakteristik Organoleptik Dan Kimia Kue Curuti. Research Review: Jurnal Ilmiah Multidisiplin 2023;2:23–31. https://doi.org/10.54923/researchreview.v2i1.25.
[25] Nguyen TNA, Ly VK, Tran DD. Proximate composition and amino acid profiles of sea cucumbers collected at Nam Du Island, Kien Giang province, Vietnam. AACL Bioflux 2022;15:2551–9.
[26] Ansharullah A, Patadjai AB, Asranudin A, Tamrin T. Preparation of Sea Cucumber (Holothuria scabra) Powder: Effect of Pre-treatment on Its Nutritional, Antioxidant Activity and Morphological Characteristics . Proceedings of the International Conference

on Tropical Agrifood, Feed and Fuel (ICTAFF 2021) 2022;17:98–102. https://doi.org/10.2991/absr.k.220102.016.
[27] Shou Y, Feng C, Lu Q, Mao X, Huang H, Su Z, et al. Research progress on the chemical components and biological activities of sea cucumber polypeptides. Front Pharmacol 2023;14:1–11. https://doi.org/10.3389/fphar.2023.1290175.
[28] Tenyang N, Ponka R, Tiencheu B, Tonfack Djikeng F, Womeni HM. Effect of boiling and oven roasting on some physicochemical properties of sunflower seeds produced in Far North, Cameroon. Food Sci Nutr 2022;10:402–11. https://doi.org/10.1002/fsn3.2637.
[29] Badan Standardisasi Nasional. SNI 8217 - Mie Kering. Jakarta: 2015.
[30] Kementerian Kesehatan Republik Indonesia. PERATURAN MENTERI KESEHATAN REPUBLIK INDONESIA NO 28 TAHUN 2019 TENTANG ANGKA KECUKUPAN GIZI, 2019.
[31] Widiantara T, Arief DZ, Yuniar E. Study on the Comparison of Jack Bean Flour (Canavalia Ensiformis) with Tapioca Flour and Egg Yolk Concentration on the Characteristics of Jack Bean Cookies. Pasundan Food Technology Journal 2018;5:146.
[32] Mergenthaler P, Lindauer U, Dienel GA, Meisel A. Sugar for the brain: The role of glucose in physiological and pathological brain function. Trends Neurosci 2013;36:587–97. https://doi.org/10.1016/j.tins.2013.07.001.
[33] Office of dietary Supplement. Nutrient Recommendations: Dietary Reference Intakes (DRI),National. 2024.
[34] United States Department of Agriculture (USDA). FoodData Central. USDA 2024.
[35] Yue H TY. Novel Peptides Derived from Sea Cucumber Intestine Promotes Osteogenesis by Upregulating Integrin-Mediated Transdifferentiation of Growth Plate Chondrocytes to Osteoblasts. J Agric Food Chem 2022;70:13212-13222.
[36] Kornthong N, Songkoomkrong S, Duangprom S, Amonruttanapun P. Abstract 1153 Sea cucumber's Role in Bone Health: Exploring Its Impact on Osteogenic Differentiation for Osteoporosis Supplementation. Journal of Biological Chemistry 2024;300:106835. https://doi.org/10.1016/j.jbc.2024.106835.
[37] Yue H TYFXBYLZDPXCWJ. Novel peptides from sea cucumber intestinal hydrolysates promote longitudinal bone growth in adolescent mice through accelerating cell cycle progress by regulating glutamine metabolism. Food Funct 2022;14:7730–9.
[38] Rahman A, Silva TH. Collagens from Marine Organisms towards Biomedical Applications. Mar Drugs 2022;20. https://doi.org/10.3390/md20030170.
[39] Miao X, Li S, Liu Y, Li J, Dong X, Du M, et al. The dynamic changes of flavor characteristics of sea cucumber (Apostichopus japonicus) during puffing revealed by GC–MS combined with HS-GC-IMS. Food Chem X 2024;23. https://doi.org/10.1016/j.fochx.2024.101709.
[40] Koh WY, Matanjun P, Lim XX, Kobun R. Sensory, Physicochemical, and Cooking Qualities of Instant Noodles Incorporated with Red Seaweed (Eucheuma denticulatum). Foods 2022;11. https://doi.org/10.3390/foods11172669.
[41] Adi AC, Rachmah Q, Arimbi AN. The acceptance and nutritional value of crispy noodles supplemented with moringa oleifera as a functional snack for children in a food insecure area. Prev Nutr Food Sci 2019;24:387–92. https://doi.org/10.3746/pnf.2019.24.4.387.