Food Research 10 (1) : 91 - 95 (February 2026)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

RESEARCH PAPER

Formulation and physicochemical analysis of hand-made enteral nutrition through tongkol (*Euthynnus affinis*) substitution

[1,*]Rahmawaty, S., [2]Danitasari, N.I. and [3]Abdillah, M.M.

[1]*Department of Nutrition Science, Faculty of Health Science, Universitas Muhammadiyah Surakarta, Indonesia. Jl. A. Yani Tromol Pos 1 Pabelan Kartasura, Surakarta, Central Java, Indonesia, 57102*
[2]*Instalation of Nutrition, PKU Muhammadiyah Yogyakarta Hospital, Jl KH. Ahmad Dahlan No. 20 Ngupasan, Gondomanan, Yogyakarta, DIY Indonesia, 55122*
[3]*Chemical Laboratory, Faculty of Health Science, Universitas Muhammadiyah Surakarta, Indonesia. Jl. A. Yani Tromol Pos 1 Pabelan Kartasura, Surakarta, Central Java, Indonesia, 57102*

Article history:
Received: 31 October 2024
Received in revised form: 14 January 2025
Accepted: 12 March 2025
Available Online: 27 January 2026

Keywords:
Enteral,
Formulation,
Psychochemical,
Tongkol,
Tuna

DOI:
https://doi.org/10.26656/fr.2017.10(1).326

Abstract

Provision of nutritional support through enteral nutrition (EN) with good-quality foods is important to reduce the risk of hospitalized malnutrition. Hand-made enterals, which are often made by blending whole foods until they become liquid so they can be administered through a feeding tube, are increasingly popular today due to patients' greater tolerance for real food mixtures. The present study aimed to formulate and examine physicochemical characteristics of enteral substitutes with tongkol, a local tuna (*Euthynnus affinis*), to ensure the quality of the formula. A local hand-made enteral standard formula called modisco was re-formulated by adding tongkol, hence meeting the standard for enteral diet. The formula (ensikol) was analysed for physicochemical including viscosity, flow rate, pH, and peroxide number, e.g., protein, fat, carbohydrate, ash, and water compounds, by micro Kjeldahl, Mojonnier, by difference, and gravimetric, respectively. The addition of steamed tongkol fish, 22% the total weight of modisco ingredients, provided adequate psychochemical aspects for enteral nutrition with superior protein content (5.12 g%) compared to the modisco (3.98%) ($p<0.05$). The ensikol could be an alternative to a hand-made polymeric enteral formula for individuals who need nutrition support.

1. Introduction

Hospital malnutrition due to inadequate oral intake is a common problem of hospitalized patients (Correia *et al*., 2021). It is reported in more than 40% of 92 studies conducted in northeast and southeast Asia (Inciong *et al*., 2020), including in Indonesia (Syam *et al*., 2018; Witjaksono *et al*., 2021). A study at the national referral hospital in Indonesia, Cipto Mangunkusumo Hospital Jakarta, showed a high prevalence of hospital malnutrition upon admission and exit at 65% and 70%, respectively, whereas 65% of patients did not show an improvement in their nutritional status (Syam *et al*., 2018); the ratio was about 45% in ambulatory patients (Witjaksono *et al*., 2021). Hospital malnutrition can lead to a longer length of stay (LOS) (Suriadji *et al*. 2017; Ruiz *et al*., 2019; Kang *et al*., 2022; Guenter *et al*., 2022) due to a higher risk of suffering from infection or non-infection complications (David *et al*., 2021; Kang *et al*., 2022). In addition, it increases the risk of hospital readmission (Lo *et al*., 2021; Cruz *et al*., 2022; Guenter *et al*., 2022), mortality (Correia *et al*., 2021; Kang *et al*., 2022; Guenter *et al*., 2022), cost (Suriadji *et al*., 2017; Kang *et al*., 2022; Guenter *et al*., 2022), and economic burden (Inciong *et al*., 2022).

Provision of nutritional support, such as enteral nutrition (EN), a liquid formula or blended food delivered to the gastrointestinal is important for patients who are suffering from, or have a risk of malnutrition to fulfill their nutritional needs and prevent the worsening of clinical outcomes. It is recommended that EN within the first 24-48 h after admission should be administered for critically ill patients when oral feeding is not possible and not contraindicated or is not tolerated by the EN (Prieto 2011), such as in the case of gastrointestinal problems. In other words, the patients have a functional gastrointestinal (GI) tract that is capable of digesting and absorbing EN formula administered into the lumen of the GI tract. The formula can be served in the form of

*Corresponding author.
Email: *setyaningrum_r@ums.ac.id*

eISSN: 2550-2166
Published by Rynnye Lyan Resources

commercial or handmade EN. Commercial formulas are more practical with specific nutrients according to individual needs. However, they are economically more expensive than hand-made EN.

Early EN intervention showed a positive impact and reduced LOS in malnourished hospital patients (Somanchi, 2011). In contrast, patients who did not receive preoperative EN experienced postoperative complications about 50% higher than those who received preoperative EN of 21% (Gregory *et al*., 2018). Hence, it is important to provide an EN formula with good quality foods that could support the patients' recovery needs and also prevent complications. Physicochemical quality of EN is important to ensure the formula meets the established standards. Patients under critical conditions require adequate protein intake (Silvah *et al*., 2021) and omega-3 long-chain polyunsaturated fatty acids (n-3 LCPUFA) intake to modulate the inflammatory response (Molfino *et al*., 2017). These nutrients are mostly found in animal protein, e.g., oily fish. Limited data are available in Indonesia regarding the handmade EN manufacturing process by adding oily fish. Among the various types of local oily fish often consumed by Indonesians, e.g., kembung, kakap, selar, tembang, kakap merah, and bawal, tongkol (local Indonesian tuna-*Euthynnus affinis*) has a relatively affordable price with the highest content of EPA and DHA of 6.035% and 23.47%, respectively (Sukarsa, 2004). The present study aimed to formulate and analyse physicochemical characteristics of tongkol-substituted EN (ensikol) compared to the modisco to ensure the quality of the ensikol.

2. Materials and methods

2.1 Raw materials and utensils

The ingredients used in making the ensikol included steamed tongkol fish, skim milk, granulated sugar, coconut oil, egg, corn starch, and water. The utensils to make the enteral included a 2 L capacity blender, steamer, cooking pot, food thermometer, stirrer, and stove.

2.2 *Ensikol formula preparation and cooking process*

The first step in preparing the ensikol formula was weighing the ingredients, including steamed tongkol fish, skim milk, granulated sugar, coconut oil, chicken egg, corn starch, and water at 22%, 32%, 27%, 6%, 58%, 5%, and 317% of the total ingredient weight, respectively. The formula has been registered and obtained with a copyright certificate from the Ministry of Law and Human Rights, the Republic of Indonesia, with copyright number 000278302. Manufacturing the ensikol formula was performed by blending the steamed tongkol fish with enough water until smoothening, then mixing the remaining ingredients (except cornstarch) with it, and, lastly, blending all the ingredients until they are mixed well. The mixed ingredients were then cooked at a low temperature of 80°C for 5 min. The final step was slowly adding cornstarch, which had been dissolved in a little water, into the ensikol and then stirred and cooked for 15 min (Figure 1).

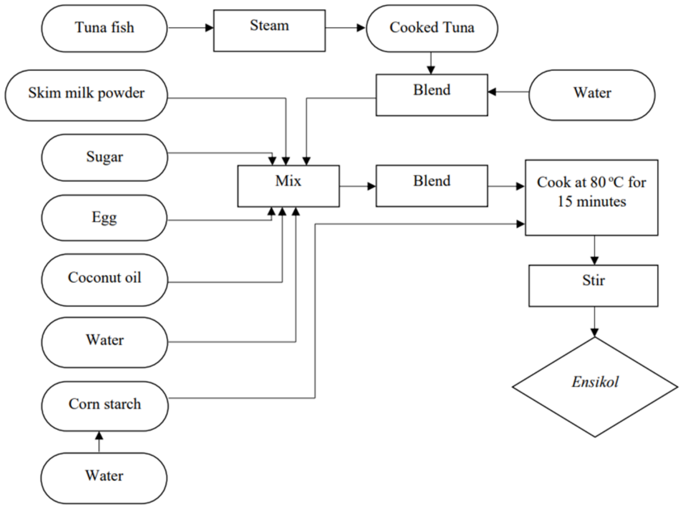

Figure 1. Manufacturing of ensikol (enteral substituted with tongkol).

2.2 Physicochemical analysis

Stability of the ensikol was measured for visual inspection of the separation process phase after it was homogenized and packed tightly, and then rested for 3 h (Machado de Sousa e*t al*., 2014). Viscosity of the ensikol was measured using Brookfield Digital Viscometer DV II+ Pro. It was considered adequate if the formula did not cause obstruction when administered through a 12-French catheter (1 French = 0.33 mm) by the gravitational method. Fluidity/flow rate evaluation was carried out using a drip test, gravitational method, using 200 mL of the diet in a plastic bag connected to the equipment to check the number of drops per minute (modified from Athar, 1995). The ensikol was analysed for peroxide (Shahidi, 2001; AOAC Official Method 965.33) and acidity (pH) levels (AOAC Official Method 973.41). Proximate numbers, including protein, fat, carbohydrate, water, and ash content, were also analysed according to the method of Kjeldahl (AOAC Official 991.20), Mojonnier ether-extraction (AOAC Official Method 989.05), by difference as 100-(% moisture+% protein+%fat+%ash) (SNI 01-2892-1992) (BSN, 1992), oven-drying (AOAC Official Method 925.10), and gravimetric incineration (AOAC Official Method 923.03), respectively.

The Kjeldahl procedure basically consists of 3 stages: (1) digestion, (2) distillation, and (3) titration. During the digestion process, organic nitrogen was transformed into ammonium (NH_4^+) at a temperature of

https://doi.org/10.26656/fr.2017.10(1).326

370°C. Using a selenium mixture catalyst, the sample was digested in H_2SO_4, converting N into $(NH_4)_2SO_4$, and then distilled with NaOH and titrated with a standard HCl solution. The crude protein content in the sample was calculated by multiplying the amount of nitrogen titrated by the conversion factor, 6.25. The Mojonnier procedure was carried out by placing the sample in a Mojonnier tube, dissolving it with ethanol and hydrolyzing it with NH_4OH to form free fatty acids, which were then extracted using diethyl ether and petroleum ether. The solvent was evaporated from the extraction results and dried in an oven at a temperature of 100°C until the weight was constant. The percentage of fat content in the sample was determined by dividing the weight of the extracted fat by the weight of the sample and multiplying by 100%. The carbohydrate count by difference was carried out by determining the moisture, protein, fat, ash, and alcohol content of the sample, and then subtracting from the total weight of the sample, and the remainder (or difference) was the total carbohydrate. Net carbohydrate was determined by subtracting dietary fiber from the total carbohydrate value. The gravimetric method for water content measurement was carried out by drying the sample in an oven at a temperature of 105°C for 5 h or until a constant weight was obtained. The water content was determined by calculating the difference between the initial weight and the final weight, which indicated the weight of water lost during the drying process. The percentage water content in the sample was calculated by dividing the weight of the water lost by the total weight of the sample, then multiplying it by 100%. Determination of ash content with the gravimetric method was carried out by placing the sample in a crucible and weighing it, and then heating the crucible containing the sample for 5 h at 525°C until white ash was formed; it was then cooled in a desiccator for 30 min, and the crucible containing the ash was weighed. The ash content 'was calculated as the weight of the ash residue divided by the initial sample weight and multiplied by 100%.

2.3 Statistical analysis

Statistical analysis was carried out using Statistical Package for the Social Sciences (SPSS) software (version 20.0, USA). The comparisons of physicochemical aspects and nutrient contents of the 3 enteral foods were measured using non-parametric tests by the Mann-Whitney test. A probability of $p<0.05$ was taken as statistically significant.

3. Results and discussion

The ensikol showed acceptable stability without phase separation by visual inspection after it was left for 3 h. Compared with the standard EN modisco, the viscosity and flow rate of the ensikol were double, at 34.31 cP and 0.91 second/mL, respectively, as measured by a 12 Fr tube, respectively. In addition, the protein content of the ensikol was significantly higher (1.2 g%) but lower in the peroxide number as well as the linolenic acid than the standard EN modisco (Table 1).

Table 1. Physicochemical analysis estimation of modisco and ensikol.

Physicochemical	Modisco	Ensikol
Viscosity (cP)	16.75	34.31
Fluidity/flow rate (by 12 Fr tube) (second/mL)	0.44	0.91
pH	6.93	6.57
Peroxide number (mL ekv/kg)	0.435	0.225
Ash (g%)	0.89	0.90
Protein N total (g%)	3.98	5.12**
Fat (g%)	1.98	1.96
Carbohydrate by difference (g%)	12.84	14.13
Energy (kcal) in 100 mL	101.24	106.29
Fatty acid compounds*		
Linoleic acid (C18:2n-6c) (mg)	0.6705	0.5155
Arachidonic acid (C20:4n-6) (mg)	0.0385	0.0875
Linolenic acid (C18:3n-3) (mg)	0.11	0.005
Eicosapentaenoic acid (EPA, C20:5n-3) (mg)	0	0.07
Docosahexaenoic acid (DHA, C22:6n-3) (mg)	0.11	0.113
Total n-3 LCPUFA (EPA+DHA)	0.11	0.183

*Values obtained by calculation based on fatty acid compounds of Indonesian foods (Sulaeman *et al*., 2015)
**Significant difference

The ensikol produced in this study was classified as a handmade polymeric enteral with a high protein content, i.e., 19.27% of total calories which is suitable for hospital/home-made enteral feeding, which can be processed and served by cooking staff at hospitals or individuals at home. The polymeric enteral with high protein content is appropriate for individuals with normal digestion, with the risk of malnutrition, catabolism, and wound healing (Hassan-Ghomi *et al*., 2017). One of the benefits of hand-made enteral is that it is easy to make at home/hospital and economical by using materials and tools available on a household/hospital scale. The mixing time and speed used in making hand-made or blenderized enteral-based row food will determine the physical quality of the enteral in terms of its softness. Apart from that, the addition of thickening agents, in this case cornstarch and eggs, also helps to increase the homogeneity and softness of the resulting enteral. However, the length of time in making homemade enteral feeds may decrease nutrients that are easily damaged by heat. A previous study showed that the

https://doi.org/10.26656/fr.2017.10(1).326

length of blending time decreases beta carotene level on ensikol substituted with yellow pumpkin rich in beta carotene (Azhari and Rahmawaty, 2023). The ingredients of the ensikol are relatively stable to heat except for protein; however, the content is higher compared to the Modisco standard enteral.

4. Conclusion

Hand-made ensikol formula contains high protein, which could be an alternative to polymeric enteral formula. It is relatively safe for the majority of consumers, except for those who have an intolerance or are allergic to the ingredients used; it is not recommended for this category.

Conflict of interest

The author declares no conflict of interest.

Acknowledgements

The research was supported by the Universitas Muhammadiyah Surakarta through Hibah Integrasi Tri Dharma (HIT) grant, Lembaga Riset dan Inovasi, with contract number: 951.4/A.3-III/FIK/IV/2022.

References

AOAC INTERNATIONAL. (1990). Determination of acidity levels (pH) (AOAC Official Method 973.41). Official Methods of the Analysis of AOAC INTERNATIONAL. 15th ed. Maryland, USA: AOAC INTERNATIONAL.

AOAC INTERNATIONAL. (2005). Peroxide value of oils and fats (AOAC Official Method 965.33). Official Methods of the Analysis of AOAC INTERNATIONAL. 18th ed. Maryland, USA: AOAC INTERNATIONAL.

AOAC INTERNATIONAL. (2005). Ash of flour (direct method) (AOAC Official Method 923.03). Official Methods of the Analysis of AOAC INTERNATIONAL. 18th ed. Gaithersburg, USA: AOAC INTERNATIONAL.

AOAC INTERNATIONAL. (2005). Solids (total) and moisture in flour (AOAC Official Method 925.10). Official Methods of the Analysis of AOAC INTERNATIONAL. 18th ed. Gaithersburg, USA: AOAC INTERNATIONAL.

AOAC INTERNATIONAL. (2006). Fat in milk (AOAC Official Method 989.05). Official Methods of the Analysis of AOAC INTERNATIONAL. 18th ed. Gaithersburg, USA: AOAC INTERNATIONAL.

AOAC INTERNATIONAL. (2006). Nitrogen (total) in milk. Kjeldahl method (AOAC Official Method 991.20). Official Methods of the Analysis of AOAC INTERNATIONAL. 18th ed. Gaithersburg, USA: AOAC INTERNATIONAL.

Athar, N. (1995). Development of indigenous enteral formulae. University of Western Sydney, Australia: PhD Dissertation.

Azhari, S. and Rahmawaty, S. (2023). β-Carotene Levels in Yellow Pumpkin (*Cucurbita moschata*) as an Enteral Substitution with Variation of Grinding Time Using a Blender. Proceedings of the International Conference on Health and Well-Being (ICHWB 2022), p. 171-178. USA: Atlantis Press. https://doi.org/10.2991/978-94-6463-184-5_17.

Badan Standarisasi Nasional (BSN). (1992). Cara uji gula (SNI 01-2892-1992). Jakarta, Indonesia: BSN. [In Bahasa Indonesia].

Correia, M.I.T.D., Sulo, S., Brunton, C., Sulz, I., Rodriguez, D., Gomez, G., Tarantino, S. and Hiesmayr, M. (2021). Prevalence of malnutrition risk and its association with mortality: Nutrition Day Latin America survey results. *Clinical Nutrition*, 40 (9), 5114-5121. https://doi.org/10.1016/j.clnu.2021.07.023.

Cruz, P.L.M., Soares, B.L.M., da Silva, J.E. and Lima E Silva, R.R. (2022). Clinical and nutritional predictors of hospital readmission within 30 days. *European Journal of Clinical Nutrition*, 76(2), 244-250. https://doi.org/10.1038/s41430-021-00937-y.

David Uihwan, L., Greg Hongyuan, F., Ryan Richard, A. and Raffi, K. (2021). The effect of malnutrition on the infectious outcomes of hospitalized patients with cirrhosis: analysis of the 2011–2017 hospital data. *European Journal of Gastroenterology and Hepatology*, 32(2), 269-278. https://doi.org/10.1097/meg.0000000000001991.

Gregory, T.B., Iris, H., Christoper, H., Emily, N., Jamal, M.M., Matthew, L.B. and Douglas, L.N. (2018). Does preoperative enteral or parenteral nutrition reduce postoperative complications in Crohn's disease patients: a meta analysis. *European Journal of Gastroenterology and Hepatology*, 30(9), 997-1002. https://doi.org/10.1097/meg.0000000000001162.

Guenter, P., Blackmer, A., Malone, A., Mirtallo, J.M., Philips, W., Tyler, R., Barrocas, A., Resnick, H.E. and Anthony, P. (2022). Update on use of enteral and parenteral nutrition in hospitalized patients with a diagnosis of malnutrition in United States. *Nutrition Clinical Practice*, 37, 94-101. https://doi.org/10.1002/ncp.10827.

Hassan-Ghomi, M., Nikooyeh, B., Motamed, S. and Neyestani, T.R. (2017). Efficacy of commercial formulas in comparison with home-made formulas for enteral feeding: A review. *Medical Journal of the Islamic Republic of Iran*, 31(1), 319-326. https://doi.org/10.14196%2Fmjiri.31.55.

Inciong, J.F.B., Chaudhary, A., Hsu, H.S., Joshi, R., Seo, J.M., Trung, L.V., Ungpinitpong, W. and Usman, N. (2020). Hospital malnutrition in northeast and southeast Asia: A systematic literature review. *Clinical Nutrition ESPEN*, 39, 30-45. https://doi.org/10.1016/j.clnesp.2020.06.001.

Inciong, J.F.B., Chaudhary, A., Hsu, H.S., Joshi, R., Seo, J.M., Trung, L.V., Ungpinitpong, W., Usman, N., Pradelli, L. and Omaralsaleh, A.J. (2022). Economic burden of hospital malnutrition: A cost-of-illness model. *Clinical Nutrition ESPEN*, 48, 342-350. https://doi.org/10.1016/j.clnesp.2022.01.020.

Kang, C.Y., Asemota, I.R., Reyes Pinzon, V. and Khamooshi, P. (2022). Impact of protein energy malnutrition on in-hospital outcomes of patients admitted for pulmonary endemic mycoses: analysis of the national inpatient sample. *American Journal of Respiratory and Critical Care Medicine*, 205, A4532-A4532. https://doi.org/10.1164/ajrccm-conference.2022.205.1_MeetingAbstracts.A4532

Lo, Y.T., Chang, C.M., Chen, M.H., Hu, F.W. and Lu, F.H. (2021). Factors associated with early 14-day unplanned hospital readmission: a matched case–control study. *BMC Health Services Research*, 21, 870. https://doi.org/10.1186/s12913-021-06902-6.

Machado de Sousa, L.R., Rodrigues Ferreira, S.M. and Madalozzo Schieferdecker, M.E. (2014) Physicochemical and nutritional characteristics of handmade enteral diets. *Nutrition Hospitalaria*, 29 (3), 568-574. https://doi.org/10.3305/nh.2014.29.3.7083.

Molfino, A., Amabile, M.I., Monti, M. and Muscaritoli, M. (2017). Omega-3 polyunsaturated fatty acids in critical illness: Anti-inflammatory, proresolving, or both? *Oxidative Medicine and Cellular Longevity*, 2017, 5987082. https://doi.org/10.1155/2017/5987082.

Prieto, M.B. and Cid, J.L.H. (2011). Malnutrition in the critically ill child: The importance of enteral nutrition. *International Journal of Environmental Research and Public Health, 8(11),* 4353-4366. https://doi.org/10.3390%2Fijerph8114353.

Ruiz, A.J., Buitrago, G., Rodriguez, N., Gomez, G., Sulo, S., Gomez, C., Partridge, J., Misas, J., Dennis, R., Alba, M.J., Chaves-Santiago, W. and Araque, C. (2019). Clinical and economic outcomes associated with malnutrition in hospitalized patients. *Clinical Nutrition*, 38, 1310-1316. https://doi.org/10.1016/j.clnu.2018.05.016.

Shahidi, F. (2001). Extraction and Measurement of Total Lipids. Current Protocol in Food Analytical Chemistry. USA: John Wiley and Sons Inc. https://doi.org/10.1002/0471142913.fad0101s07.

Silvah, J.H., Martires de Lima, C.M., Nicoletti, C.F., Barbosa, A.C., Junqueira, C.P., Freire de Carvalho da Cunha, S. and Marchini, J.S. (2021). Protein provision and lower mortality in critically ill patients with COVID-19. *Clinical Nutrition ESPEN*, 45, 507-510. https://doi.org/10.1016/j.clnesp.2021.07.005.

Somanchi, M., Tao, X. and Mullin, G.E. (2011). The facilitated early enteral and dietary management effectiveness trial in hospitalized patients with malnutrition. *Journal of Parenteral and Enteral Nutrition*, 35(2), 209-216. https://doi.org/10.1177/0148607110392234.

Sukarsa, D.R. (2004). A study of activity of omega-3 fatty acid of some marine fish in mice as the experimental animals. *Buletin Teknologi Hasil Perikanan*, 7(1), 68-79. https://doi.org/10.17844/jphpi.v7i1.1060.

Sulaeman, A., Hardinsyah, Setiawan, B. and Mulyani, R.I. (2015). The fatty acids composition were measured based on fatty acids coumpound of Indonesian foods. Bogor, Indonesia: Departemen Gizi Masyarakat FEMA IPB, PERGIZI PANGAN Indonesia, Global alliance improved nutrition, and Unilever Research and Development Center.

Suriadji, D., Wati, D.K., Sisiartha, I.G.L., Suparyatha, I.B. and Hartawan, I.N.B. (2017). Prevalence and association of cost and hospital malnutrition in pediatric intensive care unit Sanglah hospital during 2015. *Critical Care and Shock*, 20, 10-16.

Syam, A.F., Sobur, C.S., Abdullah, M. and Makmun, D. (2018). Nutritional status of hospitalized nonsurgery patients at a nationwide referral hospital in Indonesia. *Journal of International Dental and Medical Research*, 11(2), 732-739.

Witjaksono, F., Lestari, W., Sutanto, K., Wulandari, Y., Mutu Manikam, N.R. and Octovia, L.I. (2021). Proportion of malnourished ambulatory hospitalized patients based on international criteria at Cipto Mangunkusumo hospital, Indonesia. *The Journal of the Pakistan Medical Association,* 71(2), S107-S111.

https://doi.org/10.26656/fr.2017.10(1).326