Effect of fluidized bed drying on the fatty acid content of giant red shrimp (*Aristaeomorpha foliacea*) byproducts

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Abstract. Giant red shrimp (*Aristaeomorpha foliacea*) is commercially valuable shrimp species found in Mediterranean Sea. During the shrimp processing, depending on the species, size, and shellingprocedure, about 40-50% of the raw material weight is discarded as nonedible parts and named asbyproduct. Byproduct of shrimp consist of meat, peels and other residues. These byproducts stillcontain valuable nutrients and functional compounds such as fatty acids, mineral salts, proteins, chitin, and pigments. The important human health benefits are associated with Omega-3 fatty acids particularly eicosapentaenoic (EPA, 20:5 n-3) and docosahexaenoic acid (DHA, 22:6 n:3). Recovering of bioactive compounds such as Omega-3 fatty acid rich oils has increased greatly during past few decades due to the its commercial value. The aim of this study was to recover of Omega-3 fatty acid rich shrimp oil from byproducts by applying of different biomass drying methods including fluidized bed drying method (FBD) and conventional oven drying method (ODS). The results showed that Omega-3 fatty acid content and health lipid indices (AI and TI) of shrimp byproducts were significantly ($P<0.05$) affected by biomass drying methods. Omega-3 fatty acid content of fluidized bed dried shrimp byproduct was significantly higher than conventional oven dried byproduct.

Keywords:

Red shrimp, fatty acids, shrimp byproduct, fluidized bed drying

INTRODUCTION

Depending on the species, size and shelling procedure, byproducts of shrimp comprise 40-50% of the whole shrimp weight. Although shrimp byproducts contains valuable nutrients such as proteins, free amino acids, Omega-3 rich oil, chitin, carotenoids, flavours, minerals and enzymes, it discarded as waste (da Silva et al., 2017; Prameela et al., 2017; Sila et al., 2014). Polyunsaturated fatty acids (PUFA) are important fatty acids and contain more than one double bond in their carbon chain. PUFAs are categorized into two main sections; Omega-6 and Omega-3 depending on the position of the first double bond from the methyl end group of the fatty acid (Venegas-Calerón, Sayanova, & Napier, 2010). Eicosapentaenoic acid (EPA) and docosahexaenpic acid (DHA) are most valuable fatty acids found in aquatic origin biomaterials. EPA and DHA are reported to be in relation with prevention of cardiovascular diseases and have certain efficacy in preventing illnesses with an inflammatory component. It is postulated that they reduce hypertension, asthma, immune system disorders, susceptibility to mental illness, protection against heart disease, and improved brain and eye functions (Topuz, Yerlikaya, Yatmaz, Kaya, & Alp, 2017; Yerlikaya, Topuz, Buyukbenli, & Gokoglu, 2013). Unsaturated Omega-3 fatty acids, such as DHA and EPA are sensitive to oxygen, high temperature and ultraviolet light. During drying, chemical and physical reactions occur and therefore digestibility is increased owing to the protein hydrolyzation, but some thermolabile compound such as PUFA is often oxidized (Finot, 1997). Fluidized bed drying method and conventional oven drying methods are the common biomass drying method for the extraction of bioactive compounds from biomaterials. The aim of the study was to compare effect of fluidized bed drying and conventional oven drying on the fatty acid profile of shrimp byproduct.

MATERIAL AND METHODS

Giant red shrimps (*Aristaeomorpha foliacea*) were obtained from the seafood market in Antalya, Turkey. Shrimps are transported in cold chain and its byproducts, consisting heads, cephalothorax and shells were obtained manually. The shrimp byproducts were washed thoroughly with distilled water and spread over on filter paper for 10 min to remove excessive water on surface. Shrimp byproduct powder was divided two groups prior to drying process ant stored at -80°C in laboratory type deep freezer (Dairei Europe, ULTF 80).

Drying process: First group of shrimp bypoducts was dried in fluidized bed dryer (Retsch, TG 200, Germany) at 60 °C with air speed of 150 m3/hour up to water activity of 0.35 (aw: 0.35) (approximately for 3-4 hours) and marked as 'FBD'. Second group was dried in conventional oven dryer at 60°C for 28 hours up to water activity of 0.35 (aw: 0.35) and marked as 'ODS'. All dried byproducts were ground to fine particles size with laboratory type grinder (Bosch mkm 6000, Turkey) and passed through a 1.5 mm mesh screen.

Oil extraction: Oil extraction from shrimp byproduct was performed according to method of (Blig & Dyer, 1959). 10 g byproduct powder was mixed with a mixture of 10 ml chloroform and 20 ml of methanol for 3 min. 10 ml additional chloroform was added to mixture and mixture was blended 30 sec. And then, 10 ml distilled water was added and blending continued for 30 sec. Mixture was filtered through Whatman no:1 filter paper and filtrate collected in graduated cylinder. After allowing the filtrate to separate two layers, the volume of the chloroform layer was passed to rotary evaporator to evaporate chloroform. After the chloroform was evaporated completely, dryness of oil was ensured using nitrogen stream.

Fatty acid composition analysis: Methyl esters were prepared by transmethylation method using 2 M KOH in methanol and n-hexane, according to the method of (Özogul, Özogul, & Alagoz, 2007). The fatty acid composition was analysed by a gas chromatography device (Clarus 500 Perkin-Elmer, USA) equipped with a flame ionization detector and a fused silica capillary SGE column (30 m x 0.32 mm ID x 0.25 µm BP20 0.25 UM, USA). The fatty acid composition analyses were performed in triplicate and the results were given in chromatography area % as mean values.

Health lipid indices: Data of fatty acid profile was used to determine the atherogenicity (AI) and thrombogenicity index (TI). AI shows the inhibition of the aggregation of plaque and diminishing the levels of esterified fatty acids, cholesterol, and phospholipids, thereby preventing the appearance of micro-and macro-coronary diseases. TI shows the tendency to form clots in the blood vessels. AI and TI index were calculated as follows (Ulbricht & Southgate, 199).

AI =[12:0 + (4x14:0) + (16:0)] / (ΣMUFA+ ΣPUFA n-6 + ΣPUFA n-3)

TI =(14:0+16:0+18:0)/[(0.5 x ΣMUFA)+(0.5 x ΣPUFA n-6+(3x ΣPUFA n3)+(n-3 /(n-6)]

Statistical analysis: All experiments were conducted in duplicate, and all analyses were done at least in duplicate. Statistical analysis was conducted according to the statistical analysis software of SAS institute (Statistical Analysis System, Cary, NC, USA). Differences among the mean value of samples were tested by Duncan's Multiple Range Test and significance was defined at P<0.05.

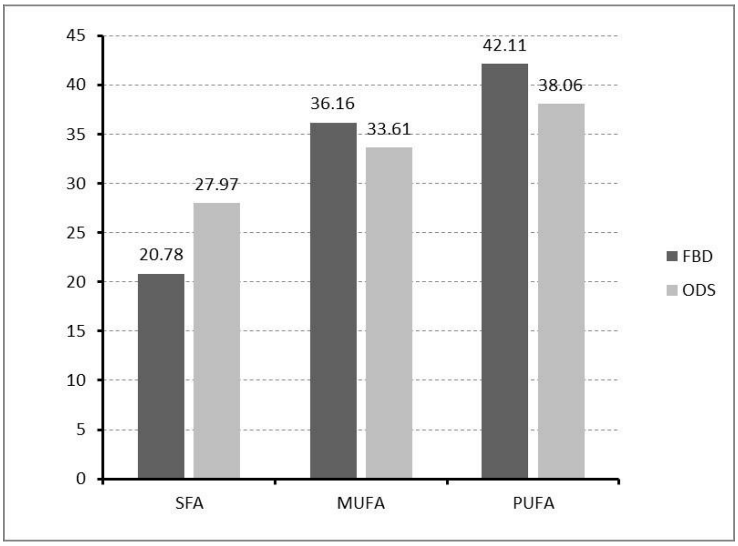

Figure 1
Fatty acid composition of oil extracted from shrimp byproducts.

RESULTS AND DISCUSSION

Fatty acid composition of red shrimp byproducts

Figure 1 shows the saturated (SF), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acid composition of oil extracted from red shrimp (*Aristaeomorpha foliacea*) byproducts. MUFA and PUFA contents of fluidized bed dried byproducts (FBD) were significantly ($P<0.05$) higher than conventional oven dried byproducts (ODS) whereas SFA content was significantly ($P<0.05$) lower than ODS. Fluidised bed drying has been recognised as a rapid, economic, gentle and uniform drying method with a high degree of efficiency compared with other drying techniques (Borgolte & Simon, 1981). PUFA content of FBD (42.11 g/100 g) was higher than that of red shrimp meat (38.88 g/100 g), whereas PUFA content of ODS was similar to PUFA content (38.06 g/100 g) of oil extracted from raw shrimp meat (Yerlikaya et al., 2013).

Figure 2 shows Omega-3 and Omega-6 fatty acid content of oil extracted from red shrimp (*Aristaeomorpha foliacea*) byproducts. Omega-3 fatty acid content of fluidized bed dried byproduct (FBD) was significantly ($P<0.05$) higher than conventional oven dried byproducts (ODS) whereas Its Omega-6 fatty acid content was lower than ODS (Figure 2). Omega-3 fatty acid contents of both FBD (23.79 g/100 g) and ODS (17.76 g/100 g) were lower than that of raw meat of red shrimp (24.56 g/100 g) (Yerlikaya et al., 2013), whereas Omega-6 content of FBD (18.32 g/100 g) and ODS (20.3 g/100 g) was almost five fold higher than that of Yerlikaya et al. (2013) (4.48 g/100 g). It could be stemmed from drying processes took place at high temperatures. Type and amount of consumed essential fatty acids and balanced intake of omega-3 and omega-6 are important for a healthy life. It is essential to decrease Omega-6 intake while increasing Omega-3 to prevent chronic disease (Simopoulos, 2002).

Figure 3 shows health lipid indices (atherogenicity (AI) and thrombogenicity (TI) indexes) of oil extracted from red shrimp (*Aristaeomorpha foliacea*) byproducts. As seen Figure 3. atherogenicity index (AI) and thrombogenicity index (TI) of oil extracted from fluidized bed dried byproducts (FBD) (0.269 and 0.184, respectively) was significantly ($P<0.05$) lower than that of conventional oven dried biomass (ODS) (0.328 and 0.325, respectively). Seafood consumption are recommended by health authorities, not only for their high-quality protein and mineral content, but also for their healthful fatty acids. AI shows the inhibition of the aggregation of plaque and diminishing the levels of esterified fatty acids, cholesterol, and phospholipids, thereby preventing the appearance of micro-and macro-coronary diseases. TI shows the tendency to form clots in the blood vessels (Ulbricht & Southgate, 1991).

Atherogenicity indexes (AI) of both FBD (0.269 and ODS (0.328) were considerable higher than that of other species of red shrimp (*Aristeus antennatus*) (0.24) (Rosa & Nunes, 2004). Thrombogenicity index (TI) of FBD (0.184) was almost similar to lower TI (0.18) of *Aristeus antennatus*, whereas TI value of ODS (0.247) was considerably higher.

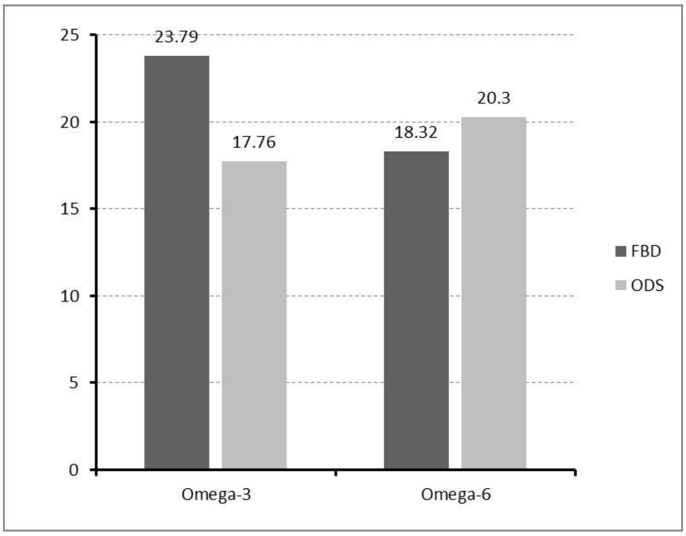

Figure 2
Omega-3 and Omega-6 fatty acid contents of shrimp by products.

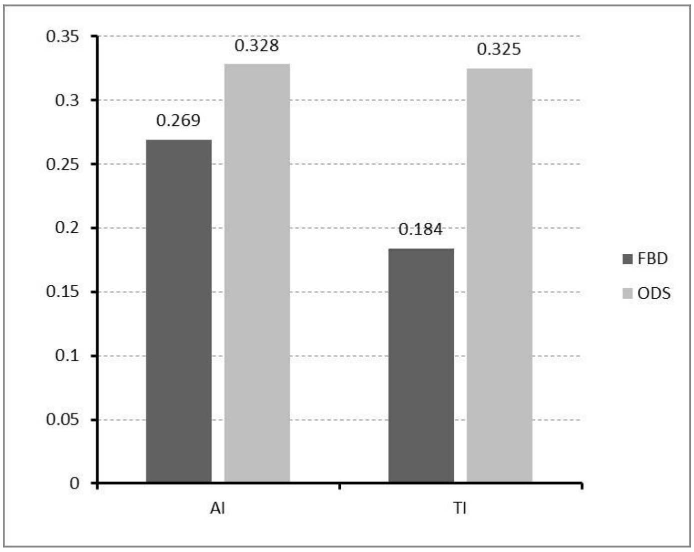

Figure 3
Atherogenicity (AI) and thrombogenicity index (TI) of shrimp by products.

CONCLUSIONS

The results of this study reveal the high nutritional quality of red shrimp byproducts oil. Fluidized bed drying of shrimp byproduct biomass contributed to its nutritional quality with preserving its omega-3 fatty acids. Conventional oven drying of shrimp byproduct biomass had lowering effect on the Omaga-3 fatty acid content of oil extracted from red shrimp byproducts since oven drying of byproducts was taken place at high temperatures for long time. Its concluded that fluidized bed drying method could be used for drying of biomass containing valuable and sensitive bioactive compounds such as omega-3 fatty acids.

REFERENCES

Blig, E., & Dyer, W. (1959). Determination of particulate lipid. Canadian Journal of Biochemistry and Physiology, 37, 91b.

Borgolte, G., & Simon, E. (1981). Fluid-bed processes in the manufacture of snack products. CCB, Review for Chocolate, Confectionery and Bakery.

da Silva, C. P., Bezerra, R. S., dos Santos, A. C. O., Messias, J. B., de Castro, C. R. O. B., & Junior, L. B. C. (2017). Bio logical value of shrimp protein hydrolysate by-product produced by autolysis. *LWT-Food Science and Technology*, 80, 456-461.

Finot, P. (1997). Effects of processing and storage on the nutritional value of food proteins. *Food Science And Technology-New York-Marcel Dekker*-, 551-578.

Özogul, Y., Özogul, F., & Alagoz, S. (2007). Fatty acid profiles and fat contents of commercially important seawater and freshwater fish species of Turkey: A comparative study. *Food chemistry*, 103(1), 217-223.

Prameela, K., Venkatesh, K., Immandi, S. B., Kasturi, A. P. K., Krishna, C. R., & Mohan, C. M. (2017). Next generation nutraceutical from shrimp waste: the convergence of applications with extraction methods. *Food chemistry*, 237, 121-132.

Rosa, R., & Nunes, M. L. (2004). Nutritional quality of red shrimp, Aristeus antennatus (Risso), pink shrimp, Parapenaeus longirostris (Lucas), and Norway lobster, Nephrops norvegicus (Linnaeus). *Journal of the Science of Food and Agriculture*, 84(1), 89-94.

Sila, A., Sayari, N., Balti, R., Martinez-Alvarez, O., Nedjar-Arroume, N., Moncef, N., & Bougatef, A. (2014). Biochemical and antioxidant properties of peptidic fraction of carotenoproteins generated from shrimp by-products by enzymatic hydrolysis. *Food chemistry*, 148, 445-452.

Simopoulos, A. P. (2002). The importance of the ratio of omega-6/omega-3 essential fatty acids. *Biomedicine & pharmacotherapy*, 56(8), 365-379.

Topuz, O. K., YERLİKAYA, P., Yatmaz, H. A., Kaya, A., & Alp, A. C. (2017). Polyunsaturated Fatty Acid (Pufa) Contents Of
Meat And Egg Of Rainbow Trout Fish (Oncorhynchus Mykiss). Scientific Papers: Series D, Animal Science-The International Session of Scientific Communications of the Faculty of Animal Science, 60.

Ulbricht, T., & Southgate, D. (1991). Coronary heart disease: seven dietary factors. *The Lancet*, 338(8773), 985-992.

Venegas-Calerón, M., Sayanova, O., & Napier, J. A. (2010). An alternative to fish oils: metabolic engineering of oil-seed crops to produce omega-3 long chain polyunsaturated fatty acids. *Progress in lipid research*, 49(2), 108-119.

Yerlikaya, P., Topuz, O. K., Buyukbenli, H. A., & Gokoglu, N. (2013). Fatty acid profiles of different shrimp species: effects of depth of catching. *Journal of aquatic food product technology*, 22(3), 290-297.

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