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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

FATTY ACIDS COMPOSITION OF ANCHOVY (*Engraulis encrasicolus* L. 1758) OIL PRODUCED IN SINOP-TURKEY

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Abstract: Anchovy oil is a very suitable supplementary ingredient for fish feeds due to the essential fatty acid composition. Almost all of anchovy oil produced in Turkey is used by aquatic/fish feed producers. In this research we determined fatty acids contents of anchovy oil produced in Turkey during the commercial catching season. The total saturated fatty acids (SFA) content of anchovy oil was determined as 32.33%, 31.65%, 31.59% in November, December and January, respectively. Within the saturated fraction, the major fatty acid was palmitic acid ($C_{16:0}$) with 18.74%, 18.27%, 18.20% ratios during the catching season. The monounsaturated fatty acids (MUFA) content ranged from 23.32% to 24.07%. Concerning the MUFA, oleic acid ($C_{18:1n-9}$) constituted the larger percentage than others. Docosahexaenoic acid (DHA) ($C_{22:6n3}$) and eicosapentaenoic acid (EPA) ($C_{20:5n3}$) contents of anchovy oil were found as average 15.64% and 9.39%, respectively. n-3 polyunsaturated fatty acids (PUFA) were higher than n-6 PUFA. Thrombogenicity (IT) and atherogenicity index (AI) values were 0.27, 0.26, 0.27 and 1.46, 1.42, 1.45 in November, December and January, respectively. The n-3/n-6 ratio was 6.29, 6.17 and 6.70 in November, December and January, respectively.

Keywords: Anchovy oil, fatty acids, AI value, IT value, n-3/n-6 ratio

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Introduction

Most fish cannot synthesize polyunsaturated fatty acids (PUFA) and therefore they must be supplied in the diet for normal growth, reproduction and health. Essential fatty acids (EFA) include PUFA of the n-3 and n-6 series, e.g. α-linolenic acid, 18:3n-3 and linoleic acid, 18:2n-6. Generally, EFA requirements of freshwater fish can be met by the supply of 18:3n-3 and 18:2n-6 fatty acids in their diets. By contrast, the EFA requirement of marine fish can only be met by supplying the correct concentrations and ratios of the long-chain PUFAs, eicosapentaenoic acid (20:5 n-3; EPA) and docosahexaenoic acid (22:6n-3; DHA) with perhaps some arachidonic acid (20:4n-6; AA), a highly unsaturated member of the n-6 series. (Nrc, 1993).

Total fish production in Turkey was reported as 662.000 t in 2006. A significant portion (about 41%) of this harvest is anchovy (Tüik, 2007). It has a great economic importance for the fishmeal and fish oil industry in Turkey. Approximately 42% (156.000 t) of the annual anchovy production is used in fish meal and fish oil industry in Turkey (Die, 2004).

In this research, fatty acid composition during the production season of anchovy oil was investigated because it is an important raw material for aquaculture feeds and consists almost overall of fish oil produced in Turkey.

Material and Methods

Anchovy oil was obtained from a local fish meal and oil factory in Sinop during the commercial catching season of anchovy (from November to January 2003). The 2.5 L anchovy oil was stored in a dark and cool place until used for analyses.

Fatty acid analyses

Fatty acid analyses were carried out using the IUPAC II.D.19 method (Iupac, 1979). Fatty acids of the anchovy and anchovy oil were analyzed using a Perkin Elmer Auto system XL Gas Chromatograph equipped with SP-2330 and a flame ionization detector (FID). Separation of fatty acid methyl esters was achieved on fused silica capillary column (30 m x 0.25 mm x 0.20 μm film thickness the oven temperature was 120^{o}C for 2 min, and programmed to 220^{o}C at heating rate of 5^{o}C/min, then held for 15 min. The injector and detector temperatures were maintained at 240^{o}C and 250^{o}C, respectively. The carrier gas was helium 10psi with a split ratio of 1/50. The air and hydrogen of pressure were 338 ml/min and 45 ml/min respectively. Fatty acids were identified by comparing the retention times of fatty acid methyl esters(FAME) with a standard 37 component FAME mixture (Supelco-Catolog No:18919-1Amp.) Results were expressed as the percentage of each fatty acid with respect to the total fatty acids. All chemical analyses were run in duplicate. The results were expressed in GC area % as mean values ± standard error.

Lipid quality indices were calculated according to Ulbricht and Southgate (1991). The atherogenic index (AI) and index of thrombogenicity (IT) were calculated as follows:

$$AI = \frac{[12:0+4\,(14:0+16:0)]}{[(n6+n3)PUFA+18:1+\Sigma MUFA]}$$

$$IT = \frac{(14:0+16:0+18:0)}{[(0.5x18:1)+0.5(\Sigma MUFA)+0.5(n6PUFA)+3(n3PUFA)+(n3PUFA/n6PUFA)]}$$

Statistic analysis

Data analysis was carried out with t-test in Microsoft Excel. Differences were studied at the $p<0.05$ level.

Results and Discussion

The fatty acid composition of anchovy oil are shown in Table 1. The total saturated fatty acid (SFA) content of anchovy oil was determined as 32.33%, 31.65%, and 31.59% in November, December and January, respectively. The SFA content insignificantly ($P>0.05$) decreased during the catching season. Palmitic acid ($C_{16:0}$) (18.4%) and myristic acid (6.5%) in anchovy oil were found at the highest content through catching season among the saturated fatty acids. Bimbo, (1990) reported that palmitic acid was 15% in anchovy oil. Also in sardine oil, South African anchovy oil and menhaden fish oil these two fatty acids were dominant in total SFA (Colin et al., 1993).

Table 1. The fatty acid composition (%) of anchovy oil during the catching season

Fatty acids (%)	Anchovy oil		
	November	December	January
C12:0	0.09 ±0.002	0.09 ±0.004	0.12 ±0.005
C13:0	0.07 ±0.000	0.07 ±0.001	0.06 ±0.003
C14:0	6.50 ±0.088	6.35 ±0.110	6.66 ±0.000
C15:0	1.01 ±0.011	0.98 ±0.011	0.98 ±0.006
C16:0	18.74 ±0.089	18.27 ±0.107	18.20 ±0.108
C17:0	1.27 ±0.005	1.29 ±0.010	1.17 ±0.004
C18:0	3.43 ±0.001	3.36 ±0.001	3.20 ±0.017
C20:0	0.63 ±0.009	0.63 ±0.002	0.62 ±0.005
C21:0	0.22 ±0.001	0.23 ±0.001	0.23 ±0.001
C22:0	0.18 ±0.000	0.18 ±0.000	0.18 ±0.000
C23:0	0.11 ±0.008	0.11 ±0.000	0.09 ±0.001
C24:0	0.08 ±0.001	0.09 ±0.005	0.08 ±0.001
Tot. SFA	**32.33 ±0.176**	**31.65 ±0.217**	**31.59 ±0.121**
C14:1	0.18 ±0.003	0.18 ±0.003	0.16 ±0.004
C15:1n5	0.03 ±0.003	0.03 ±0.002	0.02 ±0.001
C16:1n7	6.16 ±0.037	6.23 ±0.034	6.64 ±0.043
C17:1n7	0.04 ±0.003	0.03 ±0.007	0.02 ±0.001
C18:1n9t	0.13 ±0.001	0.13 ±0.002	0.14 ±0.000
C18:1n9c	14.73 ±0.005	14.87 ±0.010	15.11 ±0.053
C20:1n9	1.21 ±0.009	1.22 ±0.003	1.17 ±0.006
C22:1n9	0.28 ±0.006	0.28 ±0.003	0.25 ±0.003
C24:1n9	0.56 ±0.003	0.62 ±0.012	0.56 ±0.003
Tot. MUFA	**23.32 ±0.022**	**23.59 ±0.006**	**24.07 ±0.016**
C18:2n6t	0.18 ±0.002	0.18 ±0.000	0.16 ±0.001
C18:2n6c	1.76 ±0.005	1.80 ±0.004	1.53 ±0.005
C18:3n6g	0.16 ±0.004	0.17 ±0.001	0.15 ±0.002
C18:3n3a	1.22 ±0.004	1.24 ±0.001	1.11 ±0.004
C20:2n6	0.23 ±0.003	0.23 ±0.000	0.21 ±0.004
C20:3n3	0.11 ±0.003	0.12 ±0.001	0.10 ±0.005
C20:4n6	0.99 ±0.012	0.99 ±0.003	0.92 ±0.005
C22:2n6	0.93 ±0.011	0.93 ±0.004	0.87 ±0.006
C20:5n3	9.16 ±0.033	9.16 ±0.027	9.85 ±0.051
C22:6n3	16.23 ±0.065	16.03 ±0.069	14.67 ±0.108
Tot. PUFA	**30.97 ±0.125**	**30.85 ±0.099**	**29.57 ±0.185**
EPA+DHA	**25.39**	**25.19**	**24.52**
Tot. n-3	**26.72**	**26.55**	**25.73**
Tot. n-6	**4.25**	**4.30**	**3.84**
n-3/n-6	**6.29**	**6.17**	**6.70**
AI	**1.46**	**1.42**	**1.45**
IT	**0.27**	**0.26**	**0.27**

Each value is the mean of duplicate analyses, (±): represent standard error

The total MUFA content ranged from 23.32% to 24.07% and significantly ($p<0.05$) increased during the catching season. Oleic acid ($C_{18:1n-9}$) constituted a larger percentage (14.73%, 15.11%) than other MUFAs. Bimbo, (1990) reported that oleic acid was 10% in anchovy oil. Colin et al., (1993) reported similar results for sardine oil, South African anchovy oil and menhaden fish oil.

The highest PUFA value was found (30.97%) in November while least value (29.57%) was found in January. The PUFAs decreased during the catching season. No significant ($P>0.05$)

changes were observed between November and December. In this study, the content of n-3 PUFA in anchovy oil was determined as average 26.33%. Colin et al., (1993) reported that n-3 PUFAs were 35.3% for sardine oil, 36.8% for South African anchovy oil and 34.5% for menhaden fish oil.

Among the PUFAs, DHA was the dominant fatty acid present in the anchovy oil and DHA content varied from 14.67% to 16.23% during the catching season. The EPA content which is another important fatty acid found between 9.16% and 9.85% during the production. Seaborn et al., (1986) reported that mean values of the EPA and DHA in Menhaden Gulf oil changed according to season. Kagami et al., (2003) reported that refined fish oil contained DHA 17.3%, EPA 5.5%. Bimbo, (1990) reported 18% EPA and 16% DHA in anchovy oil.

The n-3/n-6 ratio is a good index for comparing relative nutritional value of fish oils (Pigott and Tucker, 1990). The ratio of n-3/n-6 of was 6.29 in November, 6.17 in December, and 6.70 in January, respectively. In intensively reared animals it appears that diets have become unbalanced in terms of the make-up of fat particularly polyunsaturated fatty acids. The content of n-3 fatty acids has declined and that of n-6 fatty acids increased. By supplementing with fish lipids which are rich in long chain omega-3 fatty acids (especially EPA and DHA) the balance can be restored. DHA are found mainly in fish oils and certain marine algae. Algal lipids are effective concentrated sources of EPA and DHA but are expensive to produce. Fish oil with its low price and high energy value comes into most diets on a least cost basis (Pike, 1999).

IT and AI index values were 0.27, 0.26, 0.27 and 1.46, 1.42, 1.45 in November, December and January, respectively. Valfre et al., (2003) reported IT and AI values 0.45 and 1.35 for anchovy, 0.32 and 0.94 for eel, 0.37 and 0.57 for rainbow trout, 0.25 and 0.45 for sea bass, respectively. Rueda et al., (1997) reported IT and AI values 0.2 and 0.4 for wild red porgy and 0.2 and 0.5 for reared red porgy, respectively. The same researchers reported IT and AI values 0.24 and 0.51 for reared sharpsnout seabream, 0.35 and 0.53 for wild sharpsnout seabream, respectively (Rueda et al. 2001). Turan et al. (2007) reported IT and AI values 0.63 and 2.37 for thornback ray. Kaya et al. (in press) reported IT value 0.31 and AI value 1.01 for sturgeon, respectively.

Conclusion

Anchovy oil is a very suitable supplementary ingredient for fish feeds due to the fatty acid composition.

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