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Address:
Fırat Universitesi
Fen Bilimleri Enstitüsü
23119, Elazig - TURKEY

Tel: 0 424 212 27 07
Fax: 0 424 236 99 55
e-mail: fenbilimdergi@firat.edu.tr

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U and Th Transport and Uptake in *Triticum Sativum* Cultivated Farmland in the Temrezli (Sorgun, Yozgat, Turkey) U and Th Mining Area

Güllü-KIRAT[1*], Nasuh-AYDIN[2]
[1] Department of Geological Engineering, Faculty of Architecture and Eng. Yozgat Bozok University, Yozgat, Turkey
[2] Department of Geological Engineering, Faculty of Architecture and Eng. Balikesir University, Balikesir, Turkey
[*1] gullu.kirat@bozok.edu.tr, [2] nasuhaydin@hotmail.com.tr

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Abstract: In this study, 20 samples *Triticum sativum L. (T. sativum)* plants grown in Temrezli agriculture areas were collected and the distribution and accumulation of uranium and thorium (U and Th) in stems, shells and grains of this plant were identified. In addition, plant ashes and nearby soil samples were analyzed by ICP-MS to determine the concentrations of U and Th. The mean U and Th values in the soils, stems, shells and grains of *T. sativum* plant, were calculated as 2.73 mg/kg, 0.16 mg/kg, 0.17 mg/kg, 0.16 mg/kg and 34.01 mg/kg, 1.02 mg/kg, 0.65 mg/kg, 1.09 mg/kg (in respectively). The mean U and Th enrichment coefficients of this plant were less than 1. The decrease in EC may be due to the saturation of metal uptake and/or transport. Therefore, *T. sativum* plant may be useful in phytoremediation and in remediation areas contaminated by U and Th.

Key words: Enrichment coefficient; phytoremediation; uranium; thorium; *Triticum sativum* plant.

Temrezli'de (Sorgun, Yozgat) Yetiştirilen *Triticum Sativum* Bitkisinde U ve Th Birikimi ve Taşınması

Özet: Bu çalışmada, Temrezli tarım alanlarında yetiştirilen *Triticum sativum L. (T. sativum)* bitkisinden 20 adet örnek alınarak, bu bitkinin dal, kabuk ve tohumlarındaki uranyum ve toryumun (U ve Th) dağılımı ve akümülasyonu (birikimi) tanımlanmıştır. Bitki külü ve ilişkili toprak örneklerinde U ve Th'u belirlemek için ICP-MS ile analiz edilmiştir. *T. sativum* bitkisinin topraklarında, saplarında, kabuklarında ve tohumlarında ortalama U ve Th değerleri (sırasıyla), 2.73 mg/kg, 0.16 mg/kg, 0.17 mg/kg, 0.16 mg/kg ve 34.01 mg/kg, 1.02 mg/kg, 0,65 mg/kg, 1,09 mg/kg olarak bulunmuştur. Bu bitkinin ortalama U ve Th zenginleştirme katsayıları 1'den düşüktür. EC değerlerinin düşük olması, bitki organlarının metalin doygunluğundan kaynaklanabilir. Bu nedenle, *T. sativum* bitkisi, U ve Th tarafından kirlenen alanların iyileştirilmesinde ve fitoremeditasyonunda kullanılabilir.

Anahtar kelimeler: Zenginleştirme katsayısı; fitoremeditasyon; uranyum; toryum; *Triticum sativum* bitkisi.

1. Introduction

Uranium is the naturally occurring heaviest radioactive element and consists of ^{234}U, ^{235}U and ^{238}U isotopes. The main isotopes formed during radioactive decay are $^{235}U$and ^{238}U. Th has two naturally occurring isotopes which are ^{232}Th and ^{230}Th. ^{232}Th is the main radionuclide of the ^{208}Pb decay product. ^{230}Th is found in minerals which contains U. Th coexists with sulphur, nitrogen, carbon, boron, silicon, halogens and intermetallic compounds containing many metallic elements. At high temperatures, the chemical properties of U and Th are similar, which reveals co-formation in hydrothermal beds. However, under normal surface conditions U is chemically more mobile since it is bivalent (unlike strong monovalent behaviour of Th) [1].

Inhalation of air containing U powders and the U-containing foods can cause chemical and radiological toxicity. The U compounds entering the bloodstream are filtered by the kidneys. High doses of U intake can result in acute renal failure and death [2-3].

Th existing in the blood is taken from food, water and air. After a few minutes of Th breathing comes sneezing and coughing. Th can be found in the lungs and blood. Th in the lung is thrown into stools and urine a few days later. But the Th in the blood can remain for many years [1].

The global mean of the Th content of soils varies from 3.4 to 10.5 mg/kg and varies from 0.79 to 11 mg/kg for U [4].

Plants and soil which include natural radioactive elements such as U, Th; (e.g., U, Th), although these elements in plants present could be little. The distribution of U and Th around the area is causing great damage.

* Corresponding author: gullu.kirat@bozok.edu.tr. ORCID Number of authors: [1] 0000-0002-1167-0574, [2] 0000-0001-8428-9750

Although radioactive elements such as U an Th may be found wihtin plant bodies and surrounding soils, their concentrations are mostly very low. The distribution of U and Th around the area is causing great damage [5-7].

The soils derived from mineralization zones are very rich in terms of the metal within ore minerals. The plants that grow in such soils more being effected than the other plants that grow in different soils and these plants adapt to environment or die. Based on this, the chemical analysis values of the various organs (stems, shells and grains, etc.) of the plant species which were systematically collected from study are effectively used in the determining of indicator plants (ore researches), stating of environmental pollution (phytoremeditation). Therefore, in and around of the Temrezli U deposit, organs of plants will be sampled according to the ore and plant distribution. As a result of this study, the relationship between soil-plant and mineralization brought out by analyses of the plants and the soil samples that feed the plants.

2. Study Area

The study area is located in the vicinity of Sorgun where 35 km east of Yozgat (Fig. 1). The study area is mostly composed of plain fields *T. sativum* plants. Towards the north, the altitude at the Uç Hills is over 1200 m. In Temrezli, summer is hot and arid, winter is cold and hard, and there is a terrestrial climate. This is a defining feature of the arid and steppe vegetation cover. July and August are hottest and driest months. A large part of the annual rainfall falls in the spring and autumn seasons. The mean annual rainfall is 450-500 kg per square meter. It snows in the winter. January is the coldest month of the year.

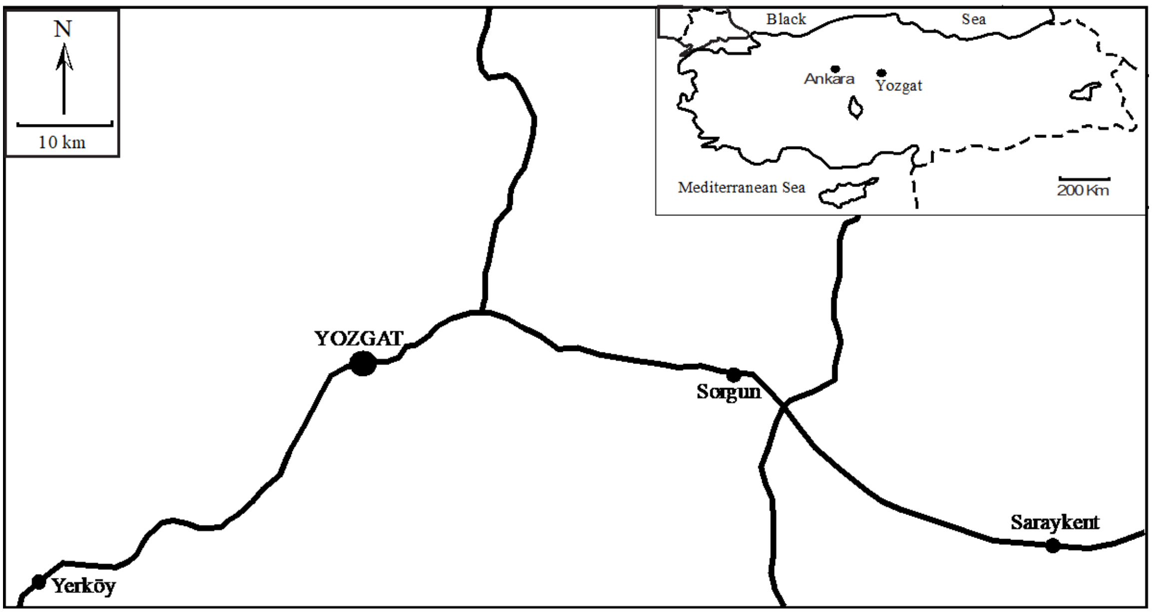


Figure 1. Location map of the study area

Temrezli U deposit is the largest known U deposit of Turkey. Geological units are observed from bottom to top Upper Cretaceous-Lower Paleocene Granitoids, Tertiary Cover Units and Quaternary alluvium (Fig. 2). This bed was discovered in the 1980s by the General Directorate of Mineral Research and Exploration (MTA). Intensive mining activities are underway in this area by a private company. ‘In – situ recovery’ will be used as a production method, which is known as one of the environmental friendly mining solution [8].

3. Plant and Soil Samples

T. sativum samples consisting of stems, shells, grains and related soils were taken from 20 locations in the Temrezli region. This plant has been selected because it has been cultivated too much in agricultural fields in the study area. Samples were collected about 20 cm deep around the *T. sativum* plant. After the soil samples have been dried at room temperature, the rocks and plant parts were removed using a sieve. The *T. sativum* samples were divided into sections and washed first with the ordinary water and then with distilled water. It was left to dry at room temperature, after plant samples were dried for 4 hours in an oven at 60 °C, 0.10 g of the ash and soil samples were added 2 ml of concentrated HNO_3 and dried by heating at microwave at 95 °C for 1 hour.

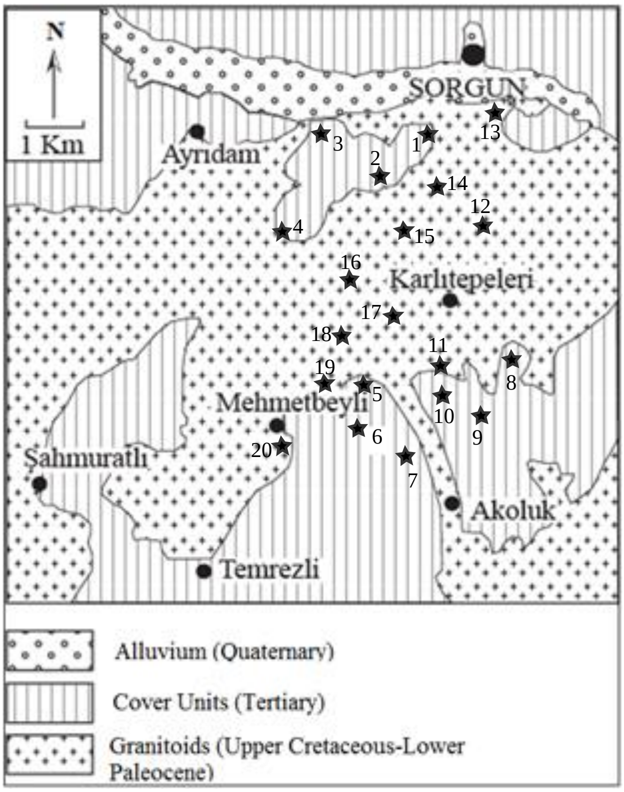


Figure 2. Geological map of the study area [9 from modified].

After the samples were cooled, 2 ml HNO_3 and HCl-HNO_3-H_2O mixture was added (HCl-HNO_3-H_2O (1:1:1, v/v; 6ml per 0.10 g of ash and soil). The resulting mixture was diluted with distilled water to a final volume of 50 ml and calculations were made according to final volume. The digests were analyzed using ICP-MS techniques for U, Th and other elements at the BILTEM (Yozgat Bozok University, Science and Technology Application and Research Center) Yozgat, Turkey.

3.1. Enrichment coefficients of stems (ECst), shells (ECsh) and grains (ECg)

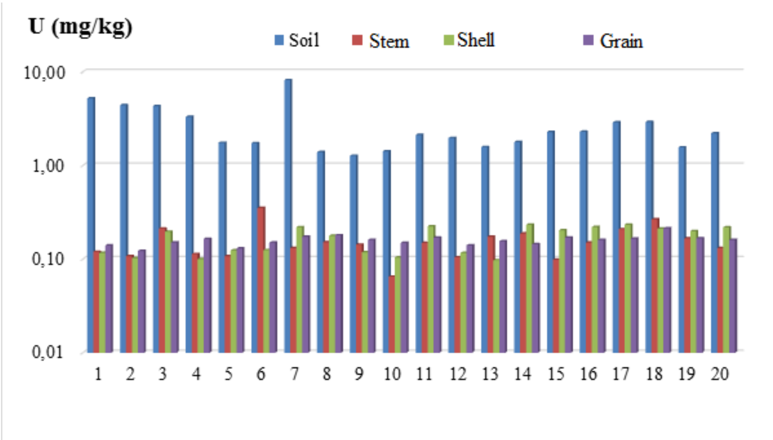
Enrichment coefficientsfor plant stems (ECst), shells (ECsh) and grains (ECg) were calculated using the ratios of the element concentration ratios in plant stems, shells and grains and soils (value of the plant stems, shells and grains divided by the value of soils). (ECst), shells (ECsh) and grains (ECg) values are used as an symbol for the transfer of elements from soil to plants [10-14]. Besides, this values indicates the capacity of a given plant species for phytoremediation [15].

4. Results and Discussion

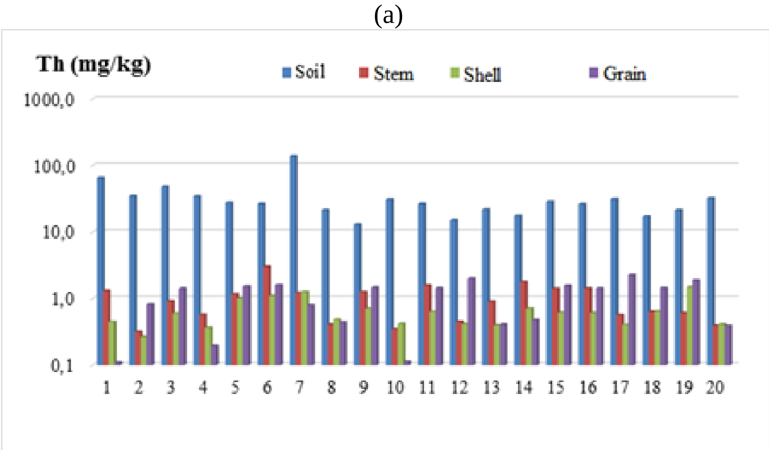
4.1. U and Th concentrations in the soils

The soil samples were collected from the Temrezli area and its around. U concentrations in the soil are between 1.27 - 8.17 mg/kg (mean: 2.73 mg/kg) (Fig. 3). The maximum limit for U concentrations in soils are 1 mg/kg recommended by WHO [16]. U concentrations in soils of Siwaqa region range between 1.83-56.8 mg/kg (mean: 12.64 mg/kg).U concentrations of surface soil range from 1.5-8 mg/kg (mean:3.17 mg/kg) in the Italy; 0.10-2.33 mg/kg (mean:0.79 mg/kg) in the Poland; 0.3-10.7 mg/kg (mean: 3.7 mg/kg) in the US.; <0.22-45 mg/kg (mean:2.3 mg/kg) in the U.S. (Alaska) and 0.72-2.05 mg/kg (mean: 1.22 mg/kg) in the Canada [4]. Soil samples have exceeded the values of U concentration in soils as recommended by WHO [16]. and the mean values of U concentration in the U.S. (Alaska), Poland and Canada soils as recommended by Kabata-Pendias and Pendias [4].

Th concentrations in the Temrezli soil samples are between 13 mg/kg and 139 mg/kg (mean: 34.01 mg/kg) (Fig. 3). Th concentrations of surface soils range from 4.2-14.1 mg/kg (mean: 8 mg/kg) in the Canada; 0.4-15 mg/kg (mean: 8 mg/kg) in the Germany; 3.6-17.8 mg/kg (mean: 9.3 mg/kg) in the Bulgaria;1.4-7.2 mg/kg (mean: 3.4 mg/kg) in the Poland; 2.2-21.0 mg/kg (mean: 7.6 mg/kg) in the U.S. and 1.6-76 mg/kg (mean: 6.1 mg/kg) in the U.S. (Alaska) [4]. In the study area, Th concentration is appeared to be very high, between 3.8 - 12.4 mg/kg in soils of the U.S. and between 8 - 27 mg/kg in soils of China [16-17]. and in soils as recommended by Kabata-Pendias and Pendias [4].



(a)



(b)

Figure 3. (a) U concentrations of the soil samples, (b) Th concentrations of the soil samples, stem, shell and grain of *T. sativum* plant.

Granites are widespread in the Temrezli area and its around (Fig. 2). Acid rocks (granites, gneisses; U: 2.5-6 mg/kg and Th: 10-23 mg/kg) generally contain more Th and U than do mafic rocks (basalts, gabbros; U: 0.3-1 mg/kg and Th: 1-4 mg/kg), and in the sediments it is thought that these elements are probably concentrated in argillaceous deposits (U: 3-4 mg/kg and Th: 9.6-12 mg/kg) than in sandstones (U: 0.45-0.59 mg/kg and Th: 1.7-3.8 mg/kg) and limestones (U: 2.2-2.5 mg/kg and Th: 1.7-2.9 mg/kg). The carrier of Th is fundamentally monazite mineral. Th is concentrated in some weathered deposits, because this monazite mineral is very robust to weathering [4]. The U and Th concentrations may be related to the Ag, Fe, Mn, Pb and V elements of the Temrezli region, because the presence of U and Th showed a positive linear correlation with the occurrence of these metals. These positive correlations (U, r = 0.574-0.028 and Th, r = 0.712-0.079) were observed between U and the metals Ag and V, and between Th and the heavy metals Ag, Fe, Mn, Pb and V, whereas negative linear correlations (U-Ca r = -0.61, U-Cd r = -0.51 and Th-Ca r = -0.74, Th-Cd r = -0.71) were observed between U and Th with the metals Ca and Cd (Table 1).

Table 1. Correlations between U and Th in soils of the study area (*Correlation is significant at the 0.05 level; ** Correlation is significant at the 0.01 level)

	B	Na	Mg	Ca	V	Cr	Mn	Fe	Co	Ni
U	0.174	0.03	-0.349	-,614(**)	,556(*)	-0.284	0.305	0.377	-0.177	-0.091
Th	-0.007	-0.002	-0.186	-,740(**)	,579(**)	-0.223	,565(*)	,532(*)	0.082	-0.075

	Cu	Zn	As	Ag	Cd	Sb	Pb	U	Th
U	-0.353	0.149	0.116	,574(*)	-,508(*)	0.028	0.318	1	,695(**)
Th	-0.273	0.354	-0.149	,712(**)	-,706(**)	0.079	,616(**)	,695(**)	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

The linear correlations between U and Th with Ag, Fe, Mn, Pb and V showed that they have been carried in hydrothermal solutions to Temrezli region. Many studies have assumed that the transfer of U and Th from soil to plants is a positive correlations relationship due to some ecological and agricultural conditions [7].

Important relationships (r = 0.79) were detected between U and Th content in the soils (r = 0.79) and in the stems (r = 0.48) in Temrezli region. This means that the more U and Th in soil, the more Th accumulates in the stems (1, 5-7, 9, 11, 14-16 number locations), in the shells (6, 7, 19 number locations) and in the grains (3, 5, 6, 9, 11, 12, 15-19 number locations) (Fig. 4).

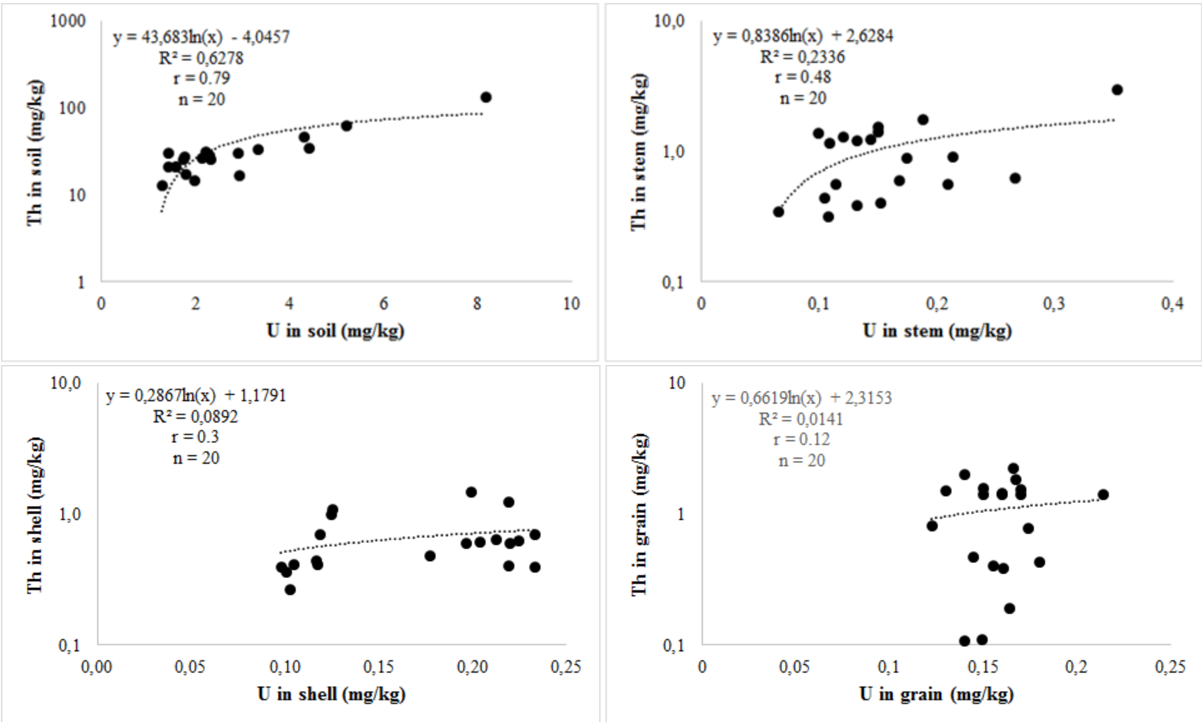


Figure 4. Correlations between U and Th in soil, stem, shell and grain in the study area.

Fig. 5 clearly shows that the EC values of U in the plant stems, shells and grains is less than 1 and the Th EC values is greater than 1 in the some location samples. Although the chemical properties of U and Th are similar, the behavior of these metals in plants and in the soil may change. Therefore, it is thought that there are other factors affecting the U and Th chemistry in the plant - soil system [7].

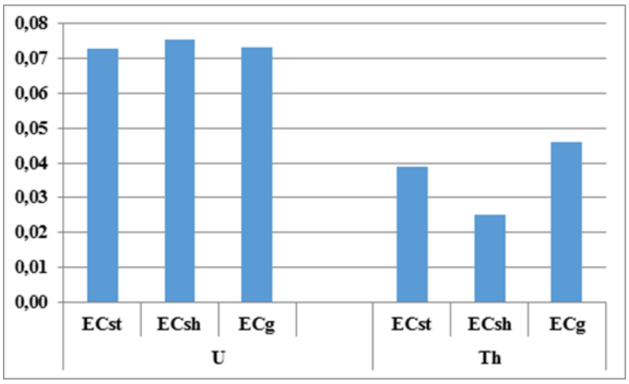


Figure 5. Mean U and Th enrichment coefficients for stems (ECst), shell (ECsh) and grains (ECg) of *T. Sativum* plant in the study area

The highest U and Th concentration in all analyzed soil samples were 8.17 and 139 mg/kg (in respectively) in the location 7, which were collected from Temrezli area. U and Th were found in high concentrations in acidic soils (pH 3.6 - 4.7) near the surface. (0 - 20 cm). In slightly acidic soil (pH = 5.8 - 7.0), U was more soluble at a significant level than Th. The Th resolution is 5 to 14 times higher than the resolution [18].

4.2. U and Th concentrations in the plants

In the Temrezli region, 20 plant species were selected for the determination of U and Th concentrations. The selected *T. Sativum* plants are grown in a wide range in this region and they are an annual plant species. The mean U and Th concentrations of *T. Sativum* plants in study area varies according to plant parts (U in the stems: 0.16 mg/kg¸U in the shell: 0.17 mg/kg, U in the grains: 0.16 mg/kg; Th in the stems: 1.02 mg/kg, Th in the shell: 0.65 mg/kg, Th in the grains:1.09 mg/kg). These concentrations were significantly higher than the U and Th values in *T. Sativum* plant stems, shells and grains. U and Th concentrations of *T. sativum* plant parts and the associated soils are given in Fig. 3.

The U concentrations for *T. Sativum* plant samples ranged between 0.07 and 0.35 mg/kg for the stems, between 0.10 and 0.23 mg/kg for the shells and between 0.12 and 0.21 mg/kg for the grains (Fig. 3). The Th concentrations for *T. Sativum* plant samples ranged between 0.32 and 3.03 mg/kg for the stems, between 0.27 and 1.50 mg/kg for the shells and between 0.11 and 2.27 mg/kg for the grains (Fig. 3). The U and Th enrichment coefficients (ECst, ECsh and ECg) for *T. Sativum* plant stems, shells and grains are shown in Fig. 5; the mean ECst, ECsh and ECg values were 0.07 mg/kg, 0.08 mg/kg and 0.07 mg/kg for U and 0.04 mg/kg, 0.03 mg/kg and 0.05 mg/kg for Th (in respectively) (Fig. 5).

5. Conclusions

The U and Th concentrations in soils from the Temrezli area varied between 1.27-8.17 mg/kg (mean: 2.73 mg/kg), and 12.97-139 mg/kg (mean: 34.01 mg/kg), which are higher than some other soils reported by other researchers. The distribution and accumulation of U and Th was examined in the stems, shells and grains of 20 *T. Sativum* plant samples that has been raised to agricultural land in the Temrezli mining area. The mean concentrations of U and Th in the stems, shells and grains of this plant were found 0.16 mg/kg, 0.17 mg/kg and 0.16 mg/kg and 1.02 mg/kg, 0.65 mg/kg and 1.09 mg/kg (in respectively).

(ECst), (ECsh) and (ECg) were calculated using the ratios of element concentrations in plant organs. The mean concentrations of U and Th in *T. Sativum* plant from the study area varied between 0.07 mg/kg, 0.08 mg/kg and 0.07 mg/kg, and 0.04 mg/kg, 0.03 mg/kg and 0.05 mg/kg (in respectively). According to these values can be used as a symbol in the transfer of elements from soil to plants. Besides, these values can be used for U and Th phytoremediation in contaminated soils.

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Importance Of Length-Length And Length-Weight Relations In Crayfish

Ayşe Gül HARLIOĞLU*
Fisheries Faculty, Firat University, Elazig, Turkey
*aharlioglu@firat.edu.tr,

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Abstract: The measurement of individual's body weight and length is a fundamental procedure in the scientific study of a species. Regression equations of the relationships between length-length and length-weight in crayfish are used to compare populations in terms of condition, growth and development, sexual maturity and populations in different regions. On the other hand, the most important factors affecting the meat yield in freshwater crayfish include ecological characteristics, genetic structure and catching time. In addition, in the determination of meat yield content, the relations between length-length and length-weight are commonly used. In this study, the importance of length-length and length-weight relationships in freshwater crayfish is explained in detail.

Key words: Decapod, population, carapace, abdomen, cheliped, claw.

Kerevitlerde Uzunluk-Uzunluk ve Uzunluk-Ağırlık İlişkilerinin Önemi

Özet: Bireylerin vücut uzunluğu ve ağırlığının ölçülmesi, bir türün bilimsel çalışmasında temel bir prosedürdür. Kerevitlerde uzunluk-uzunluk ve uzunluk-ağırlık arasındaki ilişkilerin regresyon denklemleri populasyonların kondüsyon, büyüme ve gelişme, eşeysel olgunluk ve farklı bölgelerdeki populasyonlarının karşılaştırılmasında kullanılmaktadır. Bununla birlikte, tatlısu ıstakozlarında uzunluk-uzunluk ve uzunluk-ağırlık arasındaki ilişkilerin özellikle ekonomik olarak işletilen populasyonlar açısından da bilinmesi gereklidir. Öte yandan, tatlısu ıstakozlarında et verimini etkileyen en önemli faktörler arasında, ortamın ekolojik özellikleri, genetik yapı ve avlanma zamanı bulunmaktadır. Et veriminin belirlenmesinde ise uzunluk-uzunluk ve uzunluk-ağırlık arasındaki ilişkilerden yaygın olarak yararlanılmaktadır. Bu çalışmada tatlısu ıstakozlarında uzunluk-uzunluk ve uzunluk-ağırlık ilişkilerinin önemi detaylı olarak açıklanmıştır.

Anahtar kelimeler: Dekapod, populasyon, karapaks, abdomen, kiliped kıskaç.

1. Introduction

Crayfish are accepted as keystone species in many lake and streams and they dominate the benthic biomass in many cases. There are more than 600 different crayfish species present worldwide, and they are found in all continents but not in Antarctica [1]. However, approximately 15 freshwater crayfish have been accepted as economically important especially for the last 30 years not only because of their ecological importance due to their spread over such a wide area in the natural environment but also because of the following reasons:

- Use of crayfish shell in pharmacy and medicine as row materials (i.e., chitin and chitosan production) [2-4],
- They are consumed as a luxury feedstuff [5-8],
- Wastes of crayfish processing units (i.e., viscera, muscle and shell) are used as feed additives and fertilizers [9-13],
- Indirect use of crayfish (i.e., keeping crayfish in aquariums as a hobby, recreational, cultural, ethical, aesthetic, scientific and education values) [14, 15].

2. Importance of Length-Length and Length-Weight Relations in Freshwater Crayfish

The crayfish need moult to grow to size. Therefore, the age of the crayfish cannot be determined due to the change of shells. As a result; length-length and length-weight relationships are commonly considered in crayfish instead of age determination. In addition, length-length and length-weight relationships are considered important parameters to obtain information about the following characteristics of crayfish:

* Corresponding author: aharlioglu@firat.edu.tr. ORCID Number of author: 0000-0001-9478-6419

• Comparison of males and females [16-24],
• Estimation of egg size and egg number with growth rate and size in sexual maturity [25- 27],
• Comparison of different species [28-34],
• Comparison of different populations of same species [35-39],
• Determination of condition factor [39-43].

2.1 Determination of length – length relationships

Following body lengths are used to determine length-length relationships in crayfish [16, 33, 38]:

Carapace length (CL),
Carapace width (CW),
Abdomen length (AL),
Abdomen width (AW),
Total length (TL)
Chelae length (ChL),
Chelae width (ChW);
Cheliped length (ChpL)

Figure 1 shows the locations where the measurements of these length patents are taken in crayfish.

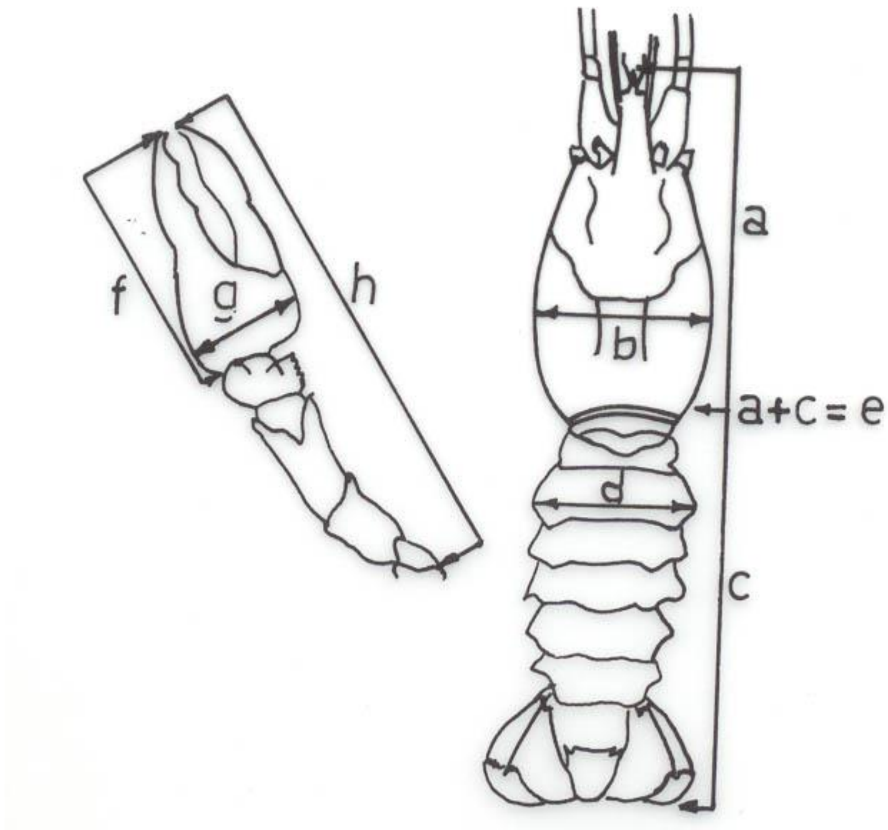

Figure 1. A diagram of freshwater crayfish showing the length measurements taken (adapted from Rhodes and Holdich, 1979) (Legend: (a): CL, from tip of the rostrum to the posteriomedial edge of the carapace, (b): CW, at the widest point of the thorax, (c): AL, from posteriomedial edge of the carapace to the tip of telson (excluding setae), (d): AW, at the widest point of the second segment, (e): TL, from the tip of rostrum to the tip of telson (excluding setae) (carapace length + abdomen length), (f): ChL, from carpal joint to the tip of the propodus, (g): ChW, at the widest point of chelae, (h): ChpL from the tip of propodus to basapodite

On the other hand, the relationship between length parameters is examined in the form below formula:

$$\log y = \log(a) + b \log(x) \tag{1}$$

The linearity of the relationship between the "r" value parameters obtained as a result of the regression analysis; The relationship is isometric when the constant "b" is "3", a negative relationship if "less than 3" and a positive allometric relationship if "greater than 3" [28, 31, 32].

2.2 Determination of length - weight relationships in freshwater crayfish

Carapace length – body weight and abdomen length – body weight relationships are commonly considered to evaluate length - weight relationships in freshwater crayfish. The relationships between length - weight are examined in the form below formula [24, 34, 36, 42, 43]:

$W = aL^b$
W = Body Weight (g)
L = Carapace Length or Carapace Width (mm)

3. Determination of Condition Factor (CF) in Freshwater Crayfish

The condition factor is a parameter that expresses the quantitative effect on the condition of the feed or the feeding method applied [44].

Following formula is used to calculate the nutritional capacity and the conditioning factor that gives information about the nutritional level in crayfish [39-41]:

$$CF = [\text{Body Weight (g)}/(\text{Carapace Length (cm)})^3\,]\times 100 \tag{2}$$

4. Conclusion

It can be concluded that providing information on the length-length and length-weight relations in crayfish is a crucial procedure in the scientific study of a species (i.e., showing differences between crayfish populations, determining relative growth, comparing populations of the same species, use of morphological charecteristics in the systematic classification of crayfish). The most commonly considered body lengths for crayfish are carapace length, total body (carapace+abdomen) length, and body wet weight. Length-length and length-weight relations are also important when crayfish are subjected to commercial use. In addition, it can be concluded that length–weight relationship of a crayfish species is used to calculate the standing stock biomass. Therefore, understanding the relationship between length-length and length-weight can have significant implications for the culture and management of aquaculture species.

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A Preliminary Study of Growth Pattern, Condition Factor and Population Structure of Sicklefin Mullet, *Liza falcipinnis* (Valenciennes, 1836) in the New Calabar River, Nigeria

Olaniyi Alaba OLOPADE[1*], Henry Eyina DIENYE[2], Samuel Kweku Konney AMPONSAH[3]
[1&2] Department of Fisheries, University of Port Harcourt, PMB 5323, Port Harcourt, Nigeria
[3]Department of Fisheries and Water Resources, University of Energy and Natural Resources, Box 214, Sunyani, Ghana
[*1]olaniyi.olopade@uniport.edu.ng, [2]Henry.dienye@uniport.edu.ng [3]samuel.amponsah@uenr.edu.gh

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Abstract: A study on growth pattern, condition factor and stock characteristics of the Sicklefin Mullet *Liza falcipinnis* Valenciennes, 1836 from the New Calabar River, Nigeria was undertaken from January to December 2017. The length of *L. falcipinnis* ranged from 9.1 to 37.1 cm while weight was between 13 to 370 g. The result of length weight relationship revealed negative allometric growth pattern with the b value of 2.38 and condition factor (k) of 0.88. The asymptotic length ($L\infty$), growth coefficient (K) and index of growth performance (φ – phi prime) were estimated at 33.1 cm, 0.18 per year and 2.295 per year respectively. The total, natural and fishing mortality rates recorded in the study were 1.17 per year, 0.56 per year and 0.61 per year respectively while the exploitation ratio (E) value was 0.52. The Logistic regression of the probability of capture routine gave an estimate of L_C 50% at 13.8 cm. The exploitation rate which maximises yield per recruit produced values of Emax was 0.88, which indicated that the species was overfished. All these results reveal the need to regulate fishing activities in the New Calabar River for sustainable exploitation of the studied fish species.

Key words: Size, growth, mortality, exploitation, *Liza falcipinnis. New Calabar River.*

Büyüme Modeli Bir Ön Çalışma, Durum Faktörü ve Yeni Kalaba River, Nijerya'da Sicklefin Kefali, *Liza falcipinnis* (Valenciennes, 1836) Nüfus Yapısı

Özet: Nijerya'daki New Calabar Nehri'nden Sicklefin Mullet *Liza falcipinnis* Valenciennes 1836 nın büyüme modeli, durum faktörü ve stok özellikleri üzerine bir araştırma Ocak-Aralık 2017 arasında yapıldı. *L. falcipinnis*'in uzunluğu 9.1 ila 37.1 cm arasında değişirken ağırlık 13 ila 370 g olarak değişmektedir. Uzunluk ağırlık ilişkisinin sonucu negatif allometrik büyüme paternini değeri b=2.38 ve koşul faktörü (k)= 0.88 ile ortaya çıkarılmıştır. Asimptotik uzunluk ($L\infty$), büyüme katsayısı (K) ve büyüme performans endeksi (φ - phi prime) sırasıyla 33.1 cm, yılda 0.18 ve yıllık 2.295 olarak hesaplandı. Araştırmada kaydedilen toplam doğal ve balıkçılık ölüm oranları sırasıyla yıllık 1.17, yıllık 0.56 ve yıllık 0.61 iken, kullanma oranı (E) değeri 0.52 olmuştur. Yakalama rutini olasılığının lojistik regresyonu 13,8 cm'de % 50 LC tahmini yapmıştır. İstihdam başına üretilen Emax değerlerini maksimuma çıkaran sömürü oranı 0,88 olup bu türlerin aşırı avlandığını göstermiştir. Tüm bu sonuçlar, çalışılan balık türlerinin sürdürülebilir kullanımı için New Calabar Nehri'ndeki balıkçılık faaliyetlerinin düzenlenmesi gerektiğini ortaya koymaktadır.

Anahtar kelimeler: Elektronik, yazarlar için talimatlar, makale şablonu.

1. Introduction

Mugilidae is represented in Nigerian freshwater by genus consisting of three species namely *Mugil cephalus*, *Liza falcipinnis* and *Mugil hyselopterus* [1]. *Liza falcipinnis* is the most widely spread species of mullets [2]. The species has the distinctive features like dark spot at the base of pectoral fin, silvery in colour with darker back and thin upper lip [1]. The biology and ecology of this species have been studied extensive [3-8].

Between 2010 and 2015, the production of mullets in Nigerian water bodies have been oscillating between 10,000 and 11,000 metric tonnes per annum. In 2012, 2013, 2014 and 2015 respectively the figures were 11,324, 10,821, 10,923 and 11,962 metric tonnes [9]. Based on these figures the stock has reached the peak. In order to reduce total catch to biologically and economically sustainable level, there is a need to assess mullets stock in Nigerian water bodies.

Stock assessment is the basis for understanding changing fishery patterns and issues such as habitat destruction, predation and optimal harvesting rates. It forms the basis for calculations leading to knowledge of the growth, mortality, recruitment and other fundamental parameters of their populations. In spite of its

* Corresponding author: olaniyi.olopade@uniport.edu.ng. ORCID Number of authors: [1] 0000-0002-9550-2956, [2] 0000-0001-6254-9179

economic importance and rate of exploitation, there has been no attempt to study the stock characteristics of the *Liza falcipinnis* in Nigerian water bodies, Nigeria.

This information is needful for sustainable management of *Liza falcipinnis* in the river, where it is caught in large numbers with unregulated fishing gears and methods. It against this background the present work set out to determine growth, mortality, yield per recruit mortality coefficient, exploitation rate and ratio, recruitment pattern virtual population for better management of this important fish species.

2. Materials and Methods

The New Calabar River, Nigeria is a partially mixed estuary system that lies between latitude 4º25′N and longitude 7º16′E (Figure 1). It runs through the most densely populated areas in the hinterland and empties into the Atlantic Ocean at the southern tip of Bonny in the south.

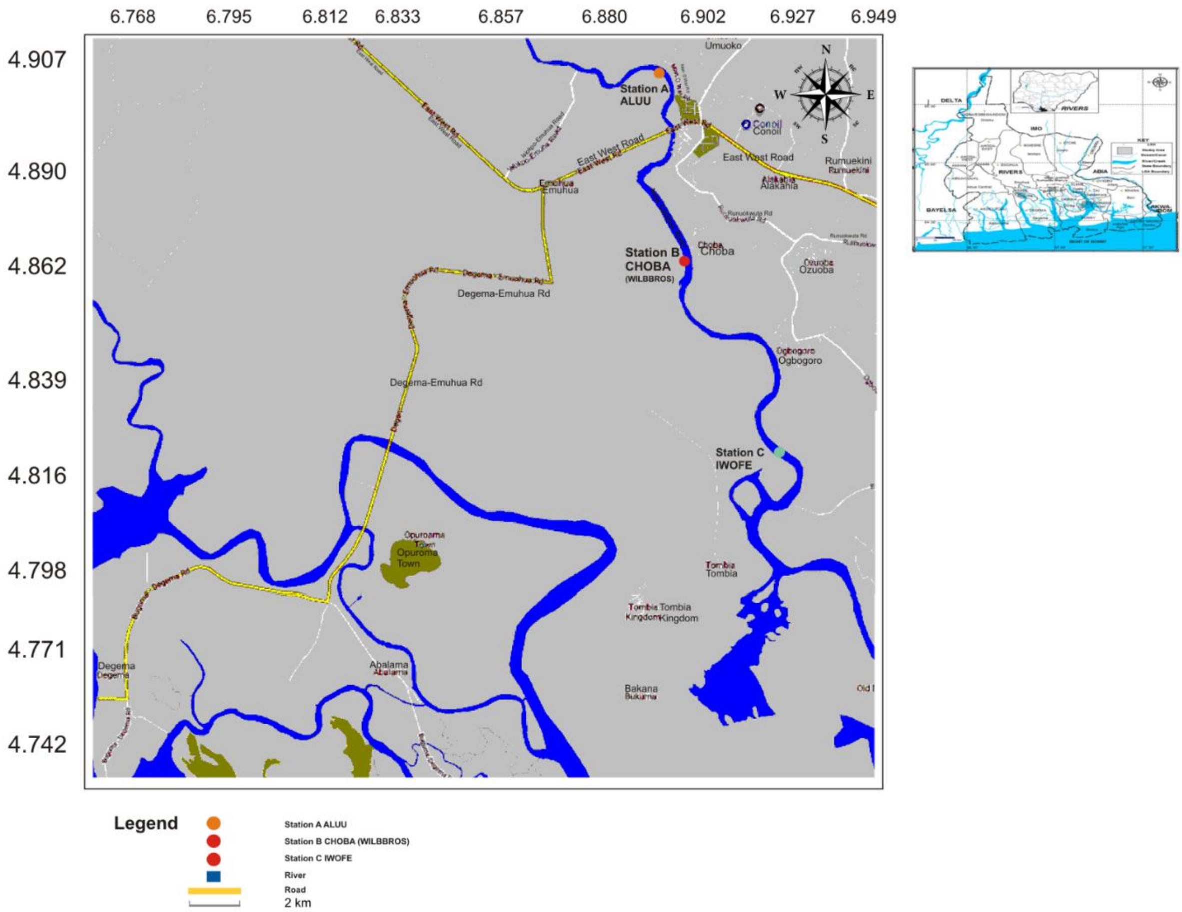

Figure 1. Map of Nigeria showing the location of sampling area

Fish specimens were sampled on a monthly basis during January 2009 to May 2010 from three major landing sites of the river (Aluu, Iwofe and Choba). Fish specimens were sampled from the catches of the local fishermen which were harvested using different types of fishing gears: seine net (80 m long with 25 and 45 mm mesh sizes), fixed gill nets (50 to 80 m long with 12.5 to 45 mm mesh sizes), cast nets (4 to 9 m diameter with 6.35 and 15 mm mesh sizes). The specimens collected were identified using the keys and works of [1]. The total length and weight of *Liza falcipinnis* specimens were measured in the laboratory using a measuring board and an electronic balance to the nearest 0.1 cm and 0.01 g respectively. The length-frequency data were pooled monthly from different sampling sites and subsequently grouped with one cm class intervals for analysis. The length-frequency distribution for *L. falcipinnis* was constructed using 1 cm intervals of total length. The length-weight relationships were estimated using the formula $W = aL^b$, where, W is the total weight in g, L is the total length in cm and 'a' and 'b' are the constants. The condition factor was calculated for the species under study using the following equation: K= (W/L^3) x100 [10]. Growth parameters such as L∞ and K were calculated according to [11, 12]. The overall growth performance index (Phi prime) for the fish were calculated empirically [13] using the formula, Phi prime = log10 K + 2 log10 L∞, where, K is expressed on annual basis and L∞ in cm. Length at first capture (Lc_{50}) was estimated by plotting cumulative percentages of length against length classes. Critical length at capture was estimated as the ratio of length at first capture to asymptotic length (L∞)

The total mortality rate (Z), natural mortality rate (M), fishing mortality rate (F) and rate of exploitation (E) were estimated by [14-15] at the mean habitat temperature which was 27.8 °C. One year recruitment pattern was obtained by projecting the length frequency data backward on to the time axis as described in the FiSAT routine. Relative yield per recruit (Y'/R) and relative biomass per recruit (B'/R) were derived from [16]. The data were analysed using FiSAT II (FAO-ICLARM Stock Assessment Tools) as explained in details [17].

3. Results

Length weight relationship and condition factor

The total length ranged from 9.1 to 37.1 cm, with a mean of 20.96±0.41 and weight ranged between 13 – 370 g with a mean value of 97.39±5.86. The length weight relationship results revealed exponent (b) value of 2.38 and highly correlation coefficient (r) value of 0.88. The condition (K) of *L. falcipinnis* ranged between 0.44 and 1.73 with a mean value of 0.88±0.02 (Table 1).

Table 1. Length weight and condition factor *L. falcipinnis*

Species	TL (cm)		TW(g)		a	b	r^2	K	
	Mean±SE	Range	Mean±SE	Range				Range	Mean±SE
L. falcipinnis	20.96±0.41	9.1 - 37.1	97.39±5.86	13 – 370	-4.07	2.38	0.88	0.44 - 1.73	0.88±0.02

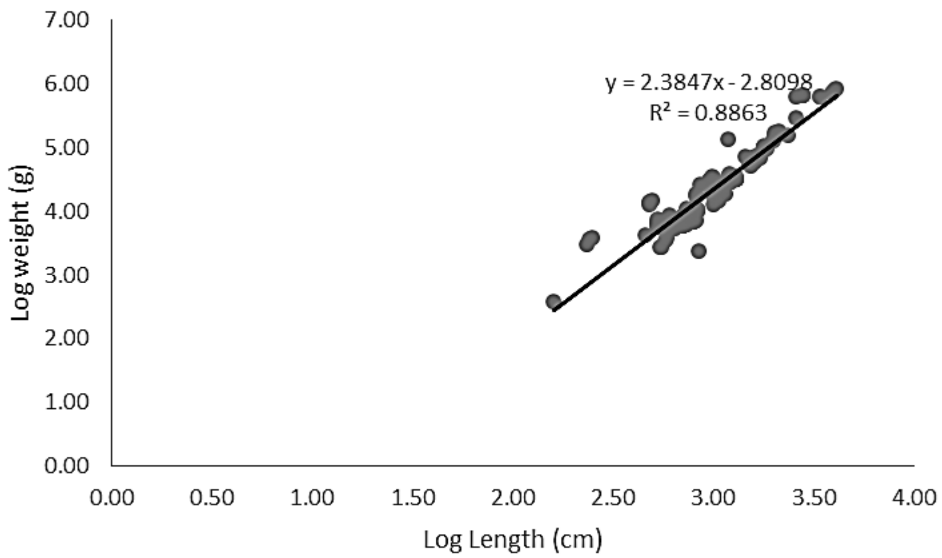

Figure 2. Length weight relationship of *L. falcipinnis* from the New Calabar River

Growth Parameters

The growth curve generated by ELEFAN I for L. falcipinnis is shown in Figure 3. The asymptotic length (L∞), growth coefficient (K) and index of growth performance (φ – phi prime) were estimated at 33.1 cm, 0.18 per year and 2.295 respectively (Table 2).

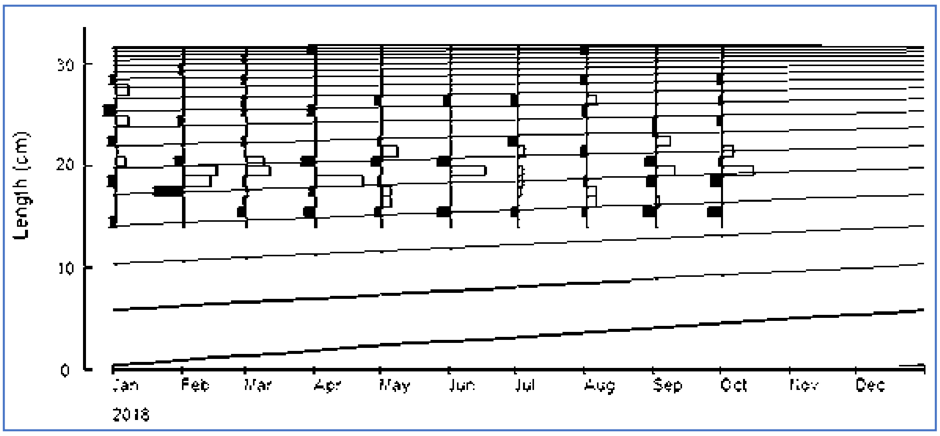

Figure 3. ELEFAN I growth curve of *L. falcipinnis* from the New Calabar River

Table 2. Population dynamics of *L. falcipinnis* from the New Calabar River

Parameters	***L. falcipinnis***
L∝	33.1 cm
Growth co-efficient – K	0.18
Φ	2.295 per year
Z	1.17 per year
M	0.56 per year
F	0.61 per year
E	0.52

Mortality and exploitation

The total mortality (Z) of *Liza falcipinnis* estimated by the length converted catch curve was 1.17 per year while the natural mortality as per Pauly's empirical formula keeping the habitat temperature as 27.8°C was found to be 0.56 per year and the estimated fishing mortality (Z-M=F) was 0.61 per year (Table 2). The exploitation ratio E was found to be 0.52 (Figure 4).

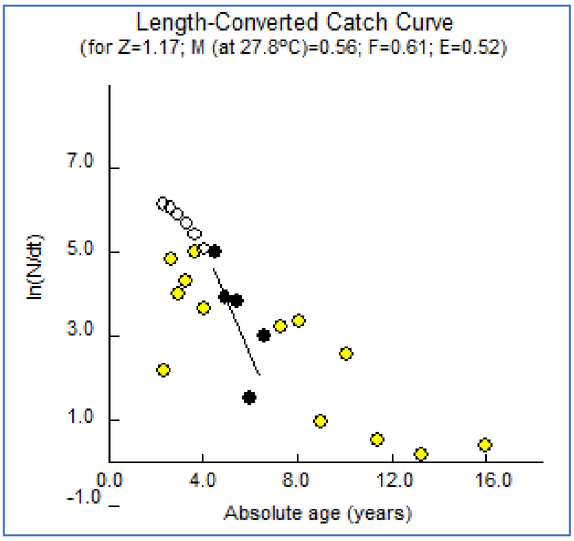

Figure 4. Length converted catch curves of *L. falcipinnis* in the New Calabar River

Recruitment strength

Figure 5 shows the recruitment pattern of *L. falcipinnis* in New Calabar River. The results revealed the bimodal recruitment pattern of *L. falcipinnis* with unequal strength pulses. The period of recruitment peak during April and July and the percentage of recruitment were 13.4% and 15.2% respectively.

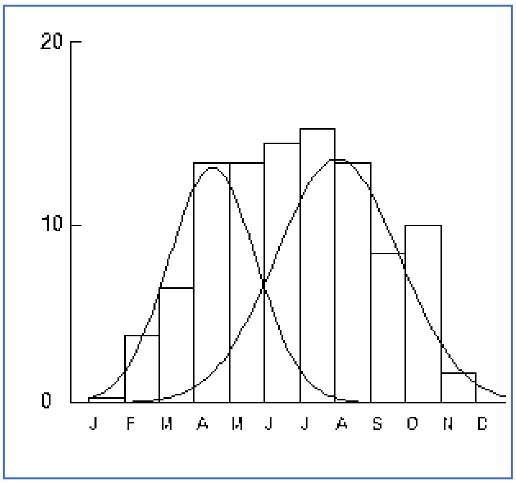

Figure 5. Recruitment patterns of the studied fish species in the New Calabar River

Probability of capture and Length at first maturity (Lc50)

The Logistic regression of the probability of capture routine gave an estimate of L50% at 13.8 cm (Figure 6). The L25% and L75% were also calculated as12.6 cm and 15.1 cm respectively. In this study, the critical length at capture (Lc50/L∞) ratio was found to be 0.42.

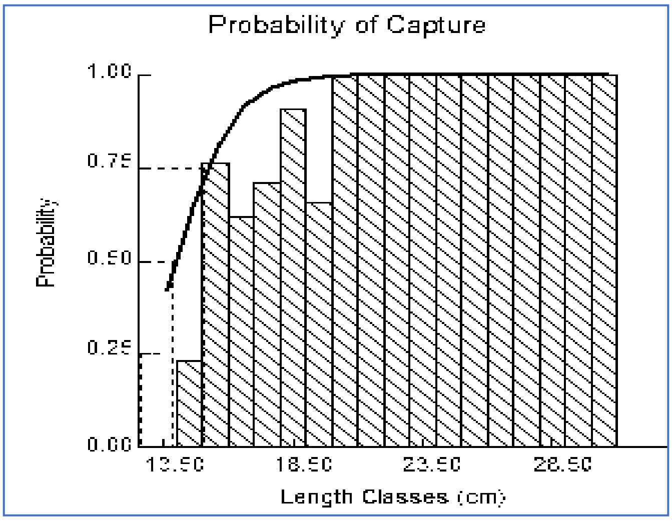

Figure 6. Length at capture (L50) of *Liza falcipinnis*

Yield-per-recruit and biomass-per-recruit

The Beverton-Holt relative yield per recruit (Y'/R) and relative biomass per recruit (B'/R) estimated using selective ogive procedure of FiSAT for the assessed fish species are given in Figure 7. The analysis indicated that the exploitation rate (E) which maximises yield per recruit produced values of Emax = 0.88, E 0.1 = 0.71 and E 0.5 = 0.36

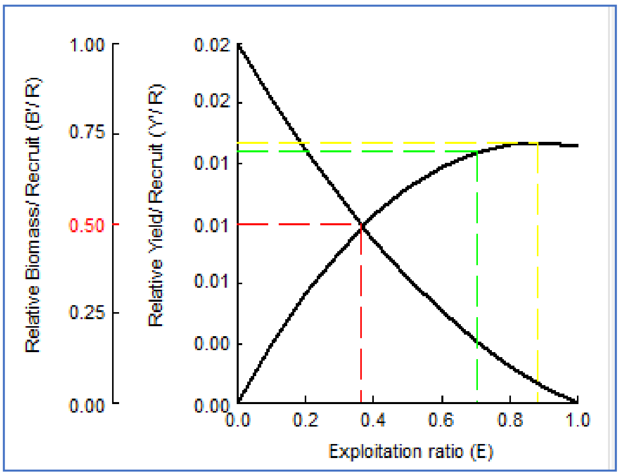

Figure 7. Yield-per-recruit and biomass-per-recruit

4. Discussion

The size of *L. falcipinnis* recorded in this study ranged from 9.1 to 37.1 cm for total length and 13 – 370 g for weight. Dankwa and Blay, [18] studies on Imo-River estuary, Qua-Iboe estuary, Cross River estuary and Bonny estuary reported between 3.4-29.7 cm (TL) for *L. falcipinnis.* Similar results were recorded [19-20]. The population of this stock is said to be dominated by the young class based on the classification proposed by [21].

The length-weight relationship revealed a highly correlation (r) and the exponent of (b) value of 2.38 indicating negative allometric growth which implies that growth in length increase faster than in weight. This result was similar to what [20] reported on *L. falcipinnis* from Badagry creek in Lagos State, Nigeria. The mean condition factor (K) in this study was estimated to be 0.88. Condition factor (K) less than 1 indicates poor wellbeing of the assessed fish species. This result was in consistency with [22] who reported almost the same value (0.82) on the same species in Qua Iboe River estuary, Nigeria.

In the present study, the bimodal recruitment pattern of *L. falcipinnis* occurred in April and July with the peak in July. The major recruitment peak is in close relation with [23] who observed that major peak in recruitment occur during wet season months (April - August) coincide with breeding period. This result was in line with [15] observed a double recruitment pulse per year for tropical fish species and for short lived species.

The $L\infty$ =33.1 cm and K = 0.18 per year observed in this study were higher than earlier for this species from and [8]. The differences between the values might be due to the fishing pressure. According to [24], the strong tendency of fish length to decrease as fishing pressure increases means that length linked changes occur in several demographic parameters. The length-based index of growth performance (φ – phi prime) was found to be2.295. This value is in agreement with [25] who reported that the ϕ' mean value for some important fishes in Africa range from 2.65 - 3.32, which they considered as low.

The total mortality (Z) recorded in this study was 1.17 per year which is slightly lower than [26] who reported total mortality of Z = 1.32 per year. The exploitation ratio E was found to be 0.52 which is almost close to 0.5 indicating that the sustainable yield of the assessed fish species is optimized at F = M [27]. The fishing mortality (0.61 per year) was also higher than natural mortality of 0.56per year. This implies that the fishing activities in the New Calabar River accounts for greater percentage of the stock's mortality. An exploitation ratio should be maintained at 0.4 level for sustainable level [28]. The result was in agreement with [29] who observed that high fishing and natural mortality are the common features of tropical fish also coincides with the present findings.

In this study, the estimated length at first capture (Lc) was estimated at 13.8 cm. The critical length at capture (Lc) was estimated as 0.42 which revealed that small sizes are vulnerable to capture. This situation is also described by [30] as growth overfishing; when fishes are caught before they can realize their full potential. The high fishing effort could lead to overfishing when the total yield decreases with increasing fishing effort [31]. Also the high fishing effort has resulted in a higher percentage of relatively young fish. In view of these results there is need to improve management of commercially important fish stocks in the New Calabar River through better monitoring and control and educating fishers about the consequence of their fishimg practices.

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Determination of Rheological Behavior of Some Molasses-Sesame Blends

Fethi Kamışlı[1], Dlshad Abdalla Mohammed
Department of Chemical Engineering, Firat University, Elazıg / Turkey.
fkamisli@firat.edu.tr

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Abstract: The aim of this study is to determine the rheological properties of some molasses-sesame paste (tahin) blends such as date syrup-tahin, mulberry molasses-tahin, grape molasses-tahin and carob syrup-tahin blends at the different ratios (20-55 %) and different temperatures (25-60°C) by using a rotary viscometer to develop models appropriate to the experimental data. The variation of viscosity of these blends with the shear rates (2.5-30 s^{-1}) showed that all considered ratios of the molasses-tahin blends were shear thinning fluids at the considered temperatures. The apparent viscosities of the blends as a function of shear strain were successfully described with the Power-law model. The model parameters such as the flow behavior index (*n*) and the consistency coefficient (*K*) of the considered blends were determined according to the experimental data. It was observed that apparent viscosities and consistency coefficients of blends increased with increasing molasses concentration and decreasing temperature. Activation energies (*Ea*) of the considered blends were determined. The relationship between concentration and consistency coefficient for each blend was described with both the exponential and power functions. A mathematical model was determined to describe the combined effects of temperature, concentrations of the molasses and shear strain on apparent viscosity with high consistency.

Keywords: Rheology, Modeling, Molasses-Sesame Paste Blends.

Bazı Pekmez-Tahin Karışımlarının Reolojik Davranışlarının Belirlenmesi

Özet: Bu çalışmanın amacı; deneysel verilere uygun bir model geliştirmek için döner viskozimetre kullanılarak, farklı konsantrasyon (% 20 -55) ve sıcaklıklarda (25-60 °C), hurma pekmezi-tahin, dut pekmezi-tahin, üzüm pekmezi-tahin ve keçiboynuzu pekmezi-tahin gibi bazı pekmez-tahin karışımlarının reolojik özelliklerinin saptanmasıdır. Bu karışımların kayma hızı (2.5-30 s^{-1}) ile viskozite değişimi, çalışılan sıcaklıklarda, göz önüne alınan tüm pekmez-tahin oranları kayma incelemeli akışkan olduklarını gösterdi. Kayma gerilmesinin fonksiyonu olarak karışımların görünür viskozitelerinin değişimi üs kanunu modeli ile başarılı biçimde tanımlandı. İncelenen karışımların akış davranış indeksi (n) ve kıvamlılık katsayısı (K) gibi model parametreleri deneysel verilere bağlı olarak saptandı. Karışımların görünür viskozitelerinin ve kıvamlılık katsayılarının pekmez konsantrasyonlarının artmasıyla arttığı ve sıcaklığın artmasıyla azaldığı gözlendi. İncelenen karışımların aktivasyon enerjileri belirlendi. Her bir karışım için konsantrasyon ile kıvamlılık katsayısı arasındaki ilişki hem üstel hem de üs fonksiyonlarıyla belirlendi. Görünür viskozite üzerine sıcaklık, pekmez konsantrasyonu ve kayma gerilmesinin birleştirilmiş etkisini yüksek uyumlulukla tanımlayan matematiksel model saptandı.

Anahtar Kelimler: Reoloji, Modelleme, Pekmez-Tahin Karışımları.

1. Introduction

Molasses-sesame paste blend that is mainly consumed for breakfast in cold seasons is one of a traditional food product in East Asian and Middle Eastern countries. Sesame paste has a high protein and dietary fiber content. When strengthened with high mineral and vitamin being contained in molasses might offer a promising nutritious and healthy substitute to consumers [1-3]. Molasses and sesame paste are usually available for sale separately in markets; thus, the blending process is carried out by the consumers. The ratio of molasses to sesame paste is determined according to the consumers taste and preference.

Molasses are commonly produced from grape, mulberry, fig, juniper, watermelon, apple, plum, carob, sugar beet and sugar cane. But in recent years, in addition to those, apricot and date have been used for the production of molasses by concentration of juices up to 70–80 % soluble dry matter content with an extended shelf-life [4-8]. Molasses processing operations vary according to origin of fruits used in production of molasses [6,7,9].

Sesame paste, known as tahin in Turkey and Arabic countries and ardeh in Iran, is a traditional food in the Middle East, which is produced by grinding the dehulled and heated sesame seeds [10].

Sesame paste is also a tradition food in East Asian and Middle Eastern countries, it has used in ingredients of many other dishes such as halawah, chickpeas, desserts, and some types of bakery [1,2,11,12]. In addition, the

[1] Corresponding author: fkamisli@firat.edu.tr, ORCID Number of author: [1]0000-0002-1769-3785

molasses is consumed as an ingredient in the formulation of some food items such as ice cream products, beverages, confectionery, bakery products [13].

Knowledge of rheological behavior is important for optimization of process design, quality control, consumer acceptance of a product and sensory assessment [2,8,14]. Consumer acceptance of molasses and sesame paste blends usually depends on the capacity of spreading on another material like bread. Therefore, the spreading of the blends is directly related with viscosity [1,2]. When the legitimate consistency, soundness and surface tension are the main concerns in expansion, generation and upkeep of the item, the solid rheological information is needed [2,15].

Rheological characterization of food pastes has been widely investigated by focusing at either individual samples or blend samples. Rheological properties of individual samples can be listed as sesame paste [3,8,16], sunflower tahini [17], fenugreek paste [14], tomato paste [18,19], ginger paste [20], molasses (pekmez) [4,6,21-24]. On the other hand, rheological properties of blend samples can be listed as grape pekmez/ tahin blends [1,2]; corn starch/grape pekmez blends [25], sesame paste/date syrup blends [13,26], honey/sesame paste blends [10] and poppy seed paste/grape pekmez blends [8]. The goal of concentration or pasteurization is to extend shelf life of dates, mulberry, grapes and carob juices with boiling to lessen water content [4-8].

The flow behavior, texture and sensory properties of new blends need to be determined for processing of those blends. Temperature and concentration are important factors in determining the rheological behavior of the blends. The use of different types of molasses in blending process is an essential component in the formation of a new product accepted by consumers. Some organizations such as military and police organizations require a specific blend ratio. However, much work has been done to improve the quality of food production in terms of edibility taste and texture. It can be obviously seen in the literature that the researchers have focused on blending at different concentrations of sesame paste/grape molasses and sesame paste/dates molasses at different temperature degrees in a hope to improve edibility taste, spread ability on bread and sensory properties etc. Thus, further investigation is required to determine rheological properties of the blends of sesame paste with other types of molasses such as dates, mulberry, grapes and carob juice. Subsequently, the major objective of this study is to determine rheological behaviors and activation energies of new mixtures of sesame paste with different types of molasses such as dates, mulberry, grapes and carob juice; furthermore, is to develop a single mathematical equation can be implemented for various effective parameters such as temperature, concentration of blend and shear rate on rheological behavior of a fluid.

2. Materials and Methods

2.1. Materials

The composition of sesame paste (tahin) bought from Merter Helva San. ve Tic. A.Ş., Istanbul was 60.2 % total oil, 9.7 % carbohydrate, and 26 % protein. °Brix values for date syrup bought from local market in Al Sulaymaneyah, Iraq mulberry molasses, grape molasses and carob molasses (all molasses) bought from the local market in Elazığ, Turkey were measured to be 73.2, 68.75, 60.56 and 77.5 respectively.

Brix level of each commercial molasses, soluble solid content, was determined by using a refractometer (METTLER TOLEDO RE50, Switzerland) in the local sugar beet processing plant (Elazığ Şeker Fabrikası).

2.2. Preparation of some molasses/sesame paste blends

In food system, there are two common types of emulsion, water in oil or oil in water. Blends of molasses and sesame pastes can be regarded as either water-in-oil or oil-in-water depending on molasses/tahin ratios. If amount of molasses is larger than that of tahin, it can be regarded as oil-in-water; otherwise it can be regarded as water-in-oil. The two non-miscible liquids; molasses and sesame paste form a two-phase system, molasses has water phase and sesame paste has oil phase. Oil particles are suspended within the water through the assistance of mechanical development of the emulsion [1,2]. Emulsion stability depends on oil and water interface. Proteins are amphiphilic molecules that are mostly used to stabilize emulsions in food products. Proteins have a key role to facilitate droplet breakup through homogenization and to stabilize the droplets against coalescence through emulsification and storage. The ability of a protein emulsifier is determined by its ability to reduce tension between the surfaces [28]. In the case of molasses and sesame paste blend, protein and lipids usually interact and thus the protein reduces the tension between surfaces of protein and lipids, which causes a stable emulsion to form [1,2].

In order to prepare a homogenous blend, the mixtures were blended consistently with a spatula until a homogenous blend was obtained. The blends were rested for 5 hours before subjecting to the rheological measurements. After making sure the samples free from entrapped air or air bubbles, the molasses-sesame paste blends such as blends of date syrup-sesame paste, mulberry molasses-sesame paste, grape molasses-sesame paste and carob syrup-sesame paste at the different weight ratios (20 %, 30 %, 40 % and 55 %) (wt./wt.) were sheared under different shear strains to measure viscosities of those blends as a function of the shear strain. The viscosity for each blend was measured at various temperatures (25, 30, 40, 50 and 60 °C) by using a rotary viscometer.

2.3. Measurement for Determining Rheological Behavior

Brookfield rotational viscometer (Model DV-II, Brookfield Engineering Laboratories) was utilized to measure viscosities of the blends by using spindle 28 and the sample cup with 12 ml sample volume was at different temperature and concentration.

For obtaining the rheograms for each blend, the shear stress and viscosity were directly read from the viscometer for each shear rate in ranges of 2.5 to 30 rpm. For all experiment, data collection for each specimen was finished after 5 revolutions at a set rotational speed. At that point for each progressive revolution, one point of viscosity and shear stress information on the set rotational speeds was recorded up to 5 values.

2.4. Statistical Analysis

The linear regression method by Microsoft Excel software was used to evaluate the experimental data about shear stresses, viscosities versus shear strain for some molasses-sesame paste mixtures. The used equations about viscosity of a blend as a function of shear strain, the consistency coefficient, the flow behavior index and coefficient of determination (R^2) were detailed. Any noteworthy contrast, among theoretical parameters; n and K beneath the effects temperature and molasses concentration ($\alpha = 0.03$) were evaluated with analysis of variance (ANOVA) test. A single equation which can be implemented for various parameters is a very important tool for engineering application. The effective parameters such as temperature, concentration, and shear strain on viscosity of a blend were combined into a single logarithmic model by utilizing multiple linear regression system with using lines function in Microsoft Excel software.

3. Results and Discussion

In order to evaluate the rheological behavior of some molasses/sesame paste blends at different concentrations of molasses and temperatures, the blends were prepared by adding molasses into the sesame paste in ratios of 20-55 % (wt. /wt.). During the measurement of viscosity of each blend, the temperatures were varied from 25 °C to 60 °C for each concentration and each shear rate. Five different rotational speeds were set to measure viscosity and shear stress for each blend at various temperatures.

The measured apparent viscosities of the blends versus shear rates are depicted in Figures 1–4. As can be seen in the figures the apparent viscosities decrease with increasing shear rates, which means the blends in question exhibit shear thinning behavior. Identical figures for 30 %, 40 % and 55 % of each type of molasses in tahin were depicted to save space they were not given here.

The model parameters such as the consistency coefficient and the flow behavior index can be determined by regression analysis based on the achieved results. According to the experimental finding, viscosities as a function of shear rates were finely fitted with Eq. (3.1) to determine the model parameters; where the slope of regression line represents a flow behavior index, *n*, and the intercept of the graph shows the consistency coefficient, *K*.

$$\mu_{ap} = K\,\dot{\gamma}^{n-1} \qquad \rightarrow \qquad ln\mu_{ap} = lnK + (n-1)\,ln\dot{\gamma} \tag{3.1}$$

Table 1, Table 2, Table 3 and Table 4 includes the values of *n*, *K* and the coefficient of determination, R^2 for the considered blends at the specified concentrations and temperatures. The equation for each curve in the figures were found to be in a power function since the equation for the best fitting curve to the experimental data were found to be in a general form of $\mu_{ap} = a\dot{\gamma}^b$.

The obtained model parameters namely flow behavior index and consistency coefficient in the range of the determination coefficient (R^2) indicate that the Power- law model seems to be convenient to describe the flow behavior of mixtures. The ranges of these model parameters for date, mulberry, grape, and carob molasses are shown in Tables 1, 2, 3 and 4 respectively. In all cases, it can be noticed that the determination coefficient (R^2) is higher than 0.85 and the flow behavior index are less than unity ($n < 1$) that means all blends exhibit the shear-thinning (pseudo plastic) behavior since pseudo plasticity is inversely proportional to the flow behavior index (Arslan et al.[2]).

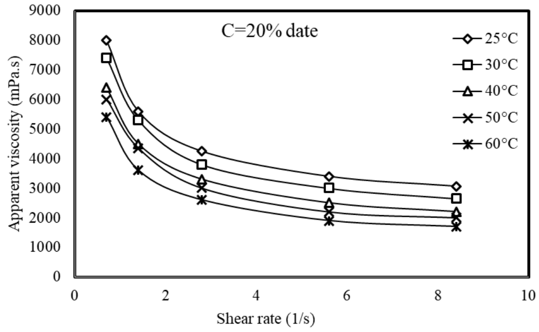

Figure 1. Variation of apparent viscosity with shear rates at different temperatures for a 20 % date molasses in sesame paste

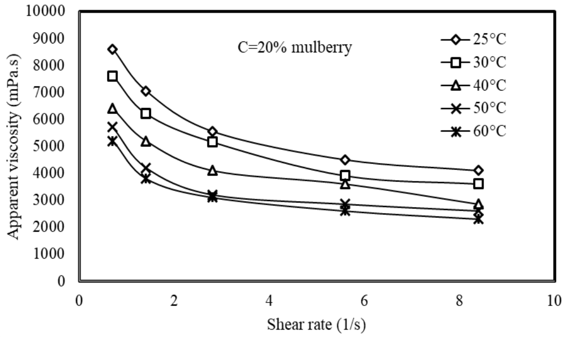

Figure 2. Variation of apparent viscosity with shear rates at different temperatures for a 20 % mulberry molasses in sesame paste

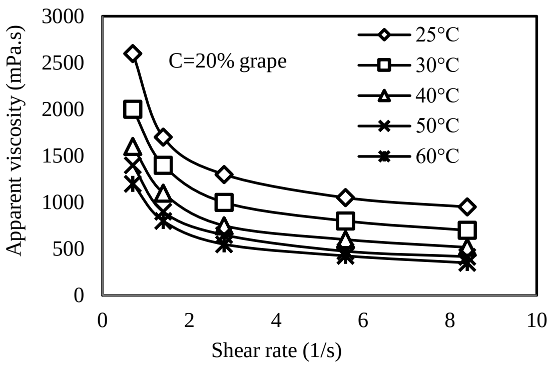

Figure 3. Variation of apparent viscosity with shear rates at different temperatures for a 20 % grape molasses in sesame paste

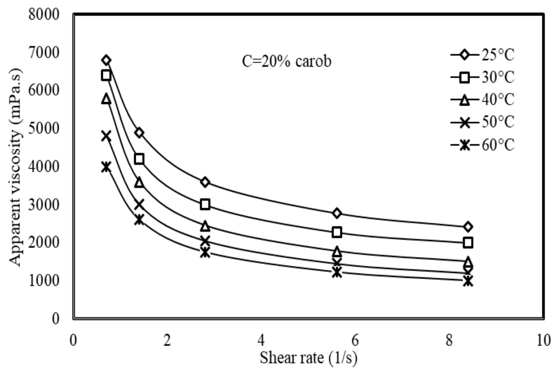

Figure 4. Variation of apparent viscosity with shear rates at different temperatures for a 20 % carob molasses in sesame paste

The major constituents of sesame paste are protein and oil whereas molasses components are mainly sugar and water. The decrease in an apparent viscosity with increasing shear rate is often explained with changing in the structure of the mixture since the uniformity level of those constituent particles increases with the shear strains [1, 29]. The structural change on the oil droplet due to the shear strains has been stated to be egg yolk stabilized mixtures by Morris[30]. More specifically, shearing leads to a gradual deformation and disruption of the oil droplets, which results in less resistance for fluid flow. Alpaslan and Hayta[1], Arslan et al.[2]); Habibi et al.[13] and Razavi et al.[26] indicated that the molasses/sesame paste blends display non-Newtonian, shear thinning behavior. Alpaslan & Hayta[1] reported that all blends of sesame paste/molasses mixtures having a molasses concentration range of 2- 6 % (wt./wt.) at the temperature variances of 30-75 °C exhibit pseudo plastic behavior. Arslan et al.[2] reported that sesame paste/molasses blends having sesame paste concentrations (20-32 %) at the various temperatures (35-65 °C) display non- Newtonian, shear thinning behavior. The date syrup /sesame paste blends, date molasses having variety solid contents of 60 and 65 °Brix, at the temperature ranges of 25-55 °C exhibit pseudo plastic behavior [13].

In the present study for all considered blends the flow behavior indices were found to be less than unity ($n < 1$), which indicate that all blends are shear thinning (pseudo plastic) fluids. The flow behavior indices of the blends such as molasses of date syrup-, mulberry molasses-, grape molasses- and carob syrup-sesame paste are in ranges of 0.52–0.64, 0.66–0.69, 0.33–0.62 and 0.44–0.59, respectively.

Although in the present study the continuous phase changes from oil to water since weight percentage of molasses in the sesame paste varies from 20 to 55 %, rheological behavior is not changed dramatically. For instance, when the percentage of a molasses in the sesame paste was increased to be larger than 50 %, a regular change in viscosity of a blend was observed.

In order to examine the effect of temperature on the rheological behavior of a few molasses/sesame paste mixes, temperature was varied from 25 °C to 60 °C. For the specified tests an increase in temperature resulted in a decrease in viscosity values (Figures 1 to 4). The noticeable decrease in viscosity of each blend was observed with increasing temperature from 25 °C to 60 °C. This property can be clarified by considering the intermolecular forces and the intermolecular spaces. When temperature of a liquid increase, the molecules in the liquid move away from one another and thus intermolecular space increases. In other words, the intermolecular spacing are essentially influenced with variation of temperature since molecular distances increases with decreasing intermolecular forces. As a result, the intermolecular forces decrease with increasing temperature. Moreover, thermal and thus kinetic energy of molecules increases with increasing temperature. Therefore, when the fluid is exposed to the shearing, molecules move over one another much more easily and the chain entanglement is also straightened out much more easily at high temperature due to low molecular forces and high kinetic energy of molecules. Consequently, the viscosity of a liquid decreases with increasing temperature.

According to the analysis of variance (ANOVA) ($\alpha = 0.03$), the flow behavior index and the consistency coefficient were strongly under the effect of temperature variance. As appeared in the Tables 3.1, 3.2, 3.3, and 3.4, the relation between the values of both *n* and *K* change with temperature inversely.

In addition, Eq. (3.2) (Arrhenius-type equation) interprets well the relation between the temperature and the consistency coefficient. According to the experimental finding, consistency coefficient as a function of temperature were finely followed with Eq. (3.2) to determine the model parameters; where the slope of regression lines from Figure 5 represents an activation energy, *Ea/R*, and the intercept of the graph shows the constants *Kt*. In order to save space, figure for date blends is given here only.

$$K = K_t e^{\left[\frac{Ea}{RT}\right]} \qquad \rightarrow \qquad lnK = lnK_t + \frac{Ea}{RT} \tag{3.2}$$

Table 5, Table 6, Table 7 and Table 8 includes the values of *Kt*, *Ea* and the determination coefficient, R^2 for the considered blends at the specified concentrations and temperatures.

The activation energy (*Ea*) decreases on increasing molasses concentration in the sesame pates. In other words, the activation energy decreases with decreasing percentage of the sesame paste in the blend. Some researchers observed similar trends about activation energy (*Ea*) and the experimental constant, *Kt*. For instance, the activation energy decreased with increasing the grape molasses or date syrup concentration in tahin (sesame paste) whereas *Kt* increased in the same investigations [1, 13, 27].

The aforementioned two cases, one is the continuous phase was added to the oil phase and other one the oil phase was added to the continuous phase. It has been concluded that increasing tahin concentration in the blend of tahin/molasses causes an increase in values of *Ea* and a decrease in values of *Kt* [2]. In the present study, concentrations of different types of molasses such as date, mulberry, grape and carob molasses were varied from 20 to 55 % in order to determine effects of concentration on the consistency coefficient, flow index and the activation energy at various temperatures. It was observed that there is a linear relationship between apparent viscosities of mixtures and molasses concentrations at any temperature. This behavior can be seen in Figures 6 at the temperature of 40 °C. It has similar trends for other temperatures.

Figures 6 illustrate the variation of the apparent viscosity as a function of shear rates at the constant temperature of 40 °C for different percentages of molasses of date. Although the identical figures were drawn for mulberry, grape and carob molasses in the sesame paste, to save space they were not given here. Figure 7 provides a comparison of the variations of apparent viscosity with shear rate for different blends at 40 °C. Date, mulberry, grape and carob molasses exhibit non-Newtonian behavior that is in accord with the study of Yogurtcu and Kamisli [6] since they showed that pekmez samples exhibit non-Newtonian behaviors. Furthermore, the apparent viscosities of molasses are inversely proportional with shear rate. This outcome affirms the discoveries by Alpaslan and Hayta [1]; Abu-Jdayil[15]; Arslan et al.[2]; Habibi et al.[13].

In order to examine the effect of each molasses concentration on the viscosity of that blend, each molasses concentration was increased from 20 % to 55 % in the tahin and viscosities of those blends were measured as a function of shear strain at a constant temperature. Although it is not shown here, it was observed that the viscosity of each blend and thus consistency coefficient of that blend increases nonlinearly with increasing ratio of a molasses in a blend.

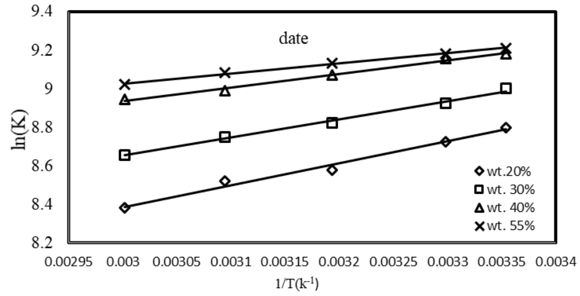

Figure 5. Variation of consistency coefficient with temperature for the various date molasses concentrations

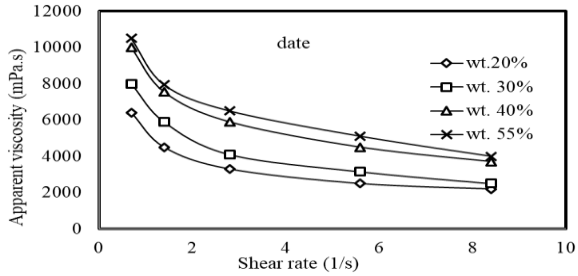

Figure 6. Effect of concentration on the apparent viscosities of date molasses/sesame paste blends at 40 °C

The effect of molasses concentration on consistency coefficient can be expressed by either exponential, $K = K_{c1}\, e^{b_1 C}$ or power function, $K = K_{c2} C^{b_2}$. As can be seen in Table 9, while the exponential model is more appropriate for the blends of date and mulberry molasses, the power model is more suitable for the blends of grape and carob molasses.

A single equation which can be implemented for various parameters is a very important tool for engineering application. Thereby, multiple linear regression of Eq. (3.5) and Eq. (3.6) is used to determine the combined effect of temperature, molasses concentration and shear rate on the apparent viscosity of molasses/sesame paste. The multiple linear regression of Eq. (3.5) and Eq. (3.6) determines variable coefficients, determination coefficients and standard error estimation.

$$\mu_a = f(\gamma, \dot{C}, T) = K\, exp\left[\frac{Ea}{R}\left(\frac{1}{T}\right) + b\, C\right]\, \dot{\gamma}^{n-1} \quad (3.5)$$

$$\mu_a = f(\gamma, \dot{C}, T) = K\, exp\left[\frac{Ea}{RT}\right]\, C^b\, \dot{\gamma}^{n-1} \quad (3.6)$$

The coefficients of determination show that both models (Eq. (3.5) and Eq. (3.6)) are convenient for the date molasses. However, Eq. (3.6) is much more appropriate than Eq. (3.5) since Eq. (3.7) has a high quality of fit ($R^2 = 0.9694$); thereby, it is suggested that the following single model can be used for date molasses blends.

$$\mu_a = 40.74135\, exp\left[\,960.9952\, \left(\frac{1}{T}\right)\right].\, C^{0.606021}.\, \dot{\gamma}^{-0.41826} \quad (3.7)$$

The determination coefficients indicate that both models (Eq. (3.5) and Eq. (3.6)) are convenient for the mulberry molasses blends. However, Eq. (3.5) is much more appropriate than Eq. (3.6) since value of R^2 (0.974849) is greater for Eq. (3.5); therefore, it is advised that the following single model equation can be used for mulberry molasses blends.

$$\mu_a = 66.34463\;\, exp\left[1320.318\left(\frac{1}{T}\right) + 0.011674\, C\right].\, \gamma^{-0.31125} \quad (3.8)$$

The determination coefficients point out that both models (Eq. (3.5) and Eq. (3.6)) are convenient for the grape molasses blends. However, Eq. (3.6) is much more appropriate than Eq. (3.5) since Eq. (3.6) has a high quality of fit ($R^2 = 0.9681$); therefore, it is suggested that the following single model can be used for grape molasses blends.

Table 1. Parameters of power-law for the date blends at the various temperatures and concentrations

	date											
	20 %			30 %			40 %			55 %		
T(˚C)	*n*	*K* (mPa.s^n)	R^2	*n*	*K* (mPa.s^n)	R^2	*n*	*K* (mPa.s^n)	R^2	*n*	*K* (mPa.s^n)	R^2
25	0.617	6626.9	0.9855	0.538	8113.3	0.9897	0.629	9719.3	0.9878	0.639	10013	0.9927
30	0.585	6166.3	0.9914	0.532	7505.5	0.9901	0.612	9468.6	0.9908	0.641	9704	0.9888
40	0.569	5315	0.9948	0.536	6798.7	0.9976	0.607	8712.6	0.9984	0.629	9231.4	0.9892
50	0.544	5013.1	0.9924	0.535	6308.8	0.9982	0.594	8014.5	0.9939	0.606	8813.1	0.9753
60	0.532	4365.1	0.991	0.522	5744.7	0.9903	0.595	7664.6	0.9988	0.573	8269.7	0.9942

Table 2. Parameters of power-law for the mulberry blends at the various temperatures and concentrations

	mulberry											
	20 %			30 %			40 %			55 %		
T(˚C)	*n*	*K* (mPa.s^n)	R^2	*n*	*K* (mPa.s^n)	R^2	*n*	*K* (mPa.s^n)	R^2	*n*	*K* (mPa.s^n)	R^2
25	0.659	7714	0.9977	0.698	8057.4	0.9972	0.699	8597.7	0.9755	0.69	10207	0.9953
30	0.691	6868.1	0.9942	0.69	7165.5	0.979	0.683	7769.1	0.9846	0.682	9401	0.9844
40	0.690	5753.2	0.9837	0.69	6311.9	0.9862	0.68	6981.9	0.9917	0.676	8418.7	0.9732
50	0.689	4809.9	0.9648	0.679	5513.6	0.9689	0.679	6168.7	0.99	0.674	7905.6	0.987
60	0.683	4461.1	0.9886	0.671	4657.2	0.9906	0.67	5792	0.987	0.661	7351.5	0.9959

Table 3. Parameters of power-law for the grape blends at the different temperatures and concentrations

	grape											
	20 %			30 %			40 %			55 %		
T(˚C)	*n*	*K* (mPa.s^n)	R^2	*n*	*K* (mPa.s^n)	R^2	*n*	*K* (mPa.s^n)	R^2	*n*	*K* (mPa.s^n)	R^2
25	0.604	2084.5	0.9715	0.525	2906.5	0.9927	0.512	3254.4	0.9964	0.496	4218.2	0.9931
30	0.579	1647.4	0.9886	0.508	2421.8	0.9945	0.462	3033.4	0.9953	0.46	4100.6	0.9982
40	0.546	1300.1	0.9869	0.456	2232.7	0.9976	0.62	2782.3	0.9943	0.461	3809.7	0.9984
50	0.515	1113.7	0.9899	0.418	2033.9	0.9971	0.382	2582	0.9942	0.389	3709.5	0.9976
60	0.511	966.88	0.9928	0.374	1876.5	0.9985	0.331	2446.5	0.9986	0.336	3496.6	0.986

Table 4. Parameters of power-law for the carob blends at the various temperatures and concentrations

	carob											
	20 %			30 %			40 %			55 %		
T(˚C)	*n*	*K* (mPa.s^n)	R^2	*n*	*K* (mPa.s^n)	R^2	*n*	*K* (mPa.s^n)	R^2	*n*	*K* (mPa.s^n)	R^2
25	0.583	5714.8	0.9963	0.599	7001.6	0.9964	0.547	11290	0.9982	0.546	17480	0.9853
30	0.534	5123.2	0.9881	0.558	6007.1	0.9667	0.556	10671	0.9933	0.527	15808	0.9905
40	0.460	4515.9	0.991	0.492	5769.1	0.9847	0.562	9176.6	0.9838	0.528	14660	0.9876
50	0.447	3762.7	0.9949	0.485	4894.4	0.9926	0.529	8390.3	0.9964	0.475	13479	0.9813
60	0.444	3194.4	0.9981	0.476	4397	0.9978	0.528	8213.7	0.9963	0.451	12990	0.996

Table 5. Finding of parameters in Eq. (3.8) for the various date molasses concentrations

C (%date)	K_t (mPa.s^n)	Ea (J/mol)	R^2
20	142.35	9499	0.9855
30	337.04	7851.1	0.9932
30	905.6	5894.7	0.9921
55	1713.68	4378.15	0.9941

Table 6. Finding of parameters in Eq. (3.8) for various mulberry molasses concentrations

C (% mulberry)	K_t (mPa.s^n)	Ea (J/mol)	R^2
20	36.474	13216.68	0.9841
30	54.293	12366.11	0.9935
40	200.52	9259.827	0.9841
55	481.84	7514	0.9801

Table 7. Finding of parameters in Eq. (3.8) for the various grape molasses concentrations

C (%grape)	K_t (mPa.sn)	Ea (J/mol)	R^2
20	1.75	17378.08	0.9646
30	62.446	9367.084	0.9287
40	219.862	6639.023	0.9865
55	729.968	4340.986	0.9850

Table 8. Finding of parameters in Eq. (3.8) for the various carob molasses concentrations

C (% carob)	K_t (mPa.s^n)	Ea (J/mol)	R^2
20	25.186	13444.5	0.9949
30	47.39	10249.25	0.9607
40	442	7991.538	0.9494
55	1099.378	6779.038	0.9566

Table 9. Determining of parameters in Eq. (3.3) and Eq. (3.4) for various concentrations of each molasses

	Exponential function (Eq. (3.3)		Power function (Eq. (3.4)	
	Values of A_1 and d_1 and the corresponded equation	R^2	Values of A_2 and d_2 and the corresponded equation	R^2
date	$Ea = 1503e^{-0.023\,C}$	0.994	$Ea = 101997C^{-0.776}$	0.971
mulberry	$Ea = 19268e^{-0.017C}$	0.959	$Ea = 80857C^{-0.584}$	0.917
grape	$Ea = 33428e^{-0.039C}$	0.962	$Ea = 100000C^{-1.361}$	0.997
carob	$Ea = 18901e^{-0.02C}$	0.955	$Ea = 106737C^{-0.693}$	0.992

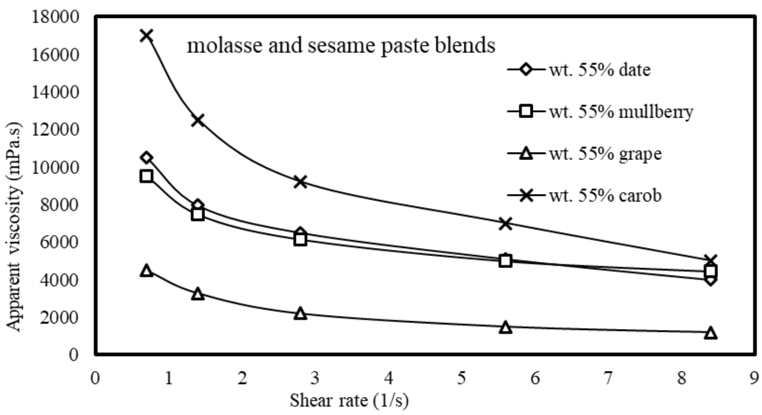

Figure 7. Variation of apparent viscosity with shear rate for date, mulberry, grape and carob molasses /sesame paste blends at the constant concentration (55 %) and temperature (40 °C)

$$\mu_a = 0.793932\, exp\left[1533.303\, \left(\frac{1}{T}\right)\right]\, C^{0.888077}\ \dot{\gamma}^{-0.53582} \quad (3.9)$$

Similarly, the determination coefficients point out that both models (Eq. (3.5) and Eq. (3.6)) are convenient for the carob molasses blends. However, Eq. (3.5) is much more appropriate than Eq. (3.6) since the value of R^2

(0.974528) is larger for Eq. (3.5); therefore, it is recommended that the following single model can be used for carob molasses blends.

$$\mu_a = 21.89981\, exp\left[\, 1419.017\, \left(\frac{1}{T}\right) + 0.036663\, C\right]\, \dot{\gamma}^{-0.4837} \tag{3.10}$$

4. Conclusions and Recommendations

In this study the flow behavior of some molasses/sesame paste mixtures at four different molasses concentrations (20-55 %) and various temperatures in range of 25-60 °C was investigated at various shear rates in the range of 2.5-30 s-1.

This study concludes that the apparent viscosity of the mixture of some molasses/sesame pastes gains a higher value with increasing molasses concentration and reducing temperature. The power-law model can be successfully used to express the relationship between apparent viscosity and shear rate of the mixtures. In addition, the experimental results indicate that the all blends considered here exhibit non- Newtonian, shear thinning behavior.

It was observed that the model parameters such as the flow behavior index and the consistency coefficient are strongly dependent on temperature. The relationship between flow behavior index and temperature are not able to formalize; however, the Arrhenius–type equation has a good interpretation of the relation between the temperature and the consistency coefficient. The impact of molasses concentration on consistency coefficient is quite large. It appears that both exponential and power functions can be utilized to describe the relationship.

Finally, in the present study four model equations were proposed to describe the combined effect of temperature, molasses concentration and shear rate on the apparent viscosity of the mixture. It was observed that the model equations are quite appropriate to define relationship among the concentration of each type of molasses (date, mulberry, grape, and carob), shear rate and temperature.

It is concluded that the obtained experimental data suggested that the model equations can be used in quality control, sensory evaluation of the product, process control applications and in designing equipment for the mixtures.

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Back-Calculation of Total Lengths of *Luciobarbus mystaceus* (Pallas, 1814) from Scale and Otolith Measurements

Can Kaan TEKSAR[1], Metin ÇALTA[2*]
[1] İzmir Food Control Laboratory Directorate, İzmir, Turkey
[2] Fisheries Faculty, Firat University, Elazig, Turkey
[1] cankaan.teksar@tarim.gov.tr, [*2] mcalta@firat.edu.tr,

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Abstract: In this study, the total lengths of *Luciobarbus mystaceus* species at previous ages were estimated from scale and otolith lengths by using back-calculation methods. For this purpose, 20 fish samples with 4-7 years in age, 37.1-47.4 cm in total length and 426.1-874.1 g in weight were obtained from a commercial fisherman in Keban Dam Lake. By using the back-calculation methods, the mean total length values for each ages calculated from scale lengths and otolith lengths were estimated as L_1=7.7, L_2=14.9, L_3=21.4, L_4=28.1, L_5=30.3, L_6=33.5, L_7=35.7 cm and L_1=7.5, L_2=14.5, L_3=19.2, L_4=26.3, L_5=29.6, L_6=33.3, L_7=33.9 cm respectively. The total lengths of fish calculated from scale and otolith measurements for all age groups were always determined smaller than observed total lengths of fish. There was a significant differences between calculated and observed lengths, but did not differ between total fish lengths calculated from scale and otolith measurements.

Key words: *Luciobarbus mystaceus*, back-calculation, fish length, Scale, Otolith.

Pul ve Otolit Ölçümlerinden *Luciobarbus mystaceus* (Pallas, 1814)'un Toplam Boyunun Geri Hesaplanması

Özet: Bu çalışmada, *Luciobarbus mystaceus* türünün daha önceki yaşlardaki toplam boyları pul ve otolit boylarından geri hesaplama yöntemleri kullanılarak tahmin edilmiştir. Bu amaçla, Keban Baraj Gölü'ndeki ticari bir balıkçıdan yaşları 4-7, toplam boyları 37,1-47,4 cm ve toplam ağırlıkları 426,1-874,1 g arasında olan 20 balık elde edildi. Geri hesaplama yöntemleri kullanılarak, pul boyu ve otolit boyundan her bir yaş için tahmin edilen ortalama toplam boy değerleri sırasıyla; L_1=7,7; L_2=14,9; L_3=21,4; L_4=28,1; L_5=30,3; L_6=33,5; L_7=35,7 cm ve L_1=7,5; L_2=14,5; L_3=19,2; L_4=26,3; L_5=29,6; L_6=33,3; L_7=33,9 cm olarak hesaplanmıştır. Tüm yaş grupları için pul ve otolit ölçümlerinden hesaplanan toplam balık boylarının, daima gözlenen toplam balık boylarından daha küçük olduğu belirlenmiştir. Hesaplanan ve gözlenen balık boyları arasında anlamlı bir fark var iken, pul ve otolit ölçümlerinden hesaplanan toplam balık boyları arasında fark yoktur.

Anahtar kelimeler: *Luciobarbus mystaceus*, geri hesaplama, balık boyu, pul, otolit**.**

1. Introduction

Age determination and growth estimation in fish are very important for sustainable fishery and fish stock management. There are more information about age determining and growth in fish [1-8]. In growth estimation studies on fish, it is not always possible to capture smaller fish due to the selectivity of fishing tools or fishing regulations of government. Therefore, the back-calculation method is widely used in estimating the growth of smaller fish that are absent or not enough in the dataset. The method is based on the assumption that the growth of the fish is proportional to the growth of the bony structures such as scale, otoliths etc. The growth rings in the chosen bony structure are used in calculating the lengths of fish at previous ages. The critical comparison of back-calculation methods used for estimation of fish growth have been done [9-13]. On freshwater fish inhabiting eastern part of Turkey, some studies have been done using the back-calculation methods to estimate fish lengths at previous ages on *Capoeta trutta* from [14], *Barbus rajanorum mystaceus* [15] and *Acanthobrama marmid* [16] from Keban Dam Lake and on *Capoeta umbla* from Hazar Lake [17]. The present study was aimed to estimate total lengths of *Luciobarbus mystaceus* species at previous ages by using back calculation methods from scale and otolith measurements.

* Corresponding author: mcalta@firat.edu.tr. ORCID Number of authors: [1] 0000-0003-0554-2725, [2] 0000-0002-1652-8972

2. Materials and Methods

Total 20 individual of *Luciobarbus mystaceus* species were obtained from commercial fishermen fishing in the Keban Dam Lake between October and November 2017. They were transferred fish systematic laboratory of Firat University Fisheries Faculty. First, total lengths and body weights of them were determined nearest ± 1 mm and 0.1 g and precision respectively. Sagittal otoliths and a few scales from the region under the first dorsal fin were removed, cleaned and kept in 96% alcohol [1] for microscopic examination. The ages of fishes were determined from both sagittal otoliths and scales. Then the lengths of each yearling age ring (annulus) were measured nearest 0.001 mm precision by using image analysis software (LAS V4.8) connected to Leica S8APO microscope. The total lengths of fish at previous ages were estimated using Fraser-Lee back-calculation method [18, 19] for scale and Dahl-Lea back-calculation method [20, 21] for otoliths.

Fraser-Lee back-calculation equation: $Ln = a + (L-a) * (Sn/S)$

Dahl-Lea back-calculation equation: $Ln = L * (Sn/S)$

Ln= back-calculated length of the fish at age "n"

L= total length of fish at the time of capture

Sn= length of scale radius or otolith at age "n"

S= length of scale radius or otolith of fish at the time of capture

a= intercept from the regression of body length on mean scale length

The results were statistically examined by means of SPSS Ver.22 programme (IBM Cooperation).

3. Results

In this study, 20 fish samples belong to *L. mystaceus* species obtained from Keban Dam Lake were used. They were 4-7 in age group, 37.1-47.4 cm in total length and 426.1–874.1 g in body weight. The regression analysis between total length and scale radius length of fish indicated that fist formation of scale started while the fish were 16.9 mm in total length. The total fish lengths of the previous ages estimated by using the back calculation methods from the scales and otolith measurements are given in Table 1. The total fish lengths at previous ages calculated from scale and otolith measurements were found to be very close to each other (Table 1 and Figure 1). However, these calculated total lengths were significantly found smaller for all age groups compared with the observed total lengths (Figure 1).

Table 1. The total fish lengths at the previous ages (L_1-L_7) estimated by using back-calculation methods from scale and otolith measurements.

Age	N	TL (cm)	Calculated from scales							Calculated from otoliths						
			L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_1	L_2	L_3	L_4	L_5	L_6	L_7
IV	4	37.1	7.3	12.1	16.5	20.1				6.7	12.6	19.0	24.5			
V	8	42.0	7.6	13.1	20.2	25.7	27.3			7.4	15.6	18.7	27.3	27.2		
VI	6	45.5	7.8	16.2	21.8	29.4	31.3	32.9		7.7	15.1	19.7	29.2	32.6	34.3	
VII	2	47.4	8.1	18.1	27.3	37.4	32.4	34.1	35.7	8.2	14.6	19.4	24.2	29.1	32.3	33.9
Mean			7.7	14.9	21.4	28.1	30.3	33.5	35.7	7.5	14.5	19.2	26.3	29.6	33.3	33.9
SD			0.4	2.8	4.5	7.3	2.7	0.8	-	0.6	1.3	0.4	2.4	2.7	1.4	-
SE			0.2	1.4	2.2	3.6	1.3	0.4	-	0.3	0.6	0.2	1.2	1.4	0.7	-

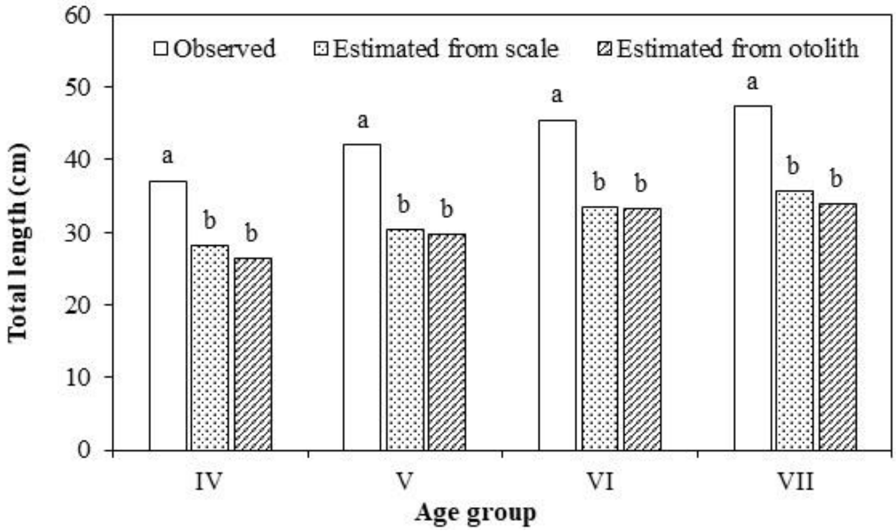

Figure 1. Observed and back-calculated total lengths of *L. mystaceus* from Keban Dam Lake. Different letters above the columns indicate significant differences ($P < 0.05$; Duncan's Multiple Range Test).

4. Discussion

In this study, 20 samples of *L. mystaceus* with 4-7 in age, 37.1-47.4 cm in length and 426.1-874.1 g in weight were examined to estimate the total lengths of fish at previous ages by using back-calculation methods from scale and otolith measurements. The total fish lengths at previous ages calculated from scale and otolith measurements were found to be very close to each other. However, the observed total lengths of fish for all age groups were always determined to be higher than the total lengths of fish calculated from both scale and otolith measurements. Similar to our result, some other studies have also been resulted that observed lengths were always higher than estimated lengths using back-calculation methods [14-17]. In addition, they were showed that the differences between calculated and measured lengths increased when earlier annuli length of scales and otoliths of older fish were used for back-calculation. The reason for this is that the bony structures measured do not show the same growth rate as the fish during the life of fish, and there may be difficulties in the age readings and measurements of bony structures.

In conclusion, back-calculation method provides important advantage to estimate the length of fish population at younger age groups that cannot normally be captured.

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A Study on the Occurrence of Egg Capsule and Juvenile Individuals of Thornback Skate, *Raja clavata*, Captured from Northeastern Mediterranean Sea

Nuri BAŞUSTA[1*], Asiye BAŞUSTA[1]
[1] Fisheries Faculty, Firat University, TR-23119, Elazig, Turkey
[1] nbasusta@hotmail.com

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Abstract: In this study, the egg capsules and juveniles of thornback skate (*Raja clavata* Linnaeus, 1758) were collected as by-catch from a commercial trawl fishing at depths between 220-298 m in the international waters of Northeastern Mediterranean Sea. Juvenile specimens and egg capsule of thornback skate were identified for the first time in this area.

Keywords: *Raja clavata*, thornback skate, egg capsule, juvenile, Northeastern Mediterranean

Kuzeydoğu Akdeniz'den Yakalanan Dikenli Vatoz (*Raja clavata*)'un Yumurta Kapsülleri ve Juvenilleri Görünürlüğü Üzerine bir Çalışma

Özet: Bu çalışmada Kuzeydoğu Akdeniz'in uluslararası sularında yapılan ticari trol avcılığında 220-298 m arası derinlikten dikenli vatoz (*Raja clavata* Linnaeus, 1758) yumurta kapsülleri ve juvenilleri hedef dışı olarak toplanmıştır. Dikenli vatoza ait yumurta kapsülü ve juvenil bireyler bu bölgeden ilk kez tanımlanmıştır.

Anahtar Kelimeler: *Raja clavata*, dikenli vatoz, yumurta kapsülü, juvenil, Kuzeydoğu Akdeniz.

1. Introduction

Thornback skate, *Raja clavata*, is Atlanto-Mediterranean species and distributed from Norway-Iceland to South Africa, extending to Madagascar. Thornback skate is a bottom species that is found on sandy or muddy substrate to depths of 300m. Females of this species lay 150 horny capsule rectangular eggs of 5x8 cm with horn-like extension on each corner [1]. *R. clavata* is common along the Turkish coasts, mainly in the Black Sea. This species is a very important component of demersal fisheries and it is captured by trawl and gillnet particularly as by catch [2]. This species is currently listed under "Near Threatened" on the IUCN Red List of Threatened Species, because there is evidence to indicate the population has declined significantly [3]. *R. clavata* is under protection in Turkish seas. However, little information is still available on its reproduction biology in the North-eastern Mediterranean. This study is to report the existence of egg capsule and juveniles of *R. clavata* captured in the international waters of North-eastern Mediterranean.

2. Materials and Methods

Juveniles and egg capsules of *R. clavata* have been collected as bycatch from commercial trawl fishing at 220-298 m depths in the international waters of North-eastern Mediterranean (between 36º 11'012 N -35º 32'732 E and 36º 03'131 N -35º 39'770 E) (Figure 1.) during the season (15 April-15 July 2015) in which fishing is prohibited in the continental shelf on the 5th of June 2015. Fish samples were transported to the eco-physiology laboratory in Faculty of Fisheries, Firat University and then they were identified, sexed and photographed. Morphometric measurements (total length and disc width) of the juveniles were taken to the nearest 1 mm and the weight of each specimen was measured with a digital scale to the nearest 0.01 g (Figure 2). Juveniles of *R. clavata* were preserved at the Museum of Fisheries Faculty, Firat University.

* Corresponding author: nbasusta@hotmail.com, ORCID Number of author: 0000-0002-4260-4772

Figure 1. Fish sampling area (O) in Northeastern Mediterranean Sea.

3. Results

Total lengths and disc width range of *R. clavata* specimens were 9.5-19.5 cm and 5.2-11.5 cm, respectively. Total weights were between 1.96 and 17.2 g (Table 1). Egg case length and egg case width were 4.5 and 3.1 cm, respectively. The fresh color of egg case was reddish brown (Figure 3). The presence of juvenile individuals and adult females of *R. clavata* in May and June, in the same area suggests that there is egg laying and nursery in the North-eastern Mediterranean.

Table 1. Morphometric measurements of juvenile *Raja clavata* captured from Northeastern Mediterranean Sea

Sample No	Total length (cm)	Disc width (cm)	Weight (g)
1	17.6	10.1	15.53
2	15.7	8.7	7.68
3	19.5	11.5	17.12
4	16.2	8.7	8.84
5	9.5	5.2	2.04
6	10.5	5.7	1.96
7	16.3	9.1	8.23

Figure 2. Juveniles of *Raja clavata* captured from Northeastern Mediterranean Sea

Figure 3. Egg capsule of *Raja clavata* captured from Northeastern Mediterranean Sea

4. Discussion

The morphological description of the egg case of thornback skate was done according to Porcu et al. (2017) [4]. It is reported that the decision regarding the use of the study area as a nursery by a given species was made considering the presence of egg capsules, small juveniles and mature females [5]. The juveniles and mature individuals of *R. clavata* in same area has also been observed in the following years (personnel observation).

These findings show that thornback skate may use this area for mating, egg laying and nursery area. It is possible to say that the generation of cartilaginous fishes that produce limited number of eggs or juveniles are under threat in this region because of using for fishing by fishermen.

Thus, this study ensures the first report of juveniles and egg case of thornback skate from the Northeastern Mediterranean.

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