How to Cite:
Indumathi, A., Begam, H. F., Sivamani, G., & Pandian, A. (2022). Composition of peroximate and types of amino acids analysis of cost-effectively essential finfishes – Lutjanus argentimaculatus, Epinephelus malabaricus in Nagapattinam Coast of Tamil Nadu, South India. *International Journal of Health Sciences*, *6*(S5), 10655–10668. https://doi.org/10.53730/ijhs.v6nS5.10861

Composition of peroximate and types of amino acids analysis of cost-effectively essential finfishes – *Lutjanus argentimaculatus, Epinephelus malabaricus* in Nagapattinam Coast of Tamil Nadu, South India

A. Indumathi
Department of Zoology, Seethalakshmi Achi College for Women (Affiliated to Alagappa University), Pallathur – 630107, Tamil Nadu, India.

H. Faritha Begam*
Department of Zoology, Seethalakshmi Achi College for Women (Affiliated to Alagappa University), Pallathur – 630107, Tamil Nadu, India.
Corresponding author Email: fariafsheen@gmail.com

Ganesan Sivamani
PG & Research Department of Zoology, A.V.V.M. Sri Pushpam College (An Autonomous Institution Affiliated to Bharathidasan University), Poondi, Thanjavur 613503, Tamil Nadu, India.
Email: ganesanmolbio@gmail.com

Arjun Pandian
Department of Biotechnology, PRIST Deemed University, Thanjavur 613403, Tamil Nadu, India.
Email: arjungri@gmail.com

***Abstract*---**The current study was undertaken to investigate the composition of peroximate in relation to the types of season, sex, and group sizes in edible tissues of the finfishes of *Lutjanus argentimaculatus* and *Epinephelus malabaricus* in Nagapattinam coast of Tamil Nadu, South India. *L. argentimaculatus*, indeterminates are 10-40 cm, male and females are 40-85 cm, in *E. malabaricus* the indeterminates are 10-30 cm, male and females are 30-60 cm. Variations in proximate composition noticed between *L. argentimaculatus* and *E. malabaricus*. In *L. argentimaculatus* indeterminates showed moisture content ranged between 75.31 and 81.75%, both the size groups of indeterminates (10-25 and 25-40 cm) exhibited elevated values during pre-monsoon (81.75 followed by 80.34%) and small values during summer (10-25 and 25-40 cm; 78.44

followed by 78.15%). Variations in proximate composition noticed in *E. malabaricus* are depicted, the moisture content ranged between 72.65 and 79.95%. The male size groups (30-40 cm and indeterminates 20-30 cm) exhibited superior values during summer (79.95 followed by 78.95%) and small values during pre-monsoon and monsoon (50-60 cm; 72.75 followed by 72.65%). The total amino acid pleased in *L. argentimaculatus* was (96.75%), results of current study shows that the important amino acids (EAA) percentage was more (53.74%) than that of supplementary amino acid (NEAA, 43.01%). The uppermost amount EAA obtained on lycine (12.16%) followed by Arginine (6.81%). Total amino acid content of *E. malabaricus* was obtained (95.52%), results of present amendment showed that the essential amino acids (EAA) percentage was extra (49.48%) than that of extra amino acid (NEAA, 46.04%). Highest amount of EAA obtained on lycine (9.28%) followed by Leucine (7.95%), NEAA uppermost in Glutamic acid (12.28%) followed by Aspartic acid (7.87%). It can be concluded that the finfishes was a plankton feeder and standing of the accumulation was in over fishing condition, overshadowing finfishes cost-effectively important for human consumption.

***Keywords*---**Aquaculture, Finfishes, Glutamic acids, Leucine, Monsoon.

Introduction

Marine finfish has gained greatly reputation outstanding to its elevated nutritional outline and enormous demand in seafood container together in international and domestic fish market. The ambition is also to guarantee replication the proceeds of the coastal fishers and fish farmers. The aquaculture finfish can produce a considerable amount of overflow, which can have objectionable repercussions on the atmospheres (Fernandes et al., 2002). The fisheries are conquered through the social cost-effectively rearward artisanal and diminutive balance fishers whose lives are directly entangled with the sea and ocean. Sea fishing is a dangerous profession and causes diminution of natural property (Abbas and Siddiqui, 2013). Oceanic finfish civilization has been gradually more resorted as earnings of ornamental the fishery possessions; replenish normal stocks whose populations have declined through over development or ecological deprivation. Preservation and processing of fish and fishery products also need accurate information on composition in biochemically (Sheril Ann Shaji and Hindumathy, 2013).

Fish constitutes an extremely significant constituent of diet for numerous people, provides greatly needed nutrients for a vigorous livelihood, traditionally been supplementary willingly obtainable to the deprived, particularly in the pastoral areas of numerous mounting countries similar to India (Vijayakumar et al., 2014). Fish tissue proteins contain twenty dissimilar amino acids counting essential and non-essential of nutritional significance (King et al., 1990). They are compulsory for the continuation of reproduction, development and vitamins synthesis. Every essential amino acid required for superior protein nourishment is current in fish

meat, the fish protein content significant when taking into account excellence and consistency of the fish meat (Majid et al., 2011).

Fish is accepted universally as a rich source of nutrition for millions. It is considered as a remedy to set right nutritional deficiencies. Fish consumption is therefore increasing rapidly in many countries. The study on amino acid showed the relative concentration of major amino acids to be homogenous in fish, the lysine to be unique and all other amino acids to differ slightly in their presence (Braekkan and Boge, 1962; Silva-Carrillo, 2012). The amino acid profile also varied in different regions of fishes. Fatty acid of muscle composition has been recorded for *Merluccius capensis, M. paradoxus* and *M. australis* (Vlieg and Body, 1988). Krajnovic-Ozretic et al. (1994) observed elevated attentiveness of extremely unsaturated fatty acids (n-3) in liver and white muscle of natural sea bass compared to their farmed counterparts. Fatty acids and lipids are 2 pelagic cottoid fishes (*Comephorus* spp.) were reported by Kozlova and Khotimchenko (2000).

Senthilkumar (2001) studied the systematic, biochemical and toxinology of Tetraodontid fishes occurring along Nagapattinam and adjacent coastal waters. Fatty acid composition of cultured and natural sea bass (*Dicentrarchus labrax*) was noticed by Alasalvar et al. (2002). The mineral nutrition of fish has been moderately well investigated and several of the achievements have been decorated in the reviews of Watanabe et al. (1989). Alasalvar et al. (2002) investigated the differences between cultured and wild sea bass (*Dicentrarchus labrax*) in trace mineral composition. Sun dried sardines of dissimilar individuality were examined for nutrient contented, digestibility nutrients, in sheep's nitrogen balances (Early et al., 2001).

Chinook salmon (*Oncorhynchus tshawytscha*) is a chief profitable and continuation resource for the Alaska people and one of the majorities of the fashionable species for sport fishing. Continuation Chinook salmon gather averaged roughly 167,000 fish from 1989 to 2006 and sport fishing landings were virtually equivalent, but in cooperation have declined considerably during the deprived return years of the previous decade (Fall et al., 2017), present marketable Chinook salmon fishery in Alaska is treasured at around $16.3 million/per year (ADFG, 2019).

Based on numerous parameters and efficiently essential *Lutjanus argentimaculatus* and *Epinephelus malabaricus* selected for the indeterminate, male and female selected based on dissimilar sizes, peroximate composition, moisture content in relation to dissimilar seasons, sex and group sizes with the examination of assessed in amino acid profiles and their percentage contributions.

Materials and Methods

Collection and preparation of samples

The finfishes were collected frequently throughout 4 different seasons; monsoon, pre monsoon, post monsoon and summer) in Nagapattinam coastal for a period of

May 2021 to April 2022. *Lutjanus argentimaculatus* and *Epinephelus malabaricus* Fishes was examined through observing the brightness of eyes, gills color and muscles texture. Identified fishes sexes and grouped into five size groups based on their total length the purpose of identification, publications of Munro (1955) and Fischer and Bianchi (1984), about 2 cm behind the head, dorsolateral epaxial white muscle portion was taken, followed through in an oven samples were dehydrated at 60°C (24 h), it's were packed in air tight polyethylene covers and reserved in desiccators, the dried samples were delicately powdered, used in further analysis.

Proximate composition

Proximate composition including moisture contents of the dried muscle tissue was estimated; determine the humidity substance (1 g) tissue freshly was oven dried at a stable temperature (105°C; 24 h) (AOAC, 1990). The size groups generally available in the markets i.e. 40-55 cm in the case of *L. argentimaculatus*, 30-40 cm in *E. malabaricus* was selected for further entire studies.
Moisture percentage (%) = Wet weight –Dry weight (mg) / Weight of the sample (mg) × 100

Amino acids

The muscle from 10 individuals in *L. argentimaculatus* and *E. malabaricus* were pooled and used in the analysis, samples collected for 24 h dried (60°C) in an oven, packed in air tight polyethylene covers and reserved in desiccators. The oven dried samples were delicately powdered facing calculate the amino acid contour. The samples were hydrolyzed for 22 h with 6-N HCl (110°C). The amino acids were determined throughout an automatic amino acid analyzer (SHIMADZU High Performance Liquid Chromatography LC 10A). The 20 µl Hydrolyzed samples were injected into column. The eluded amino acids were detected quantitatively through fluorescent detector (FLD 6A) using the reagent *o*-phthaldialdehyde. The amino acids were then documented through comparing their retention time (RT) with the standard amino acids run at matching conditions (AOAC, 1990).

Statistical analysis

The mathematical analysis were influenced through One-way Analysis of inconsistency (ANOVA) to establish the extraordinary of dissimilarity of possessions of an collection of management groups, with the DMRT (Duncan's Multiple Range Test) through resources of Statistical Package for the Social Sciences (SPSS; Version 16.0) echelon (5%) package, standards are presented as significance ($P < 0.05$) (Daoud et al., 2011).

Results and Discussions

The proximate composition in seasonal variations, moisture contents of finfishes are presented; each measurement in results represents the mean of triplicate samples for each species. It was ascertain particularly difficult to evaluate the monthly variations, selected two species exhibited wide fluctuations in their nutritional composition. For the sake of convenience, regular seasonal values

were calculated through summing the monthly values. Different size (cm) groups of indeterminates, males and females of two finfish species collected from Nagapattinam coast, Tamil Nadu, South India, *L. argentimaculatus*, indeterminates 10-40 cm, male and females 40-85, and *E. malabaricus* indeterminates 10-30 cm, male and females 30-60 (Table 1; Fig. 1).

Table 1. Size groups of indeterminates, males and females of two finfish species collected from Nagapattinam coast

Species	Indeterminates (CM)		Males and Females (CM)					
			Males	Females	Males	Females	Males	Females
Lutjanus argentimaculatus	10-25	25-40	40-55	40-55	55-70	55-70	70-85	70-85
Epinephelus malabaricus	10-20	20-30	30-40	30-40	40-50	40-50	50-60	50-60

Variations in proximate composition - moisture content of *Lutjanus argentimaculatus* and *Epinephelus malabaricus*

The proximate composition variations in noticed in *L. argentimaculatus* are depicted (Table 2). The moisture in four different seasons' monsoon, pre-monsoon, post-monsoon and summer notices, lowly and uppermost content ranged between 75.02 and 81.75%. The indeterminates size groups (10-25 and 25-40 cm) exhibited prominent values during pre-monsoon season highest amount of moisture content (81.75%) was obtained from 10-25 cm size of indeterminates followed by 80.34% observed from 25-40 cm and tiny values are noticed form 10-25 cm it showed (75.35%), followed by 25-40 showed (75.31%) in monsoon. Among the size groups in both male and female sexes; among male the elevated value was recorded in male during pre-monsoon and monsoon (40-55 cm; 80.84%; followed by 40-55 cm; 79.51%), lowest amount was obtained from summer 70-85 cm showed 75.02%. Among females uppermost moisture content was obtained from pre-monsoon 40-55 cm sizes showed 80.65% followed by 70-85 cm showed 79.50% and lowly moisture content was recorded in summer 70-85 cm noticed that (75.16%), all are showed in Table 2.

The proximate composition differences noticed in *E. malabaricus* are depicted (Table 3), the moisture content ranged between 72.65 and 79.95%. The indeterminates size groups (10-20 and 20-30 cm) exhibited prominent values during summer, 20-30 cm showed (78.95%) and 10-20 cm showed (78.33%), the lowest amount of moisture content was obtained from monsoon 10-20 cm showed (75.11%) followed by pre-monsoon 20-30 cm showed (75.11%). Among the size groups in both male and female sexes; among males lofty value was recorded during summer (30-40 cm; 79.95%; followed by 40-50 cm; 78.85%) and lowly amount was recorded in male pre-monsoon and monsoon (50-60 cm; 72.75% followed by 72.65%). Among female highest amount of moisture content was obtained in summer and pre-monsoon (30-40 cm; 77.77% followed by 76.95%), least amount of moisture content obtained in pre-monsoon (40-50 cm; 73.95% followed by 50-60 cm; 73.95%). Low values were observed in larger size groups while elevated values in smaller size groups in Table 3.

Fig. 1. Finfishes selected for present study
a. *Lutjanus argentimaculatus,* b. *Epinephelus malabaricus*

Table 2. Moisture content variations in *L. argentimaculatus* in relation to size, sex, season and groups (Dry weight % basis)

Species	Indeterminates (CM)		Males and Females (CM)					
			Males	Females	Males	Females	Males	Females
L. argentimaculatus	10-25	25-40	40-55	40-55	55-70	55-70	70-85	70-85
Monsoon	75.35± 0.16	75.31± 0.14	79.74± 0.72	79.42± 0.31	78.03± 0.33	78.04± 0.44	76.85± 0.62	76.04± 0.21
Pre-monsoon	81.75± 0.43	80.34± 0.14	80.84± 0.47	80.65± 0.72	79.51± 0.55	78.44± 0.65	77.75± 0.66	79.50± 0.51
Post-monsoon	79.44± 0.66	78.66± 0.52	78.58± 0.81	78.46± 0.54	77.41± 0.54	77.21± 0.42	76.85± 0.75	76.35± 0.44
Summer	78.44± 0.54	78.15± 0.64	78.22± 0.41	77.22± 0.41	75.05± 0.47	76.65± 0.72	75.02± 0.47	75.16± 0.44

Table 3. Moisture content variations in *E. malabaricus* in relation to size, sex, season and groups (Dry Wt % basis)

Species	Indeterminates (CM)		Males and Females (CM)					
			Males	Females	Males	Females	Males	Females
E. malabaricus	10-20	20-30	30-40	30-40	40-50	40-50	50-60	50-60
Monsoon	75.11± 0.33	75.85± 0.55	74.32± 0.32	74.05± 0.21	73.65± 0.42	74.92± 0.65	72.65± 0.22	73.92± 0.54
Pre-monsoon	75.12± 0.21	75.11± 0.12	75.13± 0.14	73.65± 0.54	73.75± 0.87	73.95± 0.95	72.65± 0.55	73.95± 0.98
Post-monsoon	77.71± 0.54	76.71± 0.51	76.23± 0.44	76.95± 0.54	75.35± 0.65	75.25± 0.55	74.35± 0.34	74.86± 0.65
Summer	78.33± 0.64	78.95± 0.75	79.95± 0.54	77.77± 0.76	78.85± 96	75.51± 0.71	75.75± 0.95	75.55± 0.77

Different types of amino acids in *Lutjanus argentimaculatus* and *Epinephelus malabaricus*

The amino acid are essential for all living organisms, it's helpful for growth and development of living things, amino acid analyses selected two species are presented in Table 4, noteworthy differences ($P < 0.05$) between the fishes were noticed in the amino acid compositions. Conversely no important difference ($P > 0.05$) was observed among the *L. argentimaculatus* and *E. malabaricus* finfishes. Amino acids, often referred to as the build proteins blocks, are compounds that cooperate abundant dangerous roles in living bodies. It's an organic compounds that functional groups are surround carboxylate and amino, with an elevation chain detailed to every amino acid (Lehninger, 2004). The rudiments in attendance in each amino acid are C, H, O_2, and N (Lehninger, 2004).

Amino acids are essential, non essential, total were analyzed in *L. argentimaculatus* and *E. malabaricus*, the highest amount of total amino acid content of *L. argentimaculatus* was noticed (96.75%), results of current revision showed that the necessary amino acids (EAA) percentage observed (53.74%). The uppermost amount EAA obtained on lycine (12.16%) followed by Arginine (6.81%), Isoleucine (6.48%) and lowly amount of EAA amino acid obtained on Valine (3.09%). Than the non essential amino acid (NEAA, 43.01%); utmost amount of NEAA was notice on glutamic acid contributed the uppermost percentage (12.43%) followed by aspartic acid (7.87%), Glycine showed (6.75%) and the lowly amount of NEAA concentration was observed on Tyrosine (2.91%), different levels of isoleucine, methionine, phenylalanine, threonine, valine, cystine, glycine, proline, serine mentioned in Table 4. The total amino acid concentration, tryptophan was completely denatured during the acid hydrolysis of proteins, so, the tryptophan content was not incorporated in the total composition of EAA (Table 4).

The entirety amino acid contents of *E. malabaricus* was obtained (95.52%), results of existing revision showed that necessary amino acids (EAA) percentage (49.48%) than that of non-essential amino acid (NEAA, 46.04%). The highest amount of EAA obtained on lycine (9.28%) followed by Leucine (7.95%), Isoleucine (6.76%) and lowest amount of EAA amino acid obtained on Valine (3.35%). In NEAA chief amount of amino acid was notice on glutamic acid contributed the uppermost percentage (12.28%) followed by aspartic acid (7.87%), Alanine showed (5.92%) and the lowest amount of NEAA concentration was observed on Tyrosine (3.20%), The different levels of isoleucine, methionine, phenylalanine, threonine, valine, cystine, glycine, proline, serine were found which is noticed in Table 4.

Table 4. Amino acid composition (Mean ± S.D.) of muscle proteins in two finfish species collected from Nagapattinam coast (Total amino acids %)

Amino acid	*Lutjanus argentimaculatus*	*Epinephelus malabaricus*
Arginine	6.81±0.51	6.56 ± 0.66
Histidine	3.68±0.21	3.33±0.62
Isoleucine	6.48±0.13	6.76 ± 0.06
Leucine	5.67±0.04	7.95 ± 0.05
Lysine	12.16±0.35	9.28 ± 0.04

Methionine	4.57±0.24	3.71±0.65
Phenylalanine	4.68±0.17	3.39±0.44
Threonine	5.88±0.67	4.16±0.08
Valine	3.09±0.05	3.35±0.14
Σ EAA	**53.74**	**49.48**
Alanine	5.48 ± 0.76	5.92 ± 0.46
Aspartic acid	7.87 ± 0.23	7.87 ± 0.23
Cystine	0.64 ± 0.09	2.65 ± 0.12
Glutamic acid	12.43 ± 0.75	12.28 ± 0.45
Glycine	6.75 ± 0.43	5.81 ± 0.52
Proline	3.25 ± 0.34	3.87 ± 0.76
Serine	3.68 ± 0.71	4.44 ± 0.43
Tyrosine	2.91 ± 0.31	3.20 ± 0.15
Σ NEAA	**43.01**	**46.04**
Σ TAA	**96.75**	**95.52**

Signify values ± S.D. duplicate samples determine for Means in the similar line sharing dissimilar superscripts are considerably dissimilar, ($P < 0.05$); standards lacking letters inside a string are not considerably different ($P > 0.05$), essential amino acids (EAA); Non-essential amino acids (NEAA); total amino acids (TAA).

The dampness content is in *S. fimbriata* (78.2%) and in *S. longiceps* (69.8%) (Sheeba et al., 2021). Edirisinghe, et al. (2000) reported the lowly entitlement of moisture (69.4%) in white sardine *S. albella* in Sri Lankan waters. As per Castrillon et al. (1997), in *Clupeapil chardus* the moisture content (60.7%) was recorded. According to Kudale and Rathod (2015) the moisture is the major component; during the study period on an average it contributed (68.60% & 68.89%) in males and females, in males and females maximum moisture content was observed in males and females, lowest moisture content was observed in 60.16% and 61.7%; varied between 59.71% to 61.06%, and 61.03% to 62.37%. The moisture content of tilapia was 2.46% lower than that of *S. fimbriata* and *C. gariepinus* (Hemung, 2013).

Several researchers (Wu et al., 2000; Kitts et al., 2004) studied the amino acid make up of fish and found that fish and fish products provide protein of the finest nutritive quality, when evaluated on the basis of its content of EAA. Totally 17 amino acids were identified in the present study, qualitatively there was no difference in amino acids between species but quantitative difference was noticed. Amino acid composition of the muscle proteins of various fish and shellfish was studied by Nair and Suseela (2000). In their study, lysine was found to be high and tryptophan low.

The study of amino acid showed that the relative amount of major amino acids is homogenous in fish. Lysine is found to be unique and all other amino acids differed slightly in their presence (Braekkan and Boge, 1962). Anon, (2002b) noticed no significant differences between the levels of amino acids. In contrast to the above, the amino acid composition in the present study exhibited significant variations among the four finfishes. Fish muscle is known to surround an outstanding amino acid composition (Venugopal et al., 1996) and is a exceptional

source of physiologically valuable amino acids like arginine, histidine, lysine and taurine (Metzner et al., 2001).

Sivashanthini (2004) observed that the muscle lipid in *Gerres abbreviatus* declined during monsoon to increase again during post-monsoon and summer months and in *G. filamentosus*, the muscle lipid was highest during pre-monsoon and it declined significantly during monsoon and post-monsoon to increase again during summer in Nagapattinam waters. Environmental parameters like temperature, rainfall, thermocline, upwelling, solar periodicity, etc. are known to greatly influence the spawning of pelagic fishes like sardines and mackerels (Jeyaprakash, 2002; Elaiyaraja et al., 2012). Biochemical constituents of fish are subjected to marked continuing changes due to different physiological and supplementary factors such as maturation and spawning (Varadharajan et al., 2009).

The power purposes; sufficient enclosure of lipid levels in diet can assist diminish the dietary protein catabolism in fishes (Guo et al., 2019). On the other tender, fish's capability to use nutritional lipid as a non-protein power foundation can be predisposed through the contented of carbohydrates dietary, which can also provide as sources of non-protein power (Guerrero-Zárate et al., 2019)? amino acids, histidine (His) is one of the mainly significant in fish diets since it is involved in a diversity of behavior, such as tissue development, protein synthesis, and mend, as well as the osmoregulation preservation (Hossain et al., 2021). Histidine has a collision on animals' immunological and antioxidant systems (Jiang et al., 2016). The antioxidant enzymes activity openly linked to its mRNA levels and can be synchronized through the transcription factor NFE2-related factor 2 (Nrf2), which is a master supervisor of the cellular antioxidant rejoinder (Ma 2013).

The fatty acid masterpiece and levels were evaluated in *Lutjanus lutjanus* bigeye snapper collected in the Malaysian South China Sea, saturated fatty acids (SAFA) proportions are ranged (55.0% - 66.5%), with the uppermost fatty acids proportions, the 2nd maximum was monounsaturated fatty acids (MUFA) ranged (30.7% - 40.2%) whereas the polyunsaturated fatty acids (PUFA) proportion was the lowly ranged (2.8% - 4.8%) was reported by Arai et al. (2015). Fish meal has traditionally been considered as an important protein source for most aquaculture species for many reasons (Khan et al., 2003), counting its protein content elevated, outstanding amino acid summary and nutrient digestibility elevated (Hardy, 2008).

In all the species, high ash values in the muscle coincided with the spawning period and low principles with post spawning months. Similar findings were observed by Sathya Shree (1981) in *Osteomugil cunnesius*. Seasonal changes in ash content have also been reported in other fishes (Das, 1978). The body energy reserves of *Osteomugil cunnesins* and *O. speigleri* were depleted during spawning and the rate of recovery after spawning varied considerably in either sex (Sathya Shree, 1981). The sexual adulthood of the fish affects the lipid contented owing to increased utilization of fat reserves throughout the spawning period. Food accessibility and ecological, water, temperature are also significant factors. Thus,

fish will have different levels of lipid contents, based on the propagation time of year and cycles (Beltran et al., 1991).

Conclusion

The proximate composition information of finfishes has fundamentally significance in the application of different technological processes; the current study showed that consumption of *L. argentimaculatus* and *E. malabaricus* during pre-monsoon and summer is beneficial in Nagapattinam coast, South India, Tamil Nadu, as good amount of EAA, NEAA are found in selected finfishes. The results of the current study obviously exposed that two species of finfishes studied are containing good quantities proximate composition of TAA, EAA and NEAA.

Reference

Abbas, G, Siddiqui PJA. 2013. The effects of varying dietary protein level on growth, feed conversion, body composition and apparent digestibility coefficient of juvenile mangrove red snapper, Lutjanus argentimaculatus (Forsskal 1775). Aquacult Res 44: 807-818.

ADFG, 2019. 2018 Alaska Commercial Salmon Harvests – Exvessel Values. Alaska Department of Fish and Game Commercial Fisheries, Anchorage, Alaska, USA.

Alasalvar C, Taylor KDA, Zubcov E, Shahidi F and Alexis M. 2002. Differentiation of cultured and wild sea bass (*Dicentrarchus labrax*): Total lipid content, fatty acid and trace mineral composition. Food Chemistry, 79: 145-150.

Anon. 2002b. Fact About Fish. The National Institute of Nutrition and Seafood Research, Norway.

AOAC. 1990. Official methods of analysis, 15th Edn. Association of Official Analytical Chemists.

Arai T, Amalina R, Bachok Z. 2015 Variation in fatty acid composition of the bigeye snapper *Lutjanus lutjanus* collected in coral reef habitats of the Malaysian South China Sea. J Biol Res (Thessalon), 22(1): 5.

Arip, M., Cembun, .-., & Emilyani, D. (2018). Strategy to improve knowledge, attitude, and skill toward clean and healthy life behaviour. International Journal of Social Sciences and Humanities, 2(3), 125–135. https://doi.org/10.29332/ijssh.v2n3.222

Beltran A, Moral A. and Martin P. (1991) Effect of seasonal factors on polyunsaturated fatty acids in smoked sardine during storage at different temperatures. Lebensim.-Wiss.-Technol., 24: 404-407.

Braekkan OR, 1962. B-Vitamins in fish and shellfish. In: Heen, E. and R. Kreuzer (Eds.), Fish in Nutrition. Fishing News (Books) Ltd., London, pp. 55-60.

Castrillon AM, Navarro P and Alvarez-Pontes E. (1997) Changes in chemical composition and nutritional quality of fried Sardine (*Clupea pilchardus*) produced by frozen storage and' Microware reheating. Journal of Science Food and Agriculture. 75: 125-132.

Daoud A, Saud A. and Arjun P. 2021. Somatic embryogenesis and in vitro plant regeneration of *Bacopa monnieri* (Linn.) Wettst, a potential medicinal water hyssop plant. Saudi Journal of Biological Sciences, 28: 353-359.

Das H. (1978) Seasonal variation in the chemical composition and calorific content of *Mugil cephalus* (Linnaeus) from Goa waters, Mahasagar, 11 (3 & 4):

117-134.
Early RJ, Mahgoub O, Lu CD, Ritchie A, Al-Halhali AS. and Annamalai K. (2001) Nutritional evaluation of solar dried sardines as ruminant protein supplement. Small Ruminant Research, 41: 39-49.
Edirisinghe EMRKB, Perera WMK. and Bamunuarachchi A. (2000) Nutritional evaluation of some small coastal fish in Sri Lanka. J Natl Aquat Resour Res Dev Agency, 36(2000): 47-53.
Elaiyaraja C, Sekar V, Rajasekaran R. and Fernando OJ. (2012) Diversity and Seasonal distribution of the turrids (Gastropoda: Turridae) among the four landing centers of Southeast coast of India, Annals of Biological Research, 3(12):5718-5723.
Fall, J.A., Godduhn, A., Hutchinson-Scarbrough, L., Jones, B., Kukkonen, M., Runfola, D., Sill, L.A., Lemons, T., 2017. Alaska Subsistence and Personal Use Fisheries 2014. Annual Report. Alaska Department of Fish and Game Division of Subsistence, Anchorage Technical Paper No. 427.
Fernandes, T.F., Eleftheriou, A., Ackefors, H., Eleftheriou, M., Ervik, A., Sanchez-Mata, A., Scanlon, T., White, P., Cochrane, S., Pearson, T.H., Read, P.A., 2002. MARAQUA: The Management of the Environmental Impacts of Marine Aquaculture. Final Report: European Union FAIR Programme, PL98-4300. Fisheries Research Services, Aberdeen, Scotland, appendices 70 pp.
Fischer W, and Bianchi G. (1984) FAO species identification sheets for fishery purposes. Western Indian Ocean (Fishing area, 51). Prepared and printed with the support of the Danish International Development Agency (DANIDA). Rome, Food and Agricultural Organization of the United Nations, Vol. I-VI.
Guerrero-Zárate, R., Álvarez-González, C.A., Jesus-Contreras, R., Peña-Marín, E.S., Martínez-García, R., Galaviz, M.A., et al. 2019. Evaluation of carbohydrate/lipid ratios on growth and metabolic response in tropical gar (Atractosteus tropicus) juvenile. Aqua-culture Research, 50: 1812-1823.
Guo, J., Zhou, Y., Zhao, H., Chen, W.Y., Chen, Y.J. & Lin, S.M. 2019. Effect of dietary lipid level on growth, lipid metabolism and oxidative status of largemouth bass, Micropterus salmoides. Aquaculture, 506: 394-400.
Hardy, RW. 2008. Farmed fish diet requirements for the next decade and implications for global availability of nutrients. In: Lim C, Webster CD, Lee CS, editors. Alternative protein sources in aquaculture diets. The Haworth Press, USA, 1-15.
Hemung BO. (2013) Properties of tilapia bone powder and its calcium bioavailability based on transglutaminase assay. Intl J Biosci Biochem Bioinform 3 (4): 306–309.
Hossain M.S., Lee S., Small B.C., Hardy R.W. 2021. Histidine requirement of rainbow trout (*Oncorhynchus mykiss*) fed a low fishmeal-based diet for maximum growth and protein retention, Aquaculture Research, 52(8): 3785–3795.
Jeyaprakash AA. (2002) Long term trends in rainfall, sea level and solar periodicity: A case study for forecast of Malabar sole and oil sardine fishery. J. mar. biol. Ass. India, 44(1&2): 163-175.
Jiang, W.D., K. Hu, Y. Liu. 2016. Dietary myo-inositol modulates immunity through antioxidant activity and the Nrf2 and E2F4/cyclin signalling factors in the head kidney and spleen following infection of juvenile fish with *Aeromonas hydrophila*, Fish & Shellfish Immunology, vol. 49, pp. 374–386.
Khan, MA, Jafri, AK, Chadha, NK, Usmani, N. 2003. Growth and body

composition of rohu (Labeo rohita) fed diets containing oilseed meals: partial or total replacement of fish meal with soybean meal. Aquacult Nutr 9: 391-396.

King I, Childs MT, Dorsett C, Ostrander JG, Monsen ER, 1990. Shellfish: Proximate composition, minerals, fatty acids and sterols. Journal of American Dietetic Association, 90: 677-685.

Kitts DD, Huynh MD, Hu C, Trites AW. (2004) Seasonal variation in nutrient composition of laskan walleye Pollock. Can J Zool, 82: 1408-1415.

Kozlova TA. and Khotimchenko SV. 2000. Lipids and fatty acids of two pelagic cottoid fishes (*Comephorus* spp.) endemic to Lake Baikal. Comp. Biochem. Physiol., 126B: 477-485.

Kudale RG. and Rathod JL. 2015. Nutritional value of fringe scale sardine, *Sardinella fimbriata* (Cuv. and Val.) from Karwar waters. International Journal of Fisheries and Aquatic Studies. 3(2): 06-09.

Lehninger, 2004. Principles of biochemistry (4th Edn) D.L. Nelson and M.C. Cox, W.H. Freeman & Co., New York, 1119.

Ma, Q. 2013. Role of nrf2 in oxidative stress and toxicity, Annual Review of Pharmacology and Toxicology, vol. 53, no. 1, pp. 401–426.

Majid A, Mokhlesi A, Bastami KD, Khoshnood R, Eshaghi N, 2011. Survey of some chemical compositions and fatty acids in cultured common Carp (Cyprinuscarpio) and grass Carp (Ctenopharyngodonidella), Noshahr, Iran. World Journal of Fish and Marine Sciences, 3: 533-538.

Metzner C, Ulrich-Merzenich G. and Luder W. (2001) Arginine and Taurine-Dietary Factors Preventing Cardiovascular Diseases? Ernahrungs-Umschau, 48: 5188.

Munro ISR. 1955. The marine and freshwater fishes of Ceylon. Dept. of External Affairs, Canberra, 349.

Nair PGV. and Suseela M. (2000) Biochemical composition of fish and shellfish. CIFT technology advisory series. Central Institute of Fisheries Technology, Cochin, p. 14.

Rusli, D., Ariani, D. N., Nurmina, N., & Rinaldi, R. (2021). Influence of exposure to children's movies on television on theory-of- mind acquisition in preschoolers. International Journal of Health & Medical Sciences, 4(1), 44-49. https://doi.org/10.31295/ijhms.v4n1.650

Senthilkumar R. 2001. Systematics, biochemical and toxinology of Tetraodontid fishes (Pisces: Tetraodontiformes) of Southeast coast of India. Ph.D. Thesis, Annamalai University, Tamil Nadu, India.

Sheeba W, Immaculate JK. and Jamila P. (2021) Comparative Studies on the Nutrition of Two Species of Sardine, *Sardinella longiceps* and *Sardinella fimbriata* of South East Coast of India. Food Science & Nutrition Technology, 6(4): 000272.

Sheril Ann S., Hindumathy Chelvaraya K. 2013. Chemical composition and amino acid profile of Sardinella longiceps collected from Western coastal areas of Kerala, India. Journal of Biology and Earth Sciences, 3: 129-134

Silva-Carrillo, Y, Hernández C, Hardy RW, González-Rodríguez B, Castillo-Vargasmachuca S, 2012. The effect of substituting fish meal with soybean meal on growth, feed efficiency, body composition and blood chemistry in juvenile spotted rose snapper Lutjanus guttatus (Steindachner, 1869). Aquaculture 364-365: 180-185.

Sivashanthini K. (2004) Comparative studies on the reproductive biology of gerreids (Pisces: Gerreidae) from Parangipettai waters, Southeast coast of

India. Ph.D. Thesis, Annamalai University, Tamil Nadu, India.
Suryasa, I. W., Rodríguez-Gámez, M., & Koldoris, T. (2022). Post-pandemic health and its sustainability: Educational situation. International Journal of Health Sciences, 6(1), i-v. https://doi.org/10.53730/ijhs.v6n1.5949
Varadharajan D, Soundarapandian P, and Dinakaran GK. (2009) Vijakumar G. Crab Fishery Resources from Arukkattuthurai to Aiyammpattinam, South East Coast of India. C Res J Biol Sci; 1(3):118-122.
Venugopal V, Chawla SP. and Nair PM. (1996) Spray dried protein powder from threadfin bream: preparation properties and comparison with FPC type-B. J. Muscle Foods, 7: 55.
Vijayakumar N, Sakthivel D and Anandhan V, 2014.Proximate composition of Clupeidae and Engraulidae inhabiting Thengaithittu estuary Puducherry-Southeast coast of India. International Journal of Science Inventions Today, 3(3): 298-309.
Vlieg P. and Body DR. 1988. Lipid contents and fatty acid composition of some New Zealand freshwater finfish and marine finfish, shellfish and roes. New Zealand J.Mar. Freshwater Res., 22: 151-162.
Wu Z, Qiu S. and Yang S. 2000. Examination on the biochemical composition of six pelagic fishes in Minnan-Taiwan Bank fishing ground. J. Fish. China, 24 (5): 428-431.