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Essential Omega-3 (n-3PUFA) Nutritional Content of *Ptilinopus melanosphila* and *Chalcophaps indicia* Meat

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Abstract: Ptilinopus melanosphila and Chalcophaps indica, known as Puna birds among local people of the Sula Islands, North Maluku, Indonesia, while Treron aromaticus, known as Puna Giu, belong to the Columbidae family. These birds are frequently hunted for consumption due to the delectable taste of their meat. This study aims to examine the essential Omega-3 (n-3PUFA) nutritional content, utilizing these two avian species (Ptilinopus melanosphila and Chalcophaps indicia) as samples. Local perceptions consider these birds as identical, hence this study also provides insights into the disparities between the two species based on meat quality analysis. The analysis encompasses proximate analysis, fatty acids, and amino acids, conducted on 6 samples, each encompassing 3 breast meats. These samples were mixed and blended, followed by chemical analysis at the integrated laboratory of Universitas IPB Baranangsiang, with proximate analysis executed at PAU IPB. The results reveal that Ptilinopus melanosphila meat contains crucial nutrients for human consumption, specifically long-chain omega-3 unsaturated fatty acids (n-3PUFA), which are more abundant compared to Chalcophaps indica and several other meat products. The myriad of significant benefits offered by this avian species underscores the importance of recommending its preservation to parties engaged in ex-situ conservation efforts. Furthermore, it is advocated to stimulate the establishment of regional culinary businesses specializing in nutrient-rich Black-Naped Fruit Dove meat.

Keywords: Chalcophaps indica; Essential nutrient; Omega 3 (n-3PUFA); Ptilinopus melanosphila

Introduction

Birds offer enduring benefits, both economically and environmentally. Economically, they can be utilized as a protein source, for competition, and breeding (Saputra et al., 2020). Ecologically, birds are frequently utilized as bioindicators to evaluate the extent and quality of environmental degradation (Ridwan, 2015). The Black-Naped Fruit Dove (Ptilinopus melanospila) is an endemic bird of North Maluku that warrants attention and conservation efforts. This arboreal species inhabits trees and primarily feeds on fruits. Both the Black-Naped Fruit Dove (Ptilinopus melanospila) and the Common Emerald Dove (Chalcophaps indica) belong to the dove family (Columbidae). Among local people, they are collectively referred to as puna birds. These birds are hunted for consumption due to the delectable taste of their meat. Doves hold economic significance in many countries (Wang et al., 2023).

They are among the most prevalent bird species and are widely distributed across mainland Europe (Hanane & Yassin, 2017). Dove meat is rich in essential

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nutrients, encompassing proteins, fats, vitamins, and trace elements crucial for bodily growth and development. (Manyi-Loh & Lues, 2023) notes that dove meat, besides being a good source of protein and various micronutrients, is relatively low in fat and cholesterol, particularly when consumed without the skin. An intriguing nutritional aspect of dove meat is its abundance in n-3 polyunsaturated fatty acids (Sakhawat et al., 2023). Previous studies have investigated dietary patterns and nesting site overlap within the Columbidae family (Hanane & Yassin, 2017).

However, improper handling of meat, particularly during cooking, can lead to a reduction in the nutritional value present in the meat. The cooking process induces a decrease in the total monounsaturated fatty acid (MUFA) content of breast meat, while the total polyunsaturated fatty acid (PUFA) content increases (Dwiloka et al., 2021). Conversely, the total saturated fatty acid (SFA) content in thigh meat decreases with cooking, while the total MUFA content increases. Linolenic acid, in conjunction with eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), serves as a crucial structural element of nerve cells (myelin) and contributes to sphingomyelin production (Layé et al., 2018). EPA is necessary for cell membrane formation (Mason et al., 2016), while sphingomyelin, synthesized by EPA and DHA, accelerates synaptic transmission and myelination of nerve cells (Bradbury, 2011).

Sufficient EPA and DHA levels in the brain facilitate the transmission of signals from the brain to the axons, thereby expediting signal transmission pathways (Chew et al., 2020). Neurotransmitters transmit brain signals in accordance with the brain's instructions, ensuring rapid and efficient development of motor movements in the body. Conversely, the absence of EPA and DHA traces in the brain can disrupt communication, impeding signal transmission to the axons and resulting in sluggish body functions and motor development (Von Schacky, 2021). The efficacy of synapses as messengers among nerve cells Relies on sufficient amino acid and DHA supplies, particularly during the final trimester of pregnancy, postpartum, and adolescence.

Insufficient levels of these fundamental unsaturated fats at birth are linked to low birth weight, reduced cranial circumference, and diminished placental size, potentially leading to enhanced focus in the sensory system and mental capacity later in life (Melva Diana, 2013). For the first time, the American Heart Association recommends the supplementation of omega-3 fatty acids as part of a healthy regimen to prevent cardiovascular disease. According to the association, omega-3 fatty acids can lower the incidence of cardiovascular disease, particularly coronary heart disease (Setiawan & Halim, 2022).

The novelty of this study lies in the discovery or establishment of a meat quality profile of Ptilinopus melanosphila, which has not been previously investigated, particularly regarding the essential omega-3 polyunsaturated fatty acids (n-3 PUFA) nutritional content in this species. Consequently, the results are anticipated to serve as a foundation and raise awareness among stakeholders regarding the conservation of this species and the potential for establishing regional culinary businesses unique to the Sula Islands, centered on nutrient-rich Black-Naped Fruit Dove meat. This study examines the essential omega-3 polyunsaturated fatty acids (n-3 PUFA) nutritional content in Ptlinopus melanosphila in comparison to Chalcophaps indica and meat sourced from various other animal commodities.

Method

Materials and tools

The following materials were primarily utilized in this study: general assessment, six samples of three different types of unsaturated fats and amino acids, and scientific materials including H2SO4, NaOH, HCl, and crushed hexane for general assessment; distilled water and NaCl (for PLA and PLG analysis); HCl, potassium borate mount, OPA array, mercaptoethanol, methanol, brij-30 array, borate pad, acetonitrile, sodium acetate acid derivation support (for amino acid corrosive examination); Haematoxylin, eosin dye, alcohol, Bouin's solution, paraffin, xylene, and haematoxylin.

The tools utilized in this study included a cool box, surgical tools, thermometers, precision scales, liners, ovens, porcelain dishes, burners, desiccators, heaters, test tubes, Erlenmeyer flasks, Kjeldahl tubes, Soxhlet tubes, heaters, distillators, burettes, wicks, homogenizers, needles, Shimadzu brand High Performance Liquid Chromatography (HPLC), microtome, Olympus CH30 microscope, and Canon brand digital camera. Male and female figures of Ptilinopus melanosphila and Chalcophaps indica are presented in the following :

Figure 1. Black-Naped Fruit Dove (Ptilinopus melanospila) male left, female right

Figure 2. Common Emerald Dove (Chalcophaps indica) left male, right Betin

Research Methods

Initially, samples of Ptilinopus melanosphila and Chalcophas indica were collected from Ternate, North Maluku, and Wai Ipa Village, Sanana, Sula Islands. The meat of both species was cleaned and divided into two portions: fresh meat and steamed meat. Subsequently, a general assessment was conducted to assess water, ash, fats, proteins, and sugar content (AOAC 2012) (Samudera et al., 2017). After isolating the meat from the internal organs. The Kjeldahl micro method was utilized for PLA and PLG analysis. Amino acid analysis was conducted, along with hematoxylin-eosin paraffin-based histological staining, at the Research Facility of Universitas IPB.

Analysis

The analysis conducted in this study is descriptive in nature, focusing on chemical analysis. It encompasses the presentation and explanation of data derived from the analysis of fatty acids and amino acids in the nutritional content of the two species. Additionally, comparisons are made with the meat quality of various other species based on relevant literature.

Result and Discussion

The nutritional content of the Black-Naped Fruit Dove (Ptilinopus melanospila) meat in comparison to the Common Emerald Dove (Chalcophaps indica) meat based on the results of Proximate Analysis

Based on proximate analysis of the nutritional content of the Black-Naped Fruit Dove (Ptilinopus melanosphila) and the Common Emerald Dove (Chalcophaps indica) meat, it is evident that the meat quality of the Black-Naped Fruit Dove is superior. This is attributed to its relatively high protein content of 20.96% and low fat content of 3.94%. In comparison, the Common Emerald Dove has higher fat content of 29.92% and protein content of 13.99%. Moreover, the the Black-Naped Fruit Dove meat contains fewer non-essential amino acids and higher levels of essential amino acids such as histidine, threonine, methionine, valine, phenylalanine, isoleucine, and lysine. The nutritional content of the Black-Naped Fruit Dove (Ptilinopus melanosphila) presents significant potential as an alternative food source due to its high protein and low fat content. Hence, immediate measures for the preservation of this species are imperative, considering its unique attributes including high-quality nutritional content, striking color patterns, and distinctive vocalizations.

Currently, Indonesia faces numerous challenges concerning food and nutrition security. Despite considerable progress in reducing child mortality rates and the prevalence of malnutrition indicators such as underweight, overweight, and stunted growth, significant efforts are still required to ensure all Indonesian children enjoy freedom from malnutrition (Ickowitz et al., 2016). Stunting, characterized by short stature or abnormal growth, remains a prevalent nutritional issue in Indonesia (Nuryanto et al., 2023). Therefore, understanding the importance of sufficient nutrition, both in terms of quality and quantity, particularly for children at a young age, is crucial (Gidding et al., 2005).

Table 1. Results of Proximate Analysis of the Black-Naped Fruit Dove (Ptilinopus melanospila) and the Common Emerald Dove (Chalcophaps indica) meat

Content	*Ptilinopus melanosphila (%)*	*Chalcophaps indica*(%)
Water	74.43	53.07
Ash	1.23	0.98
Fats	3.94	29.92
Proteins	20.96	13.99
Crude Fibers	0.00	1.26

Meat serves as a widely consumed source of protein and presents opportunities for development in Indonesia to address the population's demand for animal protein (Damayanti et al., 2024); (Henchion et al., 2021). Various types of meat, including beef, chevon, and chicken, contribute to fulfilling the body's protein needs (Ahmad et al., 2018); (Mazhangara et al., 2019). Additionally, alternative food sources from the Columbidae family, such as the Black-Naped Fruit Dove meat (squab), offer high nutritional value and have been traditionally consumed by local communities. The results of the nutritional content analysis, based on proximate analysis of Ptilonopus melanosphila and Chalcophas indica meat, are presented in the following. Table 1 illustrates the results of proximate analysis of the meat quality of the two bird species, highlighting the Black-Naped Fruit Dove's higher protein content and

lower fat content compared to the Common Emerald Dove. The details are provided in Table 1.

The nutritional content of the Black-Naped Fruit Dove (Ptilinopus melanospila) meat in comparison to purebred chickens, free-range chickens, ducks and muscovy ducks meat

The results of the nutritional content analysis, based on proximate analysis of the Black-Naped Fruit Dove (Ptilinopus melanospila) in comparison to several other animal (livestock) commodities, namely purebred chickens, free-range chickens, ducks, and Muscovy ducks, focusing on the protein and fat content in the breast and thighs, are presented in the following. Comparative data sources as detailed in Table 2.

Table 2. Average content of water, proteins, fats and ash in breast meat, thigh meat and skin of purebred chickens, free range chickens, ducks and Muscovy ducks

Type	Water			Proteins			Fats			Ash		
	breast	thigh	skin	breast	thigh	skin	breast	thigh	skin	breast	thigh	skin
Purebred chickens	73.10	71.24	52.54	23.05	19.27	11.46	1.30	6.80	34.20	1.16	0.99	0.49
Free range chickens	73.39	74.60	62.05	22.70	19.01	13.59	0.80	4.40	21.60	1.04	0.98	0.61
Ducks	73.97	73.91	60.19	19.11	20.19	13.63	0.50	1.72	22.00	1.11	1.09	0.45
Muscovy ducks	72.46	73.58	52.54	21.28	22.35	12.04	0.50	2.80	25.90	0.76	0.85	0.61

Based on comparative data from proximate analysis, the Black-Naped Fruit Dove meat has superior quality compared to several types of poultry mentioned above. Specifically, the protein content in the Black-Naped Fruit Dove thigh meat surpasses that of free-range chickens, purebred chickens, and ducks, while also showing lower fat content. Moreover, the Black-Naped Fruit Dove breast meat has lower fat content compared to purebred chickens and free-range chickens, although ducks and Muscovy ducks have even lower fat content. These results underscore the superior nutritional quality of the Black-Naped Fruit Dove meat over various animal commodities in terms of its protein and fat content. Protein plays a vital role in digestion and the body's capacity to regenerate tissue and produce antibodies (Bizieff et al., 2024; Cruzat et al., 2018; Yang et al., 2023). Factors contributing to heart disease include fat, cholesterol, lack of physical activity, and high blood pressure.

Fatty Acid Content of Ptilinopus melanosphila, Chalcophaps indica in comparison to several other animal (livestock) commodities

The results of analysis reveal that the Black-Naped Fruit Dove meat contains essential nutrients for humans, particularly in comparison to the Common Emerald Dove meat, as it possesses a more comprehensive profile of omega-3 long-chain unsaturated fatty acids (n-3PUFA). These long-chain unsaturated fatty acids are indispensable for human nutrition (Smolińska et al., 2024); (Carr et al., 2023). Omega-3 polyunsaturated fatty acids (n-3PUFA) play a crucial role in human health by reducing the risk of conditions such as coronary heart disease, high blood pressure, and diabetes (Yagi et al., 2017; Colussi et al., 2017; Lu et al., 2023). Nutrition studies and practices in the United States and Europe are increasingly shifting focus from addressing malnutrition to meeting nutritional needs and promoting overall health across the lifespan (de Onis & Branca, 2016).

Polyunsaturated Fatty Acids (PUFA) are long-chain unsaturated fatty acids, with omega-3 unsaturated fats falling within this category, hence termed as n-3PUFA. Omega-3 is denoted by the symbol n-3, signifying double bonds on the third carbon chain of a fatty acid, counting from the end of the alkyl group on the carbon chain. Fatty acids are simple lipids composed of hydrocarbon chains (CH) with a carboxylic group (COOH) at the base of the carbon chain and an alkyl group (CH3) at the chain's end. Typically, fatty acids consist of carbon chains ranging from C12 to C22, although exceptions exist.

Therefore, fatty acids can be represented as CH3-(CH2) x-COOH, where x indicates multiples of CH2. Considering the presence or absence of double bonds, unsaturated fats can be classified into monounsaturated and polyunsaturated fatty acids, particularly those with two or more double bonds. The results of this study reveal that the Black-Naped Fruit Dove meat contains three types of omega-3 unsaturated fatty acids or PUFA (Polyunsaturated Fatty Acids), namely: Eicosapentaenoic Acid (EPA), Docosahexaenoic Acid (DHA), and α-Linolenic Acid (Octadecanoic Acid). Meanwhile, the Common Emerald Dove meat contains only one omega-3 fatty acid, namely α-Linolenic Acid (Octadecatrienoic Acid). The breakdown of fatty acid contents is presented in the following Table 3.

Table 3. List of Fatty Acids found in the Black-Naped Fruit Dove and the Common Emerald Dove meat

Component	*Ptilinopus m*	*Chachophas i.*
Fat Content	3.31	28.39
Fatty Acid**		
Lauric Acid, C12:0	0.03	0.03
Myristic Acid, C14:0	0.51	0.50
Myristoleic Acid, C14:1	0.07	0.04
Pentadecanoic Acid, C15:0	0.02	-
Palmitic Acid, C16:0	22.87	22.97
Palmitoleic Acid, C16:1	7.18	2.34
Heptadecanoic Acid, C17:0	0.05	-
Stearic Acid, C18:0	6.24	6.68
Elaidic Acid, C18:1n9t	0.12	0.11
Oleic Acid, C18:1n9c	36.92	55.63
Linoleic Acid, C18:2n6c	2.16	0.66
Arachidic Acid, C20:0	0.07	0.04
Cis-11-Eicosenoic Acid, C20:1	0.11	0.36
Linolenic Acid, C18:3n3	0.06	0.06
Cis-11,14-Eicosedienoic Acid, C20:˛	0.05	0.11
Behenic Acid, C22:0	0.04	-
Cis-8,11,14-Eicosetrienoic Acid, C20:3n6	0.04	-
Arachidonic Acid, C20:4n6	0.74	-
Lignoceric Acid, C24:0	0.03	-
Cis-5,8,11,14,17-Eicosapentaenoic Acid, C20:5n3	0.03	-
Cis-4,7,10,13,16,19-Docosahexaenoic Acid, C22:6n3	0.07	-
Fatty Acid Total	77.42	89.53

Table 4. Fatty acid composition of various fat sources as a percentage of total fatty acids (taken from various sources

Fat sources	C10:0	C12:0	C14:0	C16:0	C16:1	C18:0	C18:1	C18:2 n-6	C18:3 n-3	C20:1	C22:1	C20:5 n-3	C22:5 n-3	C22:6 n-3
Animal Fats														
Poultry fat	-	0.1	0.1	15	2.4	5.4	31	37	4.4	-	-	-	-	-
	-	-	-	14	26	35	41	60	-	-	-	-	-	-
Tallow	-	-	2.1	27	2.5	19	35	4.9	4.3	-	-	-	-	-
	-	-	15	28	14	14	52	85	-	-	-	-	-	-
Lard	-	-	1.8	27	2.3	17	39	11	1.0	-	-	-	-	-
	-	-	72	81	49	7	11	12	-	-	-	-	-	-
Cow milk	3.75	3.9	10	23	2.6	7	24	2.5	1.2	-	-	-	-	-
	27	53	57	44	46	45	26	40	-	-	-	-	-	-
Sow milk	-	-	4	33	11	1.8	35	12	0.3	-	-	-	-	-
	-	-	71	60	-	10	20	26	-	-	-	-	-	-
Fish oil														
Anchovy oil	-	-	7.2	17	11	3.9	12	1.1	0.8	1.9	1.4	18	1.5	9.0
	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cod liver oil	-	-	62	13	7.4	1.6	20	0.9	0.5	11	4.6	11	1.4	11
	-	-	44	42	30	13	15	33	-	19	28	44	60	74
Menhaden oil	-	-	99	21	12	3.3	14	1.1	0.8	1.9	0.7	13	1.7	7.9
	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Herring	-	-	6.2	13	7.5	1.1	13	1.1	0.7	15	22	6.8	0.8	5.8
	-	-	50	58	30	33	29	42	-	11	7	72	60	86
Salmon oil (wild)	-	-	5.3	16	9.3	3.3	15	3.4	1	8.4	5.5	17	2.5	13
	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sardine oil	-	-	6.7	19	8.8	3.4	14	1.1	3.2	3.2	3.8	17	25	16
	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Based on the fatty acid composition of animal fats presented in Table 4, comparison with the results of this study indicates that the Black-Naped Fruit Dove has a more comprehensive omega-3 profile. Among the five types of animal fats (poultry fat, lard, tallow, cow milk, and sow milk), the Black-Naped Fruit Dove meat contains three polyunsaturated fatty acids, also known as long-chain unsaturated fatty acids: Eicosapentaenoic Acid (EPA) (C20:5-n3), Docosahexaenoic Acid (DHA) (C22:6-n3) and α-Linolenic Acid (Octadecatrienoic Acid) (C18:3-n3). In contrast, the meat from the aforementioned animals only contains one omega-3 fatty acid, namely α-Linolenic Acid (Octadecatrienoic Acid) (C18:3-n3). Insufficient essential fatty acids can lead to growth retardation, reduced reproductive capacity, and decreased resistance (Nwachukwu, 2020). The chemical structure of saturated fatty acids (SFA), which lack double bonds, distinguishes them from other fatty acids (Chen & Liu, 2020). Meanwhile, unsaturated fats are classified into monounsaturated fats (MUFA), which have one double bond, and polyunsaturated fats (PUFA), which have at least two double bonds (Sartika, 2008).

Amino Acid Content of Ptilinopus melanosphila and Chalcophaps indica

Table 5 illustrates the Black-Naped Fruit Dove meat has a more comprehensive amino acids, encompassing both essential and non-essential amino acids, in comparison to the Common Emerald Dove meat, both in terms of total amino acid content and amino acid composition. Glutamic acid emerges as the most abundant amino acid (Jang et al., 2024).

Table 5. List of Amino Acids found in the Black-Naped Fruit Dove and the Common Emerald Dove meat

Component	WAS (Ptilinopus melanosphila)	WTT (Chalcophaps indica)
Amino Acids		
Aspartic acid	1.51	1.47
Glutamic acid	2.87	2.46
Serine	0.53	0.60
Histidine	0.11	0.40
Glycine	0.64	0.82
Threonine	0.41	0.74
Arginine	1.57	1.10
Alanine	1.15	0.97
Tyrosine	0.87	0.52
Methionine	0.64	0.44
Valine	0.93	0.91
Phenylalanine	0.83	0.69
I-leucine	0.90	0.86
Leucine	1.67	1.35
Lysine	1.00	1.36
Total Amino Acids	15.64	14.68

The Black-Naped Fruit Dove has a total amino acid content of 15.64, while the Common Emerald Dove registers at 14.68. Glutamic and aspartic acids play crucial roles in nerve transmission (Wrońska et al., 2024), as they are both present in the brain (Kaya et al., 2024). Glutamate accounts for approximately 75% of nerve transmission in the brain (de Bartolomeis et al., 2022). The body heavily relies on protein for numerous functions(Lin et al., 2024), as amino acids, the building blocks of protein, participate in the body's metabolic processes (Ruocco et al., 2023). Proteins are composed of essential and non-essential amino acids.

Conclusion

Based on comparative data from proximate analysis, the protein content in the Black-Naped Fruit Dove thigh meat surpasses that of free-range chickens, purebred chickens, and ducks, while also showing lower fat content. Moreover, the Black-Naped Fruit Dove breast meat has lower fat content compared to purebred chickens and free-range chickens, although ducks and Muscovy ducks have even lower fat content. Based on the analysis on the fatty acid composition of animal fats, the Black-Naped Fruit Dove has a more comprehensive omega-3 profile in comparison to the five types of animal fats (poultry fat, lard, tallow, cow milk, and sow milk). The Black-Naped Fruit Dove meat contains three polyunsaturated fatty acids, also known as long-chain unsaturated fatty acids: Eicosapentaenoic Acid (EPA) (C20:5-n3), Docosahexaenoic Acid (DHA) (C22:6-n3) and α-Linolenic Acid (Octadecatrienoic Acid) (C18:3-n3). In contrast, the meat from the aforementioned animals only contains one omega-3 fatty acid, namely α-Linolenic Acid (Octadecatrienoic Acid) (C18:3-n3). The limitations of this study include the utilization of only six samples, encompassing three types each, and the focus solely on breast meat. The restricted sample size was due to the challenges in capturing these wild animals; nonetheless, these samples were deemed suitable for the study. The novelty of this study lies in the discovery or establishment of a meat quality profile of the Black-Naped Fruit Dove and Common Emerald Dove, a topic hitherto unexplored, particularly regarding the essential nutritional content of omega-3 polyunsaturated fatty acids (n-3 PUFA) in Ptilinopus melanospila and Chalcophaps indica meat. Consequently, the results are anticipated to serve as a foundation and raise awareness among stakeholders regarding the conservation of these species.

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Author Contributions

Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Writing – original draft; S. F.; Formal Analysis, Investigation, Methodology, Writing – original draft; T. D. N.,; Data Curation, Formal Analysis, Investigation, Writing – original draft, Writing – review & editing; S. U.,; Data Curation, Formal Analysis, Investigation, Writing – original draft, Writing – review & editing; R. S.; Data Curation, Formal Analysis, Investigation, Writing – original draft, Writing – review & editing; A. S. L.

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Conflicts of Interest

The authors declare no conflict of interest.

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