Journal of Agripreneurship and Sustainable Development (JASD)
www.jasd.daee.atbu.edu.ng; Volume 3, Number 3, 2020
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

NUTRITIONAL CHARACTERIZATION OF *COLUMBA LIVIA DOMESTICA* (DOMESTIC PIGEON) AND *COLUMBA GUINEA* (SPECKLED PIGEON) MUSCLE TISSUE MEAL AS POTENTIAL ANIMAL PROTEIN INGREDIENT IN AQUACULTURE

[1]Laurat, H. T., [2]Isiyaku, M. S., [2]Nasir, M. A. and [3]Umar, R.
[1]Department of Zoology, School of Life Sciences,
Modibbo Adama University of Technology, Yola, Nigeria
[2]Department of Fisheries and Aquaculture, Bayero University, Kano, Nigeria
[3]National Agricultural Extension Research and Liaison Services (NAERLS),
Ahmadu Bello University Zaria, Nigeria
Corresponding Authors' E-mail: ummeeirfan@gmail.com **Tel.:** 08030571980

ABSTRACT
The study was conducted to examine the Nutritional characterization of *columba livia domestica* (domestic pigeon) and *columba guinea* (speckled pigeon) muscle tissue meal as potential animal protein ingredient in aquaculture. The proximate composition, some mineral contents and amino acids profile were determined in *Columba liviadomestica* (domestic pigeon) and *Columba guinea* (speckled pigeon) found in Zaria, Kaduna State. The result showed significant difference in the whole weight between speckled pigeon (282.42 ±4.54) and domestic pigeon (272.66 ±8.71), gutted weight two avian species showed no significant difference ($P > 0.05$), domestic pigeon (201.50±4.10) had a higher gutted weight than speckled pigeon (180.68±6.34). There was significant difference in crude protein (66.70±0.70) content compared to speckled pigeon crude protein (62.18±0.32) contents. The ash content (4.51±0.14), crude fibre (0.82±0.17) and nitrogen free extract (9.82.±0.18) of speckled pigeon was lower than that of domestic pigeon with ash content (4.78±0.22), crude fibre (1.11±0.06) and nitrogen free extract (10.47±0.32). The study further disclosed significant difference in Mg, Na and K composition between the two columbid species; however; amino acid of both species did not differ significantly ($P>0.05$). In conclusion, speckled and domestic pigeon muscle tissues were rich in crude protein, mineral and amino acids and, therefore, recommended for use as a valuable inclusive component as animal protein sources in aquaculture feed industries.

Keywords: Aquaculture, *Columba guinea*, *Columba liviadomestica,* Fish nutrition, Nutritional Characterization.

INTRODUCTION
Aquaculture is rapidly growing globally, with over dependence on fishmeal as animal protein source in fish feed which can affect the sustainability of aquaculture in the nearest future, alternative animal protein sources are need to reduce the over dependence of fishmeal in the aquaculture feed industries this necessitated the nutritional characterization of two columbids muscle tissue (NRC, 2011). Aquaculture is rapidly growing globally, approximately half of global aquaculture production is from species that rely on feed input (NRC, 2011), and aquaculture has become a major global industry and an important source of income and food in many countries. Development of nutritious, efficient and cost-effective driven diets is a major challenge in aquaculture because the major animal protein (fishmeal) used in feed industries is very expensive for fish farmers to purchase due to over dependence on fishmeal and depletion in wild stock used in the fishmeal industry.

The nutritional quality of fish and shellfish are affected by various factors including genetic, seasonal and environmental factors, and most importantly nutrient quality of dietary components, this can cause variation in the nutritional quality of aquaculture product such fish (Alasalvar *et al*., 2002). Fish feed can be supplemented with protein and lipids riches source to make the body composition more favorable for human health because nutrition is the most important basic need, being a major determinant of health, labour, productivity and mental development. But in most developing countries of the world hunger and malnutrition are increasing due to food prices (FAO, 1980; and Pelletier *et al*., 1995).

To curb this challenge of over dependence on fish for fishmeal product in aquaculture feed industries, it is imperative to search for alternative animal and plant protein by nutrient characterization, searching for ingredient that can compete with the conventional fishmeal potentials in the fish feed industries, the columbid could proffer a lasting solution because they are readily available, could also be cultivated on a large scale with little or no resources required.

Among the columbid are speckled and domestic pigeons, belonging to the order Columbiformes and family Columbidae. There are five subfamilies within columbidae, 42 genera and 355 species, they originally originated from Europe and at present widely distributed all over the world (Johnston and Janiga, 1995). They are easily recognized and have a worldwide distribution (although they are not found in Antarctica) (Baptista *et al*., 1992; Dickinson, 2003; Lack, 2003; and Wells and Wells, 2001). Pigeon are primarily grain and seed eaters and will subsist on spilled or improperly stored grain. They also will feed on garbage, livestock manure, insect or other food materials provided for them intentionally or unintentionally by people. They require about 1ounce (30ml) of water daily (Gibbs *et al*., 2001). They range from solitary to extremely social, it is known that environmental diversification of the habitat of birds and their consecutive ways of nourishment, as well as the sorts of food they feed on constitute a source of great variety of the structure of their digestive tract (Dziala-Szczepanczyk and Wesolowskwa, 2008). If harnessed, could serve as an alternative protein to fishmeal, this prompted this study to nutritionally characterized *Columba livia domestica* (domestic pigeon) and C. *guinea* (speckled pigeon) muscle tissue meal as potential animal protein ingredient in aquaculture.

MATERIALS AND METHODS

The Study Area

The study area was Zaria, it lies the Northern Guinea savannah zone, within 11º 03′N, 07º 42′E, a region that has a tropical savannah climate with distinct wet (May to October) and dry (November to April) seasons. The mean annual rainfall is about 1,047 mm (Happold, 1987). The dusty, dry, cold harmattan wind is observed between November and January. Zaria is characterized mainly by open woodland vegetation (Hore, 1970; and (Adang *et al*., 2009)

Sample Techniques

Five (5) speckled pigeon (*Columba guinea*) were trapped from the wild with the assistance of an hunter, while five (5) domestic pigeon (*Columbia livia domestica*) were purchased from poultry market in Sabon-market Zaria, Kaduna-Nigeria, and Located within 09º 27′N, 05º 28′E, distance of about 2 km to Ahmadu Bello University Main Campus Samaru .Immediately after the birds were purchased, they were caged in a well-ventilated cages and transported to Department of Biology, Faculty of Life sciences, Ahmadu Bello University, Zaria.

Journal of Agripreneurship and Sustainable Development (JASD)
www.jasd.daee.atbu.edu.ng; Volume 3, Number 3, 2020
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

Experimental Design

Ten avian species of speckled pigeon and domestic pigeon five bird each were used for the study.

Sample Preparation

The body weight (live birds) of each bird species were obtained with a Digital Electronic balance. The birds were sacrificed with the birds on dorsal recumbence, an incision was made caudo-cranially from the vent to the shoulder joint on the lateral surface, the keel bone and associated muscles were reflected to the opposite side thereby giving access to the viscera (Hena *et al*., 2012). Then the oesophagus, crop, proventriculus, gizzard, small intestine, ceca and colon were exteriorized leaving the muscles behind. The flesh were washed thoroughly with saline water to remove blood and other dirty particles and oven dried at 40^0C for 96hours according to Maillard (1912), *Columba livia domestica* (domestic pigeon) labeled CLD1, CLD2, CLD3, CLD4 and CLD5, while *Columba guinea* (speckled pigeon) labelled SP1, SP2, SP3, SP4 and SP5.They were pulverized and stored in the air tight sampling bottles, with each portion for proximate, amino acids and mineral analysis.

Proximate Composition Determination

Pulverised muscle tissue samples of both birds were used for the analyses of crude protein (CP), crude fibre (CF), ether extract (EE), nitrogen free extract (NFE), ash and moisture content were determined according to the standard method of AOAC (1990).

Mineral Composition Determination

The ash residues were digested in HNO_3 with 50g/l of $LaCl_3$ (Larrauri *et al*., 1996). Mineral contents were determined using Air/Acetylene Flame Atomic Absorption Spectrophotometer (UNICAM 696 AA Spectrometer),

Amino Acid Profile Determination

The Amino Acid profiles in the samples were determined using methods described by Benitez (1989) and AOAC (2006). The known sample were dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Technicon sequential Multi-Sample Amino Acid Analyzer (TSM).

Analytical Techniques

Data obtained were subjected to statistical analysis, student independent T-test was used to compare the differences in the mean values of bird morphometric, proximate, minerals and amino acid profile of the two avian species using Microsoft excel 2013 package.

RESULTS AND DISCUSSION

The whole and gutted weight of domestic pigeon and speckled eye pigeon is presented in Table 1. Domestic pigeon and speckled eye pigeon mean whole weight (wet weight in gram) were (282.42 ± 4.58) and (272.66 ± 8.71) while gutted weight of speckled pigeon were (180.68 ± 6.34) and (201.50 ± 4.10), respectively. The whole weight of the two culimbids differed significantly ($P<0.05$), however there was no significant difference ($P>0.05$) in gutted weight. In this present study, the difference in weight of birds may have resulted from food availability and differences in nutrient of food composition of both birds, the whole weight of the speckled recorded in this study was higher than that reported by Deborah (2014) on *Columba livia* (272.02±13.1). this was however was similar to that of domestic pigeon reported in the study, thus the difference in speckled pigeon weight could be as a result of chances or feeding range of the feral pigeon with less disturbed human activities in the wild as they are known to be wild species while domestic pigeon as domesticated pigeon.

Journal of Agripreneurship and Sustainable Development (JASD)
www.jasd.daee.atbu.edu.ng; Volume 3, Number 3, 2020
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

Table 1: Some Morphometric of Speckled and Domestic Pigeon

Bird Morphometric	Speckled pigeon	Domestic pigeon	P value
Whole weight (g)	282.42 ± 4.54	272.66 ± 8.71	0.00
Gutted weight (g)	180.68 ± 6.34	201.50 ± 4.10	0.36

Mean ± SE with different, significantly different (P<0.05)

Proximate Composition of Domestic and Speckled Pigeon Muscle

The proximate composition of domestic and speckled pigeon muscle tissue in g/100g is presented in Table 2. Speckled eye pigeon and domestic proximate composition varied. The Fiber, moisture, crude protein content, ash, crude lipid and nitrogen free extract (NFE) in domestic pigeon were (1.11 ± 0.06), (4.94 ± 0.95), (66.70 ± 0.70), (4.78 ± 0.22), (16.54± 0.38) and (10.47 ± 0.32) while speckled pigeon were (0.82 ± 0.17), (5.22 ± 0.94), (62.18 ± 0.32), (4.51±0.14), (17.16 ± 0.11) and (9.82 ± 0.18), respectively. There was significant variation in crude protein of birds (P<0.05), however, fibre, moisture, ash, crude lipid and NFE were not significantly different in muscle tissue of the columbids. The proximate composition of the two avian species indicated a significant variation in crude protein; however other components did not differ significantly. The moisture content of these birds were higher than that reported in the flesh of *Columbia livia* by Deborah (2014), and lower than that reported by Pomianowski (2009) in the meat-type of pigeon squab (Wrocławski, King and Euro pigeon of 21 days old). The ash content was lower than that reported by Deborah (2014) and Wang (2005), but higher than that reported by Pomianowski (2009).

Table 2: Proximate Composition of Speckled and Domestic Pigeon Muscle Tissues

Proximate composition (g/100g)	Speckled pigeon	Domestic pigeon	P-value
Moisture content	5.22± 0.94	4.94 ± 0.95	0.85
Ash content	4.51 ± 0.14	4.78 ± 0.22	0.41
Lipid content	16.54± 0.38	17.16 ± 0.11	0.26
Crude fibre	0.82 ± 0.17	1.11 ± 0.06	0.24
Crudeprotein	62.18 ± 0.32	66.70 ± 0.70	0.02
NFE	9.82 ± 0.01	10.47 ± 0.32	0.21

Mean ± SE with different, significantly different (P<0.05), NFE = Nitrogen free extract

Lipid content differed significantly with that reported by Pomianowski (2009) on muscle of king and euro-pigeon and also not within range as that reported by Akpalu (2007) and Jurgens (2002) reported on chicken flesh as well as Wang (2005) on pigeon meat, it was also less than that reported by Deborah (2014) on *Columbia livia*. The crude protein was within range with that reported by Olawale (2006) on male and female *Columbia guinea* flesh which was higher than that reported by Deborah (2014), Pomianowski (2009), Wang (2005) reported on pigeon flesh similar to and higher than that reported by Akpalu (2007) and Jurgens (2002) on chicken meat. The nitrogen free extract of the two avian species showed slight difference, however not significant. The differences in crude protein observed between both birds and findings of other studies could probably due to differences in food composition, age, sex, state of digested food and captivity time.

Journal of Agripreneurship and Sustainable Development (JASD)
www.jasd.daee.atbu.edu.ng; Volume 3, Number 3, 2020
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

Amino Acids Profile of Speckled and Domestic Pigeon

Figure 1 shows the amino acids profile of speckled and domestic pigeon in g/100g protein, domestic pigeon muscle tissue had higher amino acid concentration than speckled pigeon, however, there was no significant difference (P>0.05) in amino acid concentration between the two birds. Glutamic acid was observed to have the highest concentration (speckled pigeon; 12.85, domestic pigeon; 13.57 g/100g) while Cysteine (speckled pigeon; 1.24, domestic pigeon 1.31g/100g) was observed to have the least concentration in the muscle tissue of the birds.

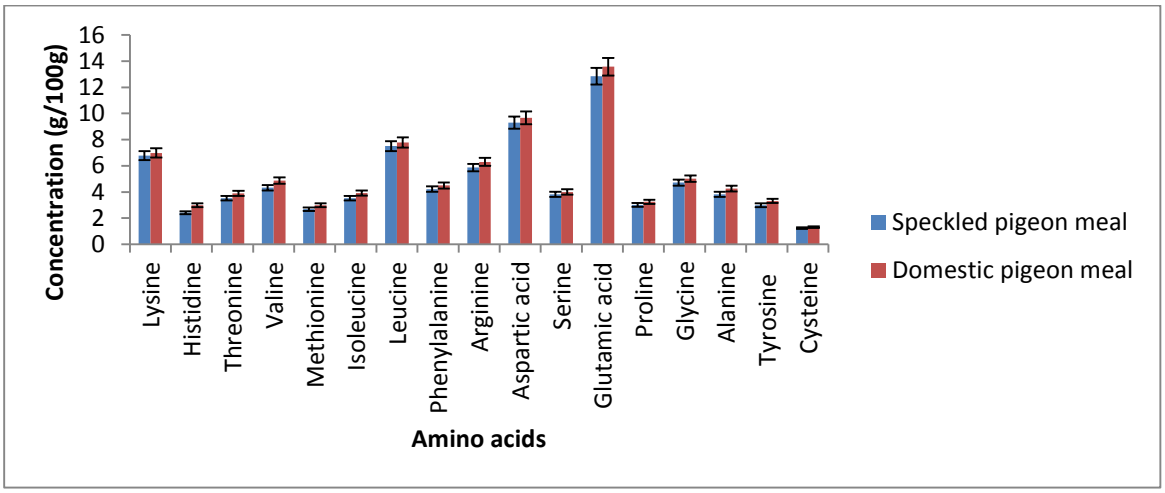

Figure 1: *Amino acid concentration in muscle tissue of speckled and domestic pigeon*

The amino acids profile of speckled and domestic pigeon, the composition of the amino acids in the two avian species show no significant difference, amino acid is known to be the building block of all protein molecules, the muscle tissue of both birds contain reasonable amount of amino acids which function in protein synthesis in the living systems. Both birds had appreciable concentration of essential amino acid (EAA) which were higher than National Research Council (NRC) channel catfish essential amino acid requirement, if incorporated into catfish feed could provide these amino acids, Campbell (2009) reported that histidine promotes growth and repairing of body tissues and the removal of heavy metal from the body, isoleusine help to increase endurance and help to heal and repair muscle tissue, leucine increases the production of growth hormone, lysine is needed for hormone production, methionine helps the body process and eliminate fat and phenylalanine is needed for normal functioning of the central nervous system, threonine plays a major role in the synthesis of purines, valine for growth and maintenance of body tissue while cysteine a sulphur amino acid can be used in place of methionine to synthesize protein. The presence of these amino acids in these birds muscle tissue gives them the potential to perform these functions.

Elemental Contents of Speckled and Domestic Pigeon

Figure 2 shows some elemental contents of speckled and domestic pigeon which were Manganese (Mn),Cobalt(Co) , Iron(Fe), Magnesium (Mg), Calcium (Ca), Zinc (Zn), Sodium (Na) and Potassium (K) with values 0.06, 0.07, 2.46, 7.32, 0.42, 7.79 and 8.03ppm for speckled pigeon while values 0.09, 0.03, 2.85, 17.44, 0.43, 20.00 and 19.05ppm for domestic pigeon, respectively. There was significant variation (P>0.05) in Mg, Na and K between both birds, domestic pigeon having significantly higher values compared to speckled pigeon.

Journal of Agripreneurship and Sustainable Development (JASD)
www.jasd.daee.atbu.edu.ng; Volume 3, Number 3, 2020
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

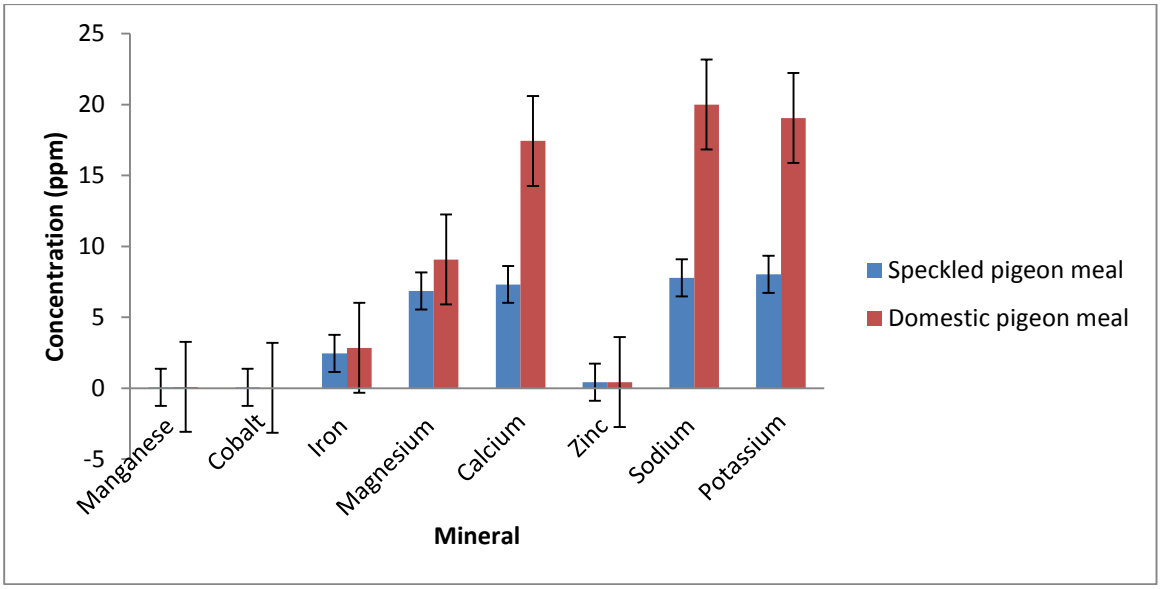

Figure 2: *Some mineral concentrations in muscle tissue of speckled and domestic pigeon*

With regards to the minerals composition of speckled and domestic pigeon with variation in different elements in the two avian species, the results (Figure 2) reveals that the speckled pigeon contain magnesium that was lower than that in domestic pigeon, the magnesium composition of these avian species were lower than that reported on raw pigeon squab meat (65.3mg/L) and that reported by Deborah (2014) on *Columbia livia* (22.47%). The Sodium composition of speckled pigeon was lower to that of the domestic pigeon and this which the two pigeon composition was in contrary to that reported by nutritional data on poultry product (Deborah, 2014 and Olawale, 2006). Potassium in domestic pigeon was higher than that of speckled pigeon; the feral pigeon composition was in contradictory to that reported in *Columbia livia* by Deborah (2014). The manganese composition of domestic pigeon was slightly higher to that in speckled pigeon and the value in domestic was almost the same to that of pigeon by nutritional data but in contrary to that pigeon composition reported in pigeon squab by nutritional data (737mg/L). Calcium in domestic pigeon was high and low in speckled pigeon which both values were lower than that reported in meat by Deborah (2014) on nutritional data on poultry product and Nacin *et al.* (2011) who reported Turkey liver to contain calcium of (31.4±0.3%) but the value of speckled pigeon in the study was similar to that reported by Mashaeir (2012) who reported calcium content of (8.88mg/dl) in speckled pigeon. Iron in domestic pigeon was slightly higher than that in speckled pigeon; both values were lower than that reported by Deborah (2014) on *Columbia livia* meat. There was no significant variation in Zinc value in the two avian species and both values were lower than that reported for pigeon squab by nutritional data and Deborah (2014). Cobalt was high in speckled pigeon than in domestic pigeon. Variation in the composition in this two avian species could be as a result of different feeding range and variety of food consumed, sample preparation or method and specificity of techniques of analysis of elements.

CONCLUSION AND RECOMMENDATIONS

The study concluded that speckled and domestic pigeon muscle tissue were characterized by high nutritional content, as domestic pigeon contains crude protein of 66.70 ± 0.70 and speckled pigeon 62.18 ± 0.32, high amino acids and minerals composition. The muscle

tissue of speckled and domestic pigeon differ significantly in crude protein, Mg, Na and K, however, there is no significant difference in the amino acids composition of both birds. It was recommended that the poultry feed industries should key into the use of muscle tissue of speckled and domestic pigeon since it has potentials in aquaculture feed formulation in order to reduce cost and increase nutrients composition of supplement diets.

REFERENCES

Adang, K. L., Oniye, S. J., Ezealor, A. U., Abdul, P. A., Ajanusi, O. J. and Yoriyo, K. P. (2009). Ectoparasites and Intestinal Helminths of Speckled Pigeon (*Columbia guinea* Hartlaub and Finsch 1870) in Zaria, Nigeria. *Science World Journal*, **4**(2): 1-5.

Akpalu, W., Muchapondwa, E. and Zikhali, P. (2007). *Can the restrictive harvest period policy conserve mopane worms in southern Africa? A bio-economic modelling approach.* University of Pretoria, working, 65: 1-11.

Alasalvar, C., Taylor, K. D. A., 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 Chemistr,* **79**: 145 – 150.

Association of Official Analytical Chemicals. (1990). *Official Method of Analysis of the AOAC.* **In:** Arlington, V.A. Fifteen Edition, 1298.

Association of Official Analytical Chemicals. (2006). *Official Method of Analysis of the AOAC.* **In:** W. Horwitz. Eighteen Edition, Washington; D. C.).

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

Baptista, L., Trail, P. and Horblit, R. (1992). *Family Columbidae (Pigeons and Doves)*. In: del Hoyo. Elliolt, J. Sargatal, editions. Handbook of the Birds of the World, Volume 4. Barcelona; Lynx Editions. Pp.60-243.

Benitez, L.V. (1989). *Amino acid and fatty acid profiles in Aquaculture nutrition studie.* **In**: S. S., De Silva (ed.). *Fish nutrition Reseach in Asia.*Proceedings of the third Asian Fish nutrition Network meeting. Pp.23-35.

Campbell, M. G. (2009). *The Nine Essential Amino Acids.* Pp.1-6, http://campbellmgold.com. Deborah, P. (2014). Proximate, Physical and Mineral compositions of Pigeon meal used as fish Bait. Sri paramakalyani centre for Environmental Sciences, Manonmaniam Sundarnar University, Alwarkurichi, Tamil Nadu. *Journal of Chemical and Pharmaceutical Research*, **6(**1): 669-673

Dickinson, E. (2003). *The Howard and Moore Complete Checklist of the Birds of the World.* 3rd edition. London; Christopher Helm.

Dziala-Szczepanczyk, E. and Wesolowskwa, I. (2008). Morphometric Characteristics of Esophagus and Intestine in tufted Ducks (*Aythya fuligula*) wintering on the Baltic coastal area in North-Western Poland. *Electronic journal of polish Agriculture Universities*, **111**(14): 1-35.

FAO (1980). *State of food and agriculture*. Food and Agriculture Organization in Developing Countries. Rome, Italy.

Gibbs, D., Barness, E. and Cox, J. (2001). *Pigeons and Doves: a Guide to the Pigeons and Doves of the World.* Sussex: Pica Press

Happold, D. C. D. (1987). *The Mammals of Nigeria*. Clarendon Press, Oxford. Pp 46.

Hena, S. A., Sonfada, M. L., Danmaigoro, A., Bello, A. and Umar, A. A. (2012). Some Comparative Gross and Morphometrical Studies on the Gastrointestinal Tract in Pigeon

(*columbia livia*) and Japanese quail (*coturnix japonica*). *Scientific Journal of Veterinary Advances*, **1**(2): 57-64.

Hore, P. N. (1970). *Weather and climate of Zaria.* **In:** Zaria and its Regions. Pp.46.

Johnston, R. F. and Janiga, M. (1995). *Feral Pigeons.Possible Relevance of Pigeons as an Indicator Species for Monitoring Air Pollution*. Oxford University Press, New York, USA. Pp.319.

Jurgens, M. H. (2002). *Animal feeding and Nutrition*. 9th Edition. Kendall/ Hunt publishing company. IOWA. Pp 104-107.

Lack, P. (2003). *Pigeons and Doves*. In current perrins edition. The New Encyclopedia of Birds. Oxford: Oxford university press. Pp.288-295.

Larrauri, J. A., Rupe´rez, P., Borroto, B. and Saura-Calixto, F. (1996). Mango peels as a new tropical fiber: Preparation and characterization. *Lebensm. Wiss. Technol*., **x**(29): 729-733.

Maillard, Y. (1912). *Maillard Reaction Products in Processed Food*: *Pros and Cons, Food IndustrialProcesses - Methods and Equipment.* Deborah. Markowicz Bastos, Érica Monaro, Érica Siguemoto and Mariana Séfora (2012), Dr. Benjamin Valdez (Ed.).

Nacin, Z., Nahed, F., Wafa, B. A. D., Mohamed, S., Lotfi, M. and Ayadi, M. A. (2011). Comparative embryotoxicity and proteotoxicity of three carrier solvent to zebra fish (*Daniorerio*) embryos. *Ecotoxicol. Environ. Saf.* **63**: 378-388.

National Research Council (2011). *Committee on the Nutrient Requirements of Fish and Shrimp. Nutrient requirements of fish and shrimp.* Washington, DC: National Academies Press.

Olawale, A., Wakilu, A., Yomi, A. and Patricia, A. (2006). Effect of oral administration of glucans on the resistance of gilthead seabream to pasteurellosis. *Aquaculture*, **219**: 99-109.

Pelletier, D. L., Frongillo, E. A., Schroeder, D. G. and Habicht, J. P. (1995). The Effect of Malnutrition on Child Mortality in Developing Countries. *Bull World Health Organization*, **3**: 443-448.

Pelletier, David L., Frongillo E. A., Edward A., Schroeder, D. G. and Habicht, J. P. (1995). The Effects of malnutrition on child mortality in developing countries. http://www.who.int/iris/handle/10665/47438.

Pomianowski, J. F., Mikulski, D., Pudyszak, K., Cooper, R. G., Angowski, M., Jóźwik, A. and Horbanczuk, J. O. (2009). Chemical composition, cholesterol content, and fatty acid profile of pigeon meat as influenced by meat-type breeds. *Poultry Science*, **88**: 1306-1309.

Wang, D., Zhaisw, Z., Zhang, X., Bai, Y. Y., An, S. H. and Xu, Y. N. (2005). Evaluation of Nutritional value of field Cricket as a Poultry feedstuff. Asian-Australia, *Journal of Animal Science*, **18**: 667-670.

feedstuff. Asian-Australia, *Journal of Animal Science*, **18**: 667-670.

Wells, J. and Wells, A. (2001). *Pigeons and Doves.* **In**: current Elphick, J. Duning, D. Sibbey editions. The Sibley Guide to Bird Life and Behaviour. New York: Afred A. Knopt. Pp.319-325.