American Journal of Food Science and Technology, 2020, Vol. 8, No. 1, 36-41
Available online at http://pubs.sciepub.com/ajfst/8/1/5
Published by Science and Education Publishing
DOI:10.12691/ajfst-8-1-5

Pigmeat Consumption Survey and Impact of Algo-Bio® (Alternative to Antibiotics) in Pig Food on Meat Nutritive Quality in Côte d'Ivoire

KONE Tadiogo Naty Amine[1,*], AKPRO Lathro Anselme[2], ADINGRA Kouassi Martial-Didier[3], GBOGOURI Grodji Albarin[2], GUESSENND Kouadio Nathalie[4], DADIE Adjehi[1]

[1]Laboratory of Biotechnology and Microbiology, Department of Food Science and Technology, Nangui Abrogoua University, Abidjan, Côte d'Ivoire.
[2]Laboratory of Nutrition and Food Safety, Department of Food Science and Technology, Nangui Abrogoua University, Abidjan, Côte d'Ivoire.
[3]Laboratory of Food Biochemistry and Tropical Processing, Department of Food Science and Technology, Nangui Abrogoua University, Abidjan, Côte d'Ivoire.
[4]Department of Bacteriology-Virology, National Reference Center for Antibiotics, Institut Pasteur of Côte d'Ivoire, Abidjan, Côte d'Ivoire
*Corresponding author: natykone@yahoo.fr

Received December 25, 2019; Revised February 04, 2020; Accepted February 21, 2020

Abstract Bacterial resistance to antibiotics is a worrying situation in breeding which lead public health risk. So, the use of seaweed-based food supplements is attracting increasing attention because it is a alternative to antibiotics. The purpose of this paper is to determine the impact of pigs algae-food supplement on meat nutritive quality. Pig consumption survey has been achieved with 400 consumers in Abidjan. Biochemical properties of meat from control, Algo-Bio® treated pigs and those treated with tetracycline were determined using standard analytical methods. Organoleptic characteristics of each meat were determined by hedonic test. According to survey, 110 consumers prefers ribs making this part the most valued. Rib were used for physico-chemical and organoleptic characteristics determination. In Algo-Bio® treated pigs, ash (1.1%) and protein (23.6%) levels were high compared to others. Fat levels were 6.1%, 6.9% and 5% respectvely for controls, Algo-Bio® treated pigs and those treated with tetracycline. Algo-Bio® treated pig's meat was least moisture (66.5%). Minerals were found in high amounts in pig treated with Algo-Bio®. These pigs meat were the most appreciated and obtained highest scores in hedonic test (7.9 for flavor, 7.3 for tenderness and 8.1 for juiciness). The *Longissimus thoracis* muscles of pigs whose diet has been supplemented with algae-based food supplement have good nutritive and organoleptic characteristics compared to those treated with tetracycline.

Keywords: *pigs, Algo-Bio®, Longissimus thoracis, meat, quality, nutritive, tetracycline*

Cite This Article: KONE Tadiogo Naty Amine, AKPRO Lathro Anselme, ADINGRA Kouassi Martial-Didier, GBOGOURI Grodji Albarin, GUESSENND Kouadio Nathalie, and DADIE Adjehi, "Pigmeat Consumption Survey and Impact of Algo-Bio® (Alternative to Antibiotics) in Pig Food on Meat Nutritive Quality in Côte d'Ivoire." *American Journal of Food Science and Technology*, vol. 8, no. 1 (2020): 36-41. doi: 10.12691/ajfst-8-1-5.

1. Introduction

Antibiotics are used in animal food to treat clinical disease, prevent and control common diseases events, and enhance animal growth [1,2,3]. The different applications of antibiotics in animals fods have been described as therapeutic use, prophylactic use, and subtherapeutic use. However, the use of these substances exerts a selection pressure that promotes the survival of resistant bacteria in the different flora of animals [4,5,6]. These resistant bacteria from animal can be transmitted to humans through contact with animals, their environment or by food and transfer resistance genes to commensal and infectious bacteria of human origin [7,8]. The resistance of microorganisms to antimicrobials, and in particular bacterial resistance to antibiotics is a worrying situation worldwide because it poses a public health risk. Faced with this phenomenon, the search for new active molecules has become a necessity. As a result, the use of seaweed-based food supplements in livestock farming is attracting increasing attention because it is promising natural alternative to antibiotics in preventive breeding and promotes sustainable animal feeding.

Supplement's food are defined as foodstuffs meant to complete the normal diet and which are concentrated sources of nutrients or other substances with a nutritional

or physiological effect, alone or in combination [9]. Supplement's food may consist of vitamins and minerals, substances for nutritional or physiological purposes, plants or plant preparations which must lead to the manufacture of safe products which are not harmful to the health of consumers [10]. The biologically active compound of algae include proteins, polyunsaturated fatty acids, pigments, polyphenols, minerals, vitamins, and polysaccharides. The algae-based food supplement (Algo-Bio®) is essentially composed of sulphated polysaccharides of marine origin (MSP) extracted from green algae (*ulva lactuca*) which provide a health benefit to the animal [11]. These effects are reflected in a beneficial physiological action on animals respiratory and digestive systems and in stimulation of immunity, which limits antibiotics use in livestock farming [12]. Algae have long been used in animal feed as liquid or solid food supplements to improve animal health performance [13]. They also improve the animal's growth by stimulating feeding [14] and is a natural prophylactic alternative to the use of antibiotics in pig farming. This study explores one aspect of it, based on impact of Algo-Bio ® food supplement use in pig farming, an area in full expansion in Côte d'Ivoire, on nutritional quality and organoleptic caracteristics of meat in comparison with those treated with tetracycline, most used in pig farm in Côte d'Ivoire.

2. Material and Methods

2.1. Study Areas

The study was conducted in Adiopodoumé areas, a city in the district of Abidjan (Côte d'Ivoire) from March 2018 to October 2018 on a semi-intensive livestock system farm. Indeed, Adiopodoumé areas has a high concentration of pig farms.

2.2. Breeding and Treatement of Piglets

The piglets use for breeding was aged 8 weeks, recently weaned. They had a good health and never administered with antibiotics. So, 3 batches (A, B and C) containing 2 piglets each was constituted. Piglets in batch A were used as controls and did not receive any treatment. The piglets in batch B were administered with an algae-based feed supplement (Algo-Bio® Searup Still) in drinking water at a dose of 0.5 mL/10 Kg of weight for five days with an interval of 15 days during the conduct of the farm. Then, piglets in batch C were administered with tetracycline at times of need in drinking water at a dose of 1 g/5 L of water. At 36 weeks of age, the meat from these three batches of pigs was used to determine the physico-chemical and organoleptic characteristics.

2.3. Survey on Pig Consumption

A consumption survey was conducted to identify the part of pig's meat most consumed and the most used cooking methods by the population in Abidjan. Four reference sites for the marketing of fresh pork meat were selected for the survey. They are Bingerville (Bangui district), Yopougon (Gabriel gare district), Marcory (Carrefour Kaïra) and Abobo (Belle-ville district). 400 people of which 100 by site selected were interviewed. It is about of transversal and descriptive survey which been with a questionnaire.

2.4. Nutritional Characteristics of Pig's Meats

2.4.1. Assessment of Macronutrients Contents

The physicochemicals assessment has been done on the parts more consumed of the pork meat according to the consumption investigation. Indeed, in laboratory, each pork meat sample of batches A, B and C was washed dissected into small pieces and were ground in the blender. Moisture, protein, fat, and ash contents of frog meat samples were determined following the standard procedures. The moisture content were determined according AOAC method [15] by drying 3 g of ground sample at 105°C until the weight became constant. Each value was an average of three measurements. The crude ash was carried out by incineration of 1 g of ground sample in an oven at 550°C for 6 hours until the weight became constant . For the determination of crude protein, 1 g of ground sample was used according to BIPEA method [16] using Kjeldahl. The protein content from each sample was expressed by multiplying the nitrogen content by a conversion factor (6.25). Crude fat was extracted by Soxhlet method according to AOAC. About 10 g of ground sample was introduced into a cartridge and then introduced into an extractor. Then, 300 ml of hexane are introduced into a pre-weighed flask. The extraction was done at the solvent reflux for 6 hours. After 6 hours, the extraction flask is removed from the Soxhlet apparatus and the solvent evaporated on a rotary evaporator. The flask containing the fat is dried in an oven at 70°C for 12 hours and weighed. All samples were done in duplicate and result expressed as average of each element.

2.4.2. Minerals Analysis

Minerals determined in this study were calcium, potassium, phosphorus, magnesium, iron, zinc and selenium. The determination of minerals was carried out by atomic absorption spectrometry flame AAS 20 VARIAN. About 1 g of dried sample was placed in the crucible and then pre-calcined at 200°C for one hour, the calcined at high temperature 550° C for 6 hours in an oven until the obtaining a white ash. After cooling, 5 ml of nitric acid (HNO3 6M, 1 N) was added to the resultant ashes, and the mixture was stirred on a hotplate until dryness. Then 5 ml of the nitric acid (HNO3 3M) was added to the residue and the mixture was placed again in an oven for 30 min. The residue was recovered in 10 ml of hydrochloric acid and then placed in flask. The elements contained in the solution were determined by Atomic Absorption Spectrometry.

2.5. Organoleptic Characteristics of Meat from Lots A, B and C

Organoleptic characteristics of each meat (from batches A, B and C) were determined by a hedonic test, aimed at assessing the taster's level of satisfaction or appreciation. Naïve subjects, constituting a jury of 60 members, were

selected at random (ISO standard NF 1136 V09-031) [15] among potential consumers of pig. These meats have been boiled in water and grilled without seasoning. For each batch and cooking method, the samples were treated separately. Each judge received all three samples in identical containers, coded with random numbers. A sensory evaluation sheet was filled out after tasting by each panelist. A scale of categories ranging from "extremely pleasurable" to "extremely unpleasant" was used. The sensory attributes that were retained during this study are flavour, juiciness and tenderness. Finally, each of the judges gave their overall assessment according to their preference.

2.6. Statistical Analysis

Descriptive statistics (frequency, mean, standard deviation) were used for the quantitative variables. An analysis of variance (ANOVA test) was carried out with the XLSTAT software version 2017 to study the degree of difference between the variables with a significance threshold (α) of 0.05.

3. Results and Discussion

3.1. Survey on Pig Consumption

3.1.1. Characteristics of Pork Meat Consumers

The majority of people interrogated in consumption survey was female (76%). The proportion of out-of-school consumers was 25.7%, those with primary, secondary and tertiary education were 27.5%, 25% and 21.7% respectively. In addition, the pork meat is more consumed by people aged 19 to 45 years (Table 1).

3.1.2. Most Consumed Parts of Pig

The survey showed that 110 persons from the 400 interviewed consumers preferred the ribs making this part the most favorite. Then, 89, 63 and 51 consumers prefered respectively ham, head and paws. Pork meat consumption survey is shown in Table 2.

3.1.3. Most Used Cooking Methods According to Survey

Cooking methods in sauce, frying, braised or grilled, oven and others (combinations of two cooking process) of pig were identified during the investigation. The majority of consumers (113 people) have preference for cooking in sauce, followed by 99 people for grilling (Figure 1).

Table 1. Characteristics of pork meat consumers

Characteristics	Number of consumers (n = 400)	Percentage (%)
Sex of consumers		
Male	96	24
Female	304	76
Educational level of consumers		
Uneducated	103	25,7
Primary school level	110	27,5
Secondary school level	100	25
University graduate	87	21,7
Age of consumers		
≤ 18 ans	48	12
19 - 45 ans	306	76,5
46 - 59 ans	39	9,7
≥ 60 ans	7	1,7

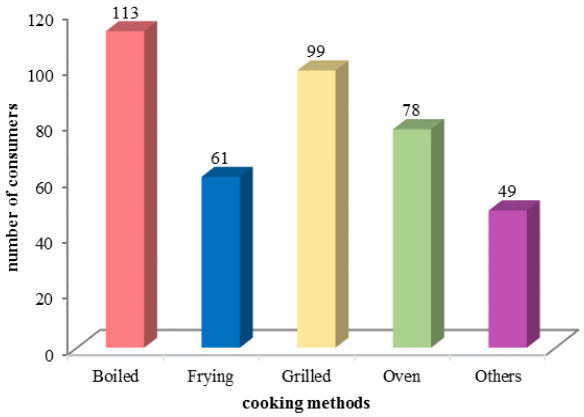

Figure 1. Methods of pigs cooking by surveyed consumers

3.2. Nutritive Contents of Pork Meat (Muscle *Longissimus Thoracis)*

3.2.1. Chemical Composition of *Longissimus Thoracis* Rib Muscles

Ash and protein contents were relatively high in *Longissimus thoracis* pigs treated with Algo-Bio® (1.1% and 23.6%) and in control pigs (0.7% and 14.9%) par rapport à ceux observés chez les porcs traités avec la tétracycline (0.6% and 13.9%). Fat levels were significantly different (6.1% for controls pigs, 6.9% for those treated with Algo-Bio® and 5 for tetracycline treated pigs). In addition, the meat of pigs treated with Algo-Bio® was the least moist with 66.5% fresh weight (Table 3).

Table 2. Pork meat consumption survey

	Parts of pig							
Survey Sites	ribs	knuckle	shoulder	Ham	Chest	Head	Paws	Others
Yopougon	21	13	09	29	07	08	11	02
Koumassi	40	01	05	25	0	13	08	08
Abobo	31	0	0	16	02	27	19	05
Bingerville	18	06	08	19	15	15	13	06
Totals	110	20	22	89	24	63	51	21

Table 3. Chemical composition of *Longissimus thoracis* muscles of pigs

Parameters	Chemical composition (%FW)		
	Control pig	Algo-Bio® treated pig	Tetracycline treated pig
Moisture	68,5 ± 0,65[b]	66,5 ± 0,44[c]	70,7 ± 0,67[a]
Ash	0,7 ± 0,01[b]	1,1 ± 0,18[a]	0,6 ± 0,04[b]
Fat	6,1 ± 0,15[b]	6,9 ± 0,05[a]	5 ± 0,35[c]
Proteins	14,9 ± 1,31[b]	23,6 ± 0,85[a]	13,9 ± 0,08[b]

In a row, means values followed by different superscript are statistically different (P < 0.05), *FW: fresh weight

3.2.2. Mineral Composition of *Longissimus Thoracis* Muscles of Pigs

The mineral composition of the meat indicates that the mineral values are relatively high in the meat of the pig treated with Algo-Bio®. Potassium, phosphorus, iron, zinc and selenium were found in high amounts in Algo-Bio®-treated pig compared to meat from control and tetracycline treated pigs (Table 4).

Table 4. Mineral composition of *Longissimus thoracis* muscles of pigs

	Mineral composition		
	Control pig	Algo-Bio® treated pig	Tetracycline treated pig
Calcium (mg/100 g)	7,1 ± 0,15[b]	7,7 ± 0,25[a]	6,7 ± 0,14[b]
Potassium (mg/100 g)	338,7 ± 1,48[b]	397,9 ± 2,81[a]	339,5 ± 1,74[b]
Phosphorus (mg/100 g)	210,5 ± 0,48[b]	252,5 ± 2,65[a]	199 ± 1,81[c]
Magnesium (mg/100 g)	25,4 ± 0,34[b]	27 ± 0,10[a]	23,5 ± 0,57[c]
Iron (mg/100 g)	0,7 ± 0,01[b]	1,3 ± 0,15[a]	0,7 ± 0,04[b]
Zinc (mg/100 g)	2,9 ± 0,06[b]	3,3 ± 0,15[a]	1,8 ± 0,26[c]
Selenium (µg/100 g)	11,3 ± 0,17[b]	19,8 ± 1,41[a]	17,9 ± 0,82[a]

In a row, means values followed by different superscript are statistically different (P < 0.05)

Animals characteristics and their husbandry conditions determine the nutritional qualities of the meat. Chemical analysis of ribs muscles showed that the meat of pigs treated with Algo-Bio® had a high proteins and ash contents compared to the control and tetracycline pig's meat. Indeed, the proteins content in the meat of pigs treated with Algo-Bio® was 22.9%. These important contents proteins in the meat could be explained by the consumption of Algo-Bio® by the piglets. In fact, Algo-Bio® is a dietary supplement rich in amino acids. Amino acid composition of food ration, including the content of essential amino acids, would affect animal growth and the relative proportions of lean and fatty tissues. Amino acids are foremost building blocks allowing protein synthesis. They are known as anabolic factors, which induce protein gain by stimulating protein synthesis while inhibiting protein degradation. These effects on protein renewal have been demonstrated in mammals in the work of Tesseraud et al. [17] and Hocquette et al. [18]. The amount of protein in the meat therefore depends on the supply of amino acids in the feed of the animals in breeding. Studies conducted by Culioli et al [19] shows that amino acids thus play an essential role in regulating metabolism, growth, development, immune response and more broadly animal health. Algo-Bio® would give meat a high protein value with an amino acid content appropriate to human needs. In addition, meat from the Algo-Bio® treatment had low moisture contents. There was no significant differences between the fat content in the meat of the control pigs and those treated with the food supplement. Then, there is a direct relationship between the fatty acids composition provided to pig food and those assessed in the meat. Therefore, it is possible to use this relationship to introduce into pig feed fatty acids considered good for human health, or even essential to cover its needs in order to find them on the consumer's plate. Pigs, as monogastric animals, have the particularity of directly storing fatty acid intakes in fatty and muscular tissues [20,21]. Algae are rich in polyunsaturated fatty acids, especially omega 3 and omega 6 acids. It appears that the contribution of the seaweed-based food supplement (Algo-Bio®) in the pig diet could provide good fat for meat and health benefits for consumers. Indeed, omega 3 and omega 6 acids play an important role in the prevention of cardiovascular disease, osteoarthritis and diabetes [22,23]. Moisture varied between muscles and inversely with respect to fat content. The low moisture levels of the meats resulting from the treatment with the food supplement would make it possible to avoid too rapid a deterioration of these meats. According to Feiner [24], low moisture reduces the risk of enzymatic alteration reactions and inhibits the growth of microorganisms. The meat of pigs treated with Algo-Bio® showed higher proportions of ash compared to other pigs. According to Sika et al. [25], the ash content is an indicatory of the mineral composition in a food. Therefore, ash contents would indicated if pork meat is rich or poor in mineral elements. The meat of pigs treated with the food supplement was rich in minerals. Mourot and Hermier [26] showed in their study on the modulation of pig quality through food, that the mineral content of meat is related to animal feed. Ashes from meat samples have been used to quantify some essential minerals to humans, including calcium, potassium, phosphorus, magnesium, iron, zinc and selenium. The meat of pigs whose diet has been supplemented with Algo-Bio® has higher mineral content compared to controls animals. In fact, algae draw from the sea an incomparable wealth of mineral elements such as potassium, chlorine, calcium, magnesium, sulphur, phosphorus, iodine, iron, copper, manganese, zinc, selenium and molybdenum according to Viguerie et al. [27]. According to them, these micronutrients can also change the mineral content of the meat. However, it is the offal that best responds to supplementation, while the muscle compartment remains unaffected. This would explain the insignificant differences in some minerals, namely calcium, magnesium and iron, between meat samples. It appears from this study that pig ribs are a good source of potassium, phosphorus, calcium and zinc.

3.3. Organoleptic Characteristics of Boiled *Longissimus Thoracis*

The boiled meat of pork treated with Algo-Bio® was found to be the most tender with an average score of 7.3, the juiciest (8.1) with a good flavour (7.9). Statistical analysis showed no significant difference between flavour, tenderness and juiciness of boiled meat of control and that of pigs treated with tetracycline. Organoleptic

characteristics of boiled *Longissimus thoracis* are shown in Table 5.

Table 5. Organoleptic characteristics of boiled *Longissimus thoracis*

Parameters	Types of treatment		
	Control pig	Algo-Bio® treated pig	Tetracycline treated pig
Flavor	$6,4 \pm 1,46^{b}$	$7,9 \pm 0,90^{a}$	$6,2 \pm 1,76^{b}$
Tenderness	$6,6 \pm 1,53^{ab}$	$7,3 \pm 1,33^{a}$	$5,9 \pm 1,49^{b}$
Juiciness	$6,3 \pm 1,49^{b}$	$8,1 \pm 0,86^{a}$	$6,2 \pm 1,31^{b}$

In a row, means values followed by different superscript are statistically different ($P < 0.05$)

The results of hedonic tests revealed that meat from pigs treated with Algo-Bio® obtained the best scores with averages ranging from 6.6 to 8.2 for all descriptors assessed. This meat was judged to be tender, juicy with a good flavour by the panelists. These above-average scores, according to the hedonic scale, indicate that this meat was appreciated by a large number of panelists as a pleasant product. The appreciated flavour and juiciness (succulence) of this meat would be due to its high fat content. Indeed, the lipid fraction of the meat would be responsible for its good flavour (flavours and aromas) according to Coibion [28]. According to this author, flavour compound are released during the cooking of meat from flavour precursor molecules contained in fat. Algae richness in polyunsaturated fatty acids could also explain the good flavour of meat resulting from the treatment with the Algo-Bio® observed by the tasting panel. In addition, the work carried out by Oury et al. [29] showed that rations supplemented with lipids induce changes in the flavour of the meat. As far as jutosity is concerned, it depends on the amount of muscle juice released in the mouth at the beginning of chewing. It is accentuated by the stimulation of salivation due to the presence of intramuscular fat. Meat from tetracycline treatment received the lowest scores ranging from 4.3 to 6.3 by panelists. These relatively low scores would be explained by the low fat content observed in the muscles of these pigs, which would harm juiciness and tenderness perceived by consumer.

4. Conclusion

The nutritional quality of meat corresponds to its ability to satisfy human nutritional needs. Meat from pigs fed with the algae-based food supplement was high in proteins and minerals content compared to meat from control pigs. This gives these meats an interesting nutritional value for consumer. Meat from pigs treated with Algo-Bio® presented the best organoleptic qualities compared to meat from other pigs. Algo-Bio® use in pig farming is therefore a factor favouring a better control of antibiotic resistance risks and allows to offer consumers a good quality meat, offering organoleptic and nutritional benefits.

References

[1] Landers, T.F., Cohen, B., Wittum, T.E. and Larson, E.L., "A review of antibiotic use in food animals: perspective, policy, and potential", Public Health Reports 127, 4-22, 2012.

[2] Chardon, H. and Brugère, H., "Centre d'Information des Viandes (CIV) Usages des antibiotiques en élevage et filières viandes", 2014, 34 p.

[3] Gourmelen C, Royer E, Salaün Y., Impact d'une restriction de l'usage des facteurs de croissance antibiotiques sur le coût de production du porc. Journées Recherche Porcine en France, 33 : 291-298, 2001.

[4] Harbottle, H., Thakur, S., Zhao, S. and White, D,G., "Genetics of antimicrobial resistance", *Animal Biotechnology*, 17, 111-124, 2006.

[5] Wegener, H., "Antibiotic resistance-Linking human and animal health", in: Improving Food Safety through a One Health Approach: Workshop Summary, 2012, 418 p.

[6] Sorum H, Sunde M., Resistance to antibiotics in the normal flora of animals. Veterinary Research, 32: 227-41, 2001.

[7] Akujobi, C.O., Ogbulie, J.N., Umeh, S.I. and Abanno N.U., "Antibiotic-resistant Escherichia coli in a government piggery farm in Owerri, Nigeria", *International Journal of Biological and Chemical Science*, 2 (3), 363-367, 2008.

[8] Fleury M., Impact de traitements antibiotiques sur la flore digestive du porcelet: Etude in vivo et développement d'une approche en système de fermentation in vitro. Médecine humaine et pathologie, thèse Université Rennes 1, 2015, 237 p.

[9] Markus, H. and Daniel, G., "Antibiothérapie: interactions médicamenteuses et alimentaires", *Revue Medicale Suisse*, 5, 1979-1984, 2009.

[10] Bardou, B.S. and Caillaud, K., "Les dispositifs informationnels sur les compléments alimentaires: une affaire de santé publique. International Devices", *Food Supplements*, 27, 79-104, 2015.

[11] Berri, M., Slugocki, M., Olivier, M., Holbert, S., Helloin, E., Jacques, I., Salmon, C.P.N., Legoff, M. and Demais, H., "L'activité antibactérienne et immuno modulatrice d'un extrait d'algue verte riche en polysaccharides sulfatés", *Journées Recherche Porcine*, 47, 309-310, 2015.

[12] O'Sullivan, L., Murphy, B., McLoughlin, P., Duggan, P., Lawlor, P.G., Hughes, H. and Gardiner, G.E., "Prebiotics from marine macroalgae for human and animal health applications", *Mar Drugs*, 8, 2038-2064, 2010.

[13] Cyrus, M.D., Bolton, J.J., Scholtz, R. and Macey, B.M. , "The advantages of Ulva (Chlorophyta) as an additive in sea urchin formulated feeds: effects on palatability, consumption and digestibility", *Aquaculture Nutrition*, 21 (5), 578‐591, 2015.

[14] Abdel-Warith, A.W.A., Younis, E.S.M.I. and Al-Asgah, N.A., "Potential use of green macroalgae Ulva lactuca as a feed supplement in diets on growth performance, feed utilization and body composition of the African catfish, Clarias gariepinus", *Saudi Journal of Biological Science*, 23 (3), 404‐9, 2016.

[15] AOAC, "Official Methods of Analysis" of the Association of Official Analytical Chemists, 17th edition, Washington DC, USA, 2000.

[16] BIPEA, "Recueil des méthodes d'analyse des communautés européennes", Bureau Interprofessionnel d'Études Analytiques, Gennevilliers. France, 1976, 140 p.

[17] Tesseraud, S., Métayer-Coustard, S., Boussaid, S., Crochet, S., Audouin, E., Derouet, M. and Seiliez, I., "Insulin and amino acid availability regulate atrogin-1 in avian QT6 cells", *Biochemical and Biophysical Research Communications*, 357, 181-186, 2007.

[18] Hocquette, J.F., Tesseraud, S., Cassar-Malek, I., Chillard, Y. and Ortigues-Marty, I., "Responses to nutrients in farm animals: implications for production and quality", *Animal*, 1, 1297-1313, 2007.

[19] Culioli, J., Berri, C., and Mourot, J., "Muscle foods: consumption, composition and quality", *Sciences des Aliments*, 23, 13-34, 2003.

[20] Rosenvold, K. and Andersen, H.J., "Factors of significance for pork quality", *Meat Science*, 64, 219-237, 2003.

[21] Wood, J.D., Nute, G.R., Richardson, R.I., Whittington, F. M., Southwood, O., Plastow, G., Mansbridge, R., da Costa, N., & Chang, K. C., Effects of breed, diet and muscle on fat deposition and eating quality in pigs. Meat Science, 67(4), 651-667, 2004.

[22] Ivanova, V.S.M. and Petrova, D., "Fatty acid composition of black sea Ulva rigida and Cystoseira crinita", *Bulgarian Journal of Agricultural Science*, 19, 42-47, 2013.

[23] Hooper, L., Harrison, R.A., Summerbell, C.D., Moore, H., Worthington, H.V., Ness, A., Capps, N., Davey, S.G., Riemersma, R., Ebrahim, S., Omega 3 fatty acids for prevention and treatment of cardiovascular disease. Cochrane Database of Systematic Reviews 2004, Issue 4. Art. No.: CD003177.

[24] Feiner, G., "Definitions of terms used in meat science and technology" In Meat Products Handbook Practical Science and Technology, 46 (71), 2006, 629 p.

[25] Sika, A.E., Kadji, B.R.L., Dje, K.M., Kone, F.T.M., Dabonne, S., and Koffi-Nevry, A.R., "Qualité nutritionnelle, microbiologique et organoleptique de farines composées à base de maïs (Zea mays) et de safou (Dacryodes edulis) produites en Côte d'Ivoire", *International Journal of Biological and Chemical Science*, 13 (1), 325-337, 2019.

[26] Mourot, J. and Hermier, D., "Modulation de la qualité de la viande de porc par l'alimentation", *INRA Production Animale*, 22 (1), 33-40, 2009.

[27] Viguerie, N., Millet, L. and Avizou, S., "Regulation of human adipocyte gene expression by thyroid hormone", *Journal of Clinical Endocrinology and Metabolism*, 87(2), 630-640, 2002.

[28] Coibion, L., "Acquisition des qualités organoleptiques de la viande bovine: adaptation à la demande du consommateur", Mémoire pour l'obtention du grade de Docteur vétérinaire, école nationale vétérinaire de Toulouse, 2008, 97 pages.

[29] Oury, M.P., Picard, B., Istasse, L., Micol, D. and Dumont R., "Mode de conduite en élevage et tendreté de la viande bovine", *INRA Production Animale*, 29, 309-326, 2007.