Quest Journals
Journal of Research in Agriculture and Animal Science
Volume 12 ~ Issue 8 (August 2025) pp: 09-16
ISSN(Online): 2321-9459
www.questjournals.org

Research Paper

Effect of Papaya Seed Inclusion on The Organoleptic Properties of Catfish (*Clariasgariepinus*) Fed Maggot Meal

Egbuhelu Cornelius Oguerinam
Enugu State Polytechnic Iwollo
egbuhelu@gmail.com

Abstract
Sixty (60) catfish juveniles of ten weeks old were used for the study with the objective of determining the effect of papaya seed inclusion on the organoleptic properties of catfish fed Maggot Meal (MGM). House fly maggots were collected fresh, washed, sundried,then crushed to obtain the MGM. Papaya seed were also obtained from papaya fruits purchased from the open market. The seeds were washed, sundried and crushed to obtain the Papaya Seed Meal (PSM). The fish were randomly assigned to four dietary treatments identified as T_0, T_1, T_2, and T_3. T_0 was a pure popular foreign feed known as AllerAqua^R which was not treated with any maggot meal or papaya meal.Its purpose (AllerAqua^R)was only to compare the locally compounded maggot meal based feeds with a popular foreign feed.Diets T_1, T_2, and T_3 contained MGM at 30% inclusion level at the expense of fish meal. In addition to MGM, Papaya Seed Meal (PSM) was also included as additives to the three diets (T_1,T_2 and T_3) at 0%, 1%, and 2% inclusion levels respectively. Fish were fed at 5% body weight daily for 12 weeks. Water was changed after every three days. The Organoleptic Properties/consumer response or acceptability of the catfish fed maggot meal based diets was investigated using consumer preference study involving the use of processed fish from each of the treatments placed in labeled plates for evaluation by a panel of judges who gave scores based on questionnaire given to them The results of the organoleptic analysis reveal significant ($P<0.05$) improvement on the consumer preference of fish fed maggot meal diets treated with papaya seed. Thus, the panelist's acceptability of the processed fish fed papaya seed treated maggot meal diet was superior to the control. Hence, the incorporation of papaya seed in maggot meal based diets has no adverse effect on consumer acceptability of fish.

***R**eceived 18Aug., 2025; **R**evised 28Aug., 2025; **A**ccepted 31Aug., 2025 © The author(s) 2025.*
P**ublished with open access at **www.questjournas.org

I. INTRODUCTION

High cost of animal feeds in Nigeria has been a major problem confronting the livestock industry especially the fishery sub-sector, whose protein requirement is relatively higher than those of other livestock. This high cost of feed is attributed to the rising cost of fish meal which is the major source of animal protein in livestock feeds. Besides protein, it provides energy, essential fatty acids, vitamins and minerals in animal dietary formulations (Okah and Onwujiariri, 2012). It was estimated that in continental Africa (excluding South Africa). 21% (percent) of the animal protein consumed came from fish and fishery products. (FAO.1992).However, the high cost of fish meal has forced researchers to look for its substitutes or alternatives (Tacon and Jackson, 1985, Wester*et al.* 1992). Fish Meal accounts for 45% - 65% of total cost of fish feeds and therefore, any effort to substitute it with cheaper raw materials will significantly reduce the cost of production (Okah, 2004.). This author noted that a solution to the problem of rising cost and scarcity of feed stuffs will be in seeking new and non-conventional raw material. As a consequence, nutritionists have been experimenting on the possibility of replacing fish meal with cheaper and more readily available alternatives that have comparable energy and crude protein contents. One of such raw material is Maggot Meal (Ogunji*et al.* 2006). These authors have shown that Maggot Meal (MGM) has a great benefit and potentials as protein source in animal nutrition.

The reported crude protein value of MGM range from 43 to 64% (Awoniyi*et al.*, 2003; Fasakin*et al.*.2003: Nwangbo*et al.*. 2009; Odesanya*et al.*, 2011). Adesulu and Mustapha (2000) also reported superior levels of some essential amino acids including cystine, histidine, phenylalanine, tryptophan and tyrosine in MGM than in fish meal or soy bean meal. MGM is rich also in phosphorus, trace elements and B complex vitamins (Aniebo*et al,* 2009).There have been studies on the use of maggots in the diets of African catfish, mostly *Clariasgariepinus.* The results are generally impressive, though the inclusion of MGM should be limited to 25-30% as performance tends to decrease when higher inclusion levels are used. Odusanya*et al* (2011) however, reported the crude fat of maggot to be over 30%. Thus, Jiang *et al.*, (1992) opined that maintaining the organoleptic properties and oxidative stability of Poly unsaturated Fatty Acid (PUFA)-enriched diets such as MGM have always been a challenge. Higher levels of PUFA increase the rate of fatty acid unsaturation, leading to oxidative deterioration of lipids (rancidity). Lipid oxidation affects flavor, taste, aroma, after taste, and the general nutritional value and shelf life of foods (Jiang *et al*., 1992).

This off-flavor brought about by oxidation has been the major pitfall of MGM feeding strategy (Bhal*et al*, 2011). Hayat *et al,* (2009) maintain that lipid oxidation is a major factor that determines quality and shelf-life of fish. Synthetic antioxidants such as Butylated Hydroxyanisole (BHA) and ButylaledHydroxyloluene (BITT) have effectively been used for the stabilization of foods against lipid oxidation (Cherian, 2012). However, growing concerns regarding their role in the cause of diseases like cancer have restricted their use in food products (Thomas *et al*, 2006). Sampaio*et al.* (2012) and Kasapidou*et al*, (2012) suggested that the alternatives for the synthetic antioxidants are natural antioxidants which are safer, economical and capable of preventing oxidative deterioration of food products. Thus, there is growing interest and advocacy in the use of natural antioxidants such as papaya seed, rosemary, oregano, green tea, grape seed etc to prevent lipid oxidation in food products and also in the alleviation some metabolic diseases at the same time (Dashti*et al*, 2015). Tunda and Aytunga, (2011) in consonance assert that the use of natural food preservatives can also provide protection from both spoilage and pathogenic microorganisms. Thus, food supplementation with antioxidants such as papaya seeds is being advocated Papaya seed also possess some enzymes that enhance better digestion and improved health of the intestine (Liu *el al*, 2010). These authors assert that a substance, called Carpaine, also present in papaya seeds can destroy intestinal parasites, making the intestine stay healthy, thus keeping many disorders of the body at a distance. The aim of this study is to evaluate the effect of papaya seed inclusion on the organoleptic properties of catfish fed Maggot Meal (MGM).

Objectives of the Study:

The objectives of the study were to:

i Evaluate the effect of papaya seed inclusion on the utilization of maggot meal(MGM) fed to catfish.

ii. Evaluate the effects of papaya seed inclusion on the organoleptic properties of catfish fed Maggot Meal (MGM).

Justification:

One major problem confronting all third world countries including Nigeria, is the issue of animal protein insufficiency, this results from the scarcity of feeding stuffs especially fish meal which is the main source of protein in animal feeds. The high cost of fishmeal on world market have made it necessary to look for substitutes or alternative protein sources, hence the introduction of non-conventional feeding stuffs such as maggot meal (MGM) in animal feed and dietary formulation. However, the use of MGM and other agro industrial waste in animal feed formulation is limited following their high crude fat and fatty acid contents. High fatty level of acid leads to high rate of lipid oxidation and rancidity with consequent short shelf life of meat obtained from animals fed MGM based diets. There is therefore the need for closer studies on how to improve the nutritional values of this newly discovered alternative protein source. The study of the effects of an antioxidant such as papaya seed on the flesh and organoleptic properties of catfish fed maggot meal based diets becomes imperative. The study was aimed at underscoring the potentials of papaya seed in improving the utilization of MGM in cat fish, and reducing the lipid oxidation of MGM thus improving the taste and the general organoleplic qualities of fish fed maggot meal based diets.

II. Review of Related Literature

Fishmeal is the major source of animal-based protein for livestock. Fish caught in the seas and oceans are crushed and processed into fish meal which is added as a protein provider in animal feeds and fed to pigs, cattle, poultry, including farmed fish and other classes of animals. Fishmeal has remained a popular ingredient in animal feed because of its high protein content. However, the natural fish stocks in the oceans are reducing drastically across the world following overfishing and the negative effects of climate change. Hence, using our fish stocks as source of raw-materials for the animal feed industry is no longer sustainable under the current conditions. Maggots, unlike Fishmeal, are very new as a source of protein for animals. They are very rich in proteins and contain a wide range of amino acids and minerals that provide the necessary nutrition for livestock growth. Maggot production doesn't come with the adverse environmental consequences like producing other animal protein. Unlike the prices of soybean and fishmeal which are currently going through the roof, maggots are abundant and readily available. As long as there are organic wastes, maggots can comfortably be 'farmed' in the backyard.

Maggot Production

In South Africa, AgriProtein is breeding billions of flies on a farm to mate lay eggs and produce maggots. These maggots are fed on organic waste material which is also a nutrient-rich fertilizer. The maggots are harvested and dried into a natural and sustainable animal feed. Maggot-based animal feed is more than 15 percent cheaper than other alternatives and has been proven to be highly nutritious for livestock, especially chickens (poultry), fish and pigs.Maggot Meal /MagMeal™ consists of the ground up, dried larvae that contains the nine essential amino acids, meaning it is a complete animal protein. In the study conducted by Ogunji e*t al.*(2008) to evaluate the growth and nutrient utilization of Nile tilapia fed MagMeal™ instead of a commercial fish feed. The results of the study showed that the fish gained good growth and health, and that it did not produce any stress on their systems.The study also showed a better performance in the growth of the fingerlings when fed with MagMeal™, than when they were led with other commercial fish food. Thus, for Nile tilapia and other species of fish, MagMeal™ can work as a replacement to commercial fish feed. Therefore, serving an affordable option to the rising cost of imported fish feeds.

MGM and Its Compositions;

Maggot meal produced from maggots grown on a mixture of cattle blood and wheat bran was used in substituting fish meal in African catfish, *Clariasgariepinus,* diet. A feeding trial was carried out for a period often weeks to evaluate the growth and nutrient utilization of catfish juveniles using diets in which fish meal was substituted with maggot meal at the following levels, 0, 50, and 100 %. Proximate and amino acid analyses of the maggot meal were carried out. Also the proximate composition of the least diets was determined. The results showed that indices (weight gain, length gain, daily growth rate, specific growth rate, feed conversion ratio and protein efficiency ratio). It is concluded that maggot meal is a viable alternative protein source to fish meal in the diet of African catfish. Its utilization is expected to reduce feed cost drastically, thus leading to a viable and sustainable aquaculture industry

MGM in Feed Formulations

The non significant differences of the evaluated growth and nutrient utilization indices among the three treatments imply that maggot meal can successfully replace the entire fishmeal portion of the fish diet. Other authors have observed a better performance of fish fed diets containing maggot meal over those solely fed on fish meal diets (Ogunji et a*l.,* 2006). This is a reflection of the nutritive quality and acceptance of this biomatcrial. The result also corroborates previous observation that maggot meal, like other animal protein sources was well accepted and utilized by fish (Alegbeleye*et al.* 1991; Idowu*et al.* 2003). It has been suggested that the good growth and nutrient utilization capacity offish fed maggot-based diets stem from the high biological value ie nutrient composition and digestibility, of the ingredient (Sogbesan*el al.,* 2006). Jhingrarn (1983) reported that maggots are easily digested by fish and this has been attributed to its relatively high crude fibre content, which according to Fagbenro and Arowosoge (1991) plays a significant role in feed digestion. The non significant difference in the values of FCR of the treatment diets is possibly indicative-that both protein sources compared favourably in feed to flesh conversion. It has been reported that the biological value of maggot meal is equivalent to that of whole fish meal (Ajani *et al.* 2004).

Sheppard and Newton (1999) have also reported that maggot oil is high in desirable medium chain and mono unsaturated fatty acids, and rich in phosphorus trace elements and B-complex vitamins (Teolia and Miller. 2003). Ogunji*et al,* (2006) postulated that several other ingredients of animal origin such as feather meal, poultry by-product meal, and also plant protein sources may not successfully replace fish meal in aquafeeds due to their inferior amino acid profile, and nutrient inhibition factors found in the latter class. Utilization of maggot meal will thus pave *way* for cheaper and nutritionally rich aquafeeds.

Table 3 Amino acid profile of housefly maggot meal compared with that of fish meal

Amino acid	maggot meal	Fishmeal
Histidine	3.09	1.36
Arginin	5.80	3.99
Aspartic acid	8.25	Not given
Threonine	2.03	2.60

Serine	3.23	Not given
Glutamicacid	15.3	Not given
Proline	2.85	. Not given
Glycine	4.1 1	Not given
Alanine	2.86	Not given
Cystine	0.52	0.82
Valine	3.61	3.09
Isoleucine	3.06	2.97
Leucine	6.35	4.45
Lysine	6.04	4.55
Tyro sine	2.91	1 .98
Phenylalanine	3.96	2.35
Melhionine	2.28	1.68
Tryptophan	0.69	Not given

Source; N.R.C. (1977)

Maggot meal is of high biological value. According to Akpodiete and Ologhobo (1999), maggot meal contains the ten essential amino acids and this is comparable to fish meal (Fetuga, 1977), thus, it has high nutritive value. The percentage of crude protein of 39.55%, lipid 12.5-21% and crude fiber 5.8-8.2% were reported by Ogunji*et al.* (2008a). Ogunji*et al.* (2008b) reported that the biological value of maggot meal was equivalent to that of whole fish meal and that the larvae contained no anti-nutritional or toxic factors sometimes found in alternative protein sources of vegetable origin. Fasakin*et al.* (2003) reported that crude protein content of maggot meals ranged between 43.3% and 46.7% in full -fat sun dried and hydrolyzed /defatted oven dried maggot meals respectively. 'Thus similar crude protein and lipid values were obtained in processing methods involving sun drying and oven drying either hydrolyzed or defatted maggot meals (Fasakin*et al.* 2003).

Diseases Associated With Maggot Meal

The housefly is a known carrier of pathogens and the inclusion of maggot meal in livestock diets raises concerns about potential transmission of diseases. Particularly, there is a risk that bacteria or fungi present in the maggot rearing substrate, which is usually poultry manure, carry over to the finished maggot meal, especially when the keeping quality of the maggot meal is uncertain. However, experiments have not reported contaminations due to feeding maggot meal to poultry, or fish. Indeed, none of the numerous studies on maggots as animal feed has revealed any health problems (Sheppard and Newton, 1999). Koo *et al.* (1980) observed no pathological signs associated with feeding maggot based diets to chicks. Bayandina*et al.* (1980) and Poluektova*et al.* (1980) reported that dietary maggot had no adverse effects on health of pigs. In the study carried out by Alteh and Oyedeji (1990), no disease symptom or mortality was observed when maggot meal replaced groundnut cake in broiler diets. Also, Adeniji (2007) reported zero mortality in diets containing maggot meal i.e. 25-100% maggot meal replacing groundnut cake diet implies that maggots have no pathological effect on the chicks. His result agrees with Calvert *et al.* (1969) and Teolia and Miller (1974) who both reported that no pathological changes occurred in chicks fed maggot based diets. All these observations point to the fact that after proper treatment maggots may either contain a tolerable level of micro organisms or none at all. It was recommended to dry the meal to 4-5% moisture to minimize bacterial activity. After processing, protection from moisture absorption can be achieved by water proof bagging (with cellophane or nylon) and heat-sealing

(Awoniyi*et al.*, 2004).Generally, care must be taken to assure that adequate heating takes place during the drying process so that any pathogenic organism that were present are destroyed (Rocas, 1983).

Oxidative Rancidity of Foods and MGM

The most common form of chemical deterioration is oxidative rancidity. Oxidative rancidity in fish can vary greatly, ranging from extensive flavor changes, color losses and structural damage to proteins to a more subtle "loss of freshness" which discourages repeat purchases by consumers (Skrivan*et al*, 2011). The latter is probably the most important to food processors since it is not apparent, but yet results in consumer dissatisfaction. Oxidative stability is a central parameter in the estimation of food or fish quality because of the susceptibility of fish or fish products to oxidative degeneration, which is one of the main causes of spoilage in fish products. Oxidative reactions are affected by several factors, among which are lipid composition and processing, and could be delayed by endogenous or exogenous antioxidants (Skrivan*et al*, 2011) . Biological antioxidants are molecules which, when present at low concentrations compared to those of an oxidizable substrate, significantly delays or prevents oxidation of that substrate (Jiang and Xiong, 2016).

Lipid oxidation is one of the most important problems encountered in animal products rich in polyunsaturated fatly acids such as Maggot Meal (Jiang and Xiong, 2016). Lipid oxidation is one of the most major factors affecting the quality and shelf life of fish. It causes undesirable changes in taste, odor, texture, flavor, and appearance of foods, and also destroys fat-soluble vitamins. Furthermore, the oxidative degradation of lipids can damage biological membranes, enzymes and proteins, which may pose a direct threat to human health (Liu, (2007), (Parker *et al*, 1995).Natural antioxidants of plant origin have been introduced to improve the lipid stability and enhance the sensory properties of food. The antioxidant properties of natural antioxidants of plant origin are mainly attributed to their phenolic contents, thus, their antioxidant action is similar to synthetic phenolic antioxidants (Elgasim and Al-Wesali, 2000). Microbial control in foods could be assured by suppressing one or more essential factors for microbial survival (Horace, 1982). There has been a constant search for alternative and efficient compounds for food conservation, aiming a partial or total replacement of antimicrobial chemical additives. Spices and herbs have been used for thousands of centuries by many cultures to enhance the flavor and aroma of foods. Scientific experiments since the late 19th century have documented the antimicrobial properties of some spices, herbs, and their components. Inhibitory activity of spices and derivatives on the growth of bacteria, yeasts, fungi and microbial toxins synthesis has been well reported, so they could be used in food conservation as main or as adjuvant antimicrobial compounds in order to assure the production of microbiologically stable foods.

Papaya Seed

Papaya seed is now being used for both medicinal as well as culinary purpose, it is a broad spectrum antibiotic killing a very wide variety of microorganism. Besides having potent antioxidant and antimicrobial action, it is now one of the most commonly used ingredients as a flavor enhancer in fish and meat products (Liu *et al*, 2010). In addition to its flavoring properties, papaya also possesses a wide range of medicinal attributes. These include antibacterial, antiviral, antifungal and antiprotozoan activities (Ankri and Mirelman, 1999) and beneficial effects on the liver, kidneys, cardiovascular and immune systems. There are a lot of reports concerning the antibacterial and antioxidant effects of papaya seed on fish and meat products (Kourounakis and Rekka. 1991 ; Lin *et al*., 1991; LI-Khateib and El-Rahman, 1987; Ismaiel and Pierson, 1-990).

The antioxidant activities of the ethanol, petroleum ether, ethyl acetate, n-butanol and water extract fractions from the seeds of papaya were evaluated and it was found that the ethyl acetate fraction showed the strongest DPPH and hydroxyl free radical scavenging activities, and its activities were stronger than those of ascorbic acid and sodium benzoate, respectively Elgasim and Al-Wesali, 2000). The n-butanol fraction demonstrated the greatest ABTS+ radicals scavenging activity. The ethyl acetate fraction and the n-butanol fraction not only showed higher antioxidant activities than the petroleum ether fraction, water fraction and ethanol fraction, but also showed higher superoxide union and hydrogen peroxide radicals scavenging activities than those of the other extract fractions. The high amount of total phenolics and total flavonoids in the ethyl acetate and n-bulanol fractions contributed to their antioxidant activities Elgasim and Al-Wesali, 2000). The ethyl acetate fraction was subjected to column chromatography, to yield two phenolic compounds, p-hydroxybenzoic acid and vanillic acid, which possessed significant antioxidant activities (Sampaioni 2012). Therefore, the seeds of papaya might be used as natural antioxidants.

Gap in Literature

In recent times, the use maggot as fish feed and poultry feed has been studied extensively. Even in Nigeria, there have been numerous experiments on the use of maggots in the diets of African catfish. The results are generally positive though the inclusion of MGM should be limited to 25-30% following its high contents in poly unsaturated fatty acids (Odusanya*et al,* 2011).Thus, there is growing interest and advocacy in the use of natural antioxidants such as papaya seed, rosemary, oregano, green tea, grape seed etc to prevent lipid oxidation in food products and also in the alleviation some metabolic diseases at the same time (Dashti*et al,* 2015). Food, supplementation with antioxidants such as papaya seeds is being advocated. However, not much is known on the use of a natural antioxidant such as papaya seed to counter the effects of lipid oxidation associated with maggot meal fed to catfish. The aim of this study is to evaluate the effect of papaya seed inclusion on the organoleptic .properties of catfish fed Maggot Meal (MGM).

III. Materials and Methods

Experimental Site:

The experiment was conducted at the Fishery Unit of the Enugu State Polytechnic, Iwollo. Ezeagu Local Government Area of Enugu State.

Management of Experimental Fish:

Sixty (60) catfish juveniles of ten weeks old were used for the experiment. The fish were purchased from a reputable farm in Enugu. The ponds used measured 1m by 1m in dimensions with inlet and outlet facilities. The pond bottom and walls were thoroughly washed, disinfected and flooded with water three days before the arrival of fish. The fish were starved for the first twenty four hours before being placed on the treatment diets after randomly assigned to the four dietary treatments. They were fed two times daily based on 5 percent of body weight while water was changed after every three days for the 12 weeks experimental period.

Maggot Meal for the experiment was collected from a reputable poultry farm in Enugu State Nigeria. The maggots were collected fresh, washed, sun-dried and crushed in a hammer mill to obtain the Maggot Meal (MGM). The four treatment diets formulated were Iso-nitrogenous with 45% crude protein and metabolizable energy range of 2578-3000 kcal/kg. The papaya seed for the experiment were obtained from papaya fruits purchased from the market. The seeds were sundried and crushed to fine powder.

Experimental Diets

Three experimental diets were formulated with maggot meal at 30% inclusion level at the expense of fish meal. In addition, papaya seed meal was included as additives at 0%, 1%, and 2% inclusion levels corresponding toT_1 T_2, and T_3, respectively. A popular foreign commercial feed (AllerAqua^R) was a fourth diet (T_0) used only for the purpose of comparing its quality with the quality of the locally formulated maggot meal based diets. Each treatment was replicated three times giving a total of 12 observations (3x4). There were five (5) fish per observation which will give a total of 5x12 = 60 fish used for the study.

Table 3.1; Showing the Percentage Composition of the Experimental Diets.

Ingredients.	T_1.	T_2.	T_3
Maize	22.0	21.0	20.0
MGM	30.0	30.0	30.0
Papaya Seed	0.0	1.0	2.0
Soya meal	30.0	30.0	30.0
Groundnut cake	15.0	15.0	15.0
Bone meal	2.0	2.0	2.0
Lysine	0.25	0.25	0.25
Methionine	0.25	0.25	0.25
Premix	0.5	0.5	0.5
Calculated Analysis			
CP(%)	41.9	41.9	41.9
Energy(kcal/kg)	2900	2900.	2900

Organoleptic Analysis:

The Organoleptic Properties/consumer response or acceptability of catfish fed maggot meal based diets was investigated using consumer preference study involving the use of processed fish from each of the treatments placed in labeled plates for evaluation by a panel of judges who will give scores based on questionnaire given to them (Larmond, 1992). Organoleptic Properties are described as: Taste, Odor, Color and Texture. Obviously the evaluation of these properties was performed by specially trained test panels for the identification and assessment of flavors and appearance of the fish. One piece of fish from each of the treatments boiled for fifteen minutes was given to each of the panel of judges (5 males and 5 females), while another smoked piece of fish from each treatment also given to them for evaluation and scores based on four point scale of “Like Extremely” (4 points), “Like” (3 points), “Dislike” (2 points) and “Extreme Dislike” (1 point). The boiling and smoking was to conform to usual culinary practices of fish processing.

IV. Results and Discussion

Results

4.1; **Antioxidant Analysis of Papaya Seed;**

Table 4.1 presents the results of antioxidant analysis of papaya seed. Samples were analyzed chemically according to the official methods of analysis described by the Association of Official Analytical Chemist (AOAC., 18th Edition, 2005). All analyses were also carried out in duplicates. The mean values for the Total Antioxidant Activity, Total Phenolics and Ferric Reducing Ability of Plasma (FRAP) were shown as 77.9, 33.8 and 28.8 (ug/100g) respectively.

Table 4.1; Showing the antioxidant Compounds in papaya seed

Parameters	**Value 1**	**Value 2**	**Mean**
Total Antioxidant Activity (Ug/G Or UmolTocopherolEq/G)	77.89	77.92	77.91
Total Phenolic(mg gallic acid Uq/100g)	33.78	33.76	33.77
Ferric Reducing Ability of Plasma (FRAP Ug/100g)	28.79	28.84	28.82

4.2; Organoleptic Analysis

Consumer Preference Studies were carried out with fish from the various treatments harvested and used to prepare pepper soup which is the commonest and fastest culinary method for fish. The samples were labeled and served in plates for a panel of ten judges to examine and give scores based on the flavour, taste, colour, and texture of the samples. Four Grade Point Scale of “Extreme Like” (4 points), “Like” (3 points), “Dislike” (2 points), “Extreme Dislike” (1 point) was used. The decision rule was that mean values from 3.5 and above were regarded as “Extreme Like”. Mean values from 2.5 to 3.4 were regarded as “Like”. While mean values from 1.5 to 2.4 were regarded as “Dislike, and mean values of less than 1.5 were regarded as “Extreme Dislike” the results of the organoleptic qualities were presented in table 4.5.

Table 4.2 presents the summary of the consumer preference analysis of fish pepper soup obtained from the treatment groups.

Table 4.2; Showing the consumer preference studies of fish pepper soup prepared from fish of the various treatments;

Treatments	**Colour**	**Flavour**	**Texture**	**Taste**	**Total**	**Mean**	**Decision**
T_0	3	2.7	3.2	3.3	12.2	3.04	Like
T_1	2.8	1.9	2.5	1.6	8.8	2.2	Dislike
T_2	2.8	2.2	2.5	2.3	9.8	2.45	Like
T_3	3	2.6	2.8	3.1	11.5	2.88	Like

Table 4.2 reveals a progressive increase in the consumer preference for fish fed maggot meal as the level of papaya seed meal increased. The inclusion level, “T_2” produced a mean score of 2.88 which was very close to 3.02 score of the foreign feed.

Discussion

Antioxidant Analysis of Papaya Seed;

Antioxidant analysis of Papaya seed show that the Papaya seed used for the study contains about 77.91Ug/g of Total Antioxidant Activities/Tocopherols, Total Phenolics of 33.77Ug/100g and total Ferric Reducing Ability of Plasma (FRAP) of 28.82Ug/100g. The antioxidant profile of the papaya seed is within the range reported by previous researchers such as Martins *et al,* (2019), Nile *et al,* (2018), Rodriguez-Concepcion *et al* (2018*),* Silver *et al,* (2020) and Kummar*et al, (*2022). These authors obtained similar results in their several analytic studies of the antioxidant properties of different parts of papaya and other plants and herbs. The highest Total Antioxidant of 82Ug/g was reported for rosemary herb, while Total Phenolic Property (TCP) for berries and citrus ranged between 10 -50ug/g. hence, the laboratory result of 33. 77Ug/g for the Papaya seed used in this study was still within range. The FRAP content of 28.88Ug/g of the Papaya seed was also high enough considering the amounts reported for other plants with potent antioxidant properties..

Organoleptic Results;

Table 4.2 reveals no significant differences (P>0.05) in colour, aroma, flavour and overall acceptability of fish fed maggot meal diets treated with papaya seed meal and fish fed foreign feed as their sensory scores were similar (P>0.05). The mean sensory scores of the fish showed that inclusion of papaya seed directly in feed did not have any negative effect on the sensory characteristics but rather improved it. This further agreed with Hashimoto *et al.* (2019) who opined that plant antioxidants maintained sensory acceptability while exhibiting antioxidant properties. This is in consonance with the reports of Afolabi and Ofobrukweta, (2011) who note that the presence of carotenoids in papaya seed might improve the colour of fish. Moreso, the volatile compounds in the seeds could also impact the flavor. Hence, the increased nutritional composition and the panelists' indifferent attitude as regards the overall acceptability of the fish fed papaya seed, as opposed to the ones that were not fed papaya seed. There were significant (p<0.05) differences observed in the mean scores of the fish fed maggot meal diets treated with papaya seeds and those fed maggot diets not treated with papaya seed.

The table above shows clearly that inclusion of papaya seed in the Maggot meal based diets improved the consumer preference for the fish as the papaya seed level increased. The inclusion level, "T_2" produced comparable result to the score of 3.10 recorded for the foreign feed. Thus, the panelist's acceptability of the processed fish was similar (P>0.05) to the control. Hence, the incorporation of papaya seed in maggot meal based diets has no adverse effect on the consumer preference of the fish. These results are also in agreement with the reports of Lopez, (2020) and El-Nashi *et al.* (2018). These authors demonstrated the ability of papaya seed to decrease lipid oxidation in maggot meal based diets following the antioxidative bioactive compounds (phenolics) found in papaya seed. MohdEsa*et al.,* (2010) and Turgut*et al.* (2015) alsoobserved a delay of lipid and protein oxidation in beef meatballs during frozen storage at –18 °C on the addition of natural antioxidants of up to 1.0 % probably due to the high content of polyphenols in the extract.

The results presented on table 4.2 are not unexpected, given the results of the proximate analysis of papaya seed presented in table 4.1 which reveal that papaya seed contains very high amounts of antioxidants, including phenolic compounds. Karre*et al, (*2013) note that the bioactive compounds in Phenolicsincluidecarnosic acid, carnosol and rosmarinic acid, caffeic acid and flavonoids, which have been associated with the high antioxidant activity. Ismali*et al* (2015) demonstrated that phenolics present in natural anti oxidants like papaya seed showed more beneficial effects in improving the quality of meat while also maintaining their upsensory properties.

Nuñez de Gonzalez *et al.* (2007) reported similar decrease in lipid oxidation in precooked roast beef when treated with fresh and dried papaya seed concentrates. The authors showed that the 5 % addition of the fresh concentrate induced the lowest level of TBARS (thiobarbituric acid reactive substances) expressed as malonyldialdehyde (MDA) to 0.16 mg/ kg as compared to the control group (0.62 mg/kg). There was no significant impact of papaya seed addition on the colour or flavour of meat, which is important since the observable differences in the colour of meat may lead consumers to believe that the product is not properly processed and safe to consume.

V. Conclusion

Papaya seed has been shown in this study to have strong antioxidant influence on the maggot meal based diets with consequent increased the consumer preference of the fish fed maggot meal diets. The panelist's acceptability of the processed fish was better than the control. Hence, the increased nutritional composition and the panelists' indifferent attitude as regards the overall acceptability showed that there was no adverse effect on the growth and the nutritional quality of the cooked fish.

VI. Recommendations

Papaya seed and other natural antioxidants when added to fish or meat have multiple functions such as antioxidant, antimicrobial and preservative role during processing and storage because of their high contents of bioactive compounds which have the potentials to inhibit or delay oxidation. This property can be widely used by the culinary and food industry to confer good protection capacity of the products and as well improve the consumer acceptance of food products.

REFERENCES

Ajai A. I., Mohammed Mohammed, Ekwoba L., Koleola A. (2019). Comparative Analysis of the
Proximate fatty Acids and Mineral Composition of Selected Fish Species. In *ournal of faculty of food Engeneering, Stefacel Mare University, Suceava, Romania.* Pages 136-149. ISSN 2559-6381

Albahari P, Jug M, Radić K, Jurmanović S, Brnčić M, RimacBrnčić S, (2018). Characterization
of olive pomace extract obtained by cyclodextrin-enhanced pulsed ultrasound assisted extraction. LebensmWiss Technol. 2018;92:22–31. https://doi.org/10.1016/j.lwt.2018.02.011

Atanasov AG, Waltenberger B, Pferschy-Wenzig EM, Linder T, Wawrosch C, Uhrin P, (2015)
Discovery and resupply of pharmacologically active plant-derived natural products: A review. Biotechnol Adv. 2015;33(8):1582–614. https://doi.org/10.1016/j.biotechadv.2015.08.001

Azam K, Basher M. Z., Asaduzzaman M. , Hossain M.M, Ali M.Y (2007). Assessment of Biochemical Composition of Fourteen Dried Fish Samples collected from Kuakata, Bangladesh. *In University Journal of Zoology, RajshahiUniiversity. Vol. 22. Pages 23-26.*

Aziz M, Karboune S. (2018) Natural antimicrobial/antioxidant agents in meat and poultry products as well as fruits and vegetables: A review. Crit Rev Food SciNutr. 2018;58:486– 511. 1 https://doi.org/10.1080/10408398.2016.1194256

DeJong S, Lanari MC. (2009). Extracts of olive polyphenols improve lipid stability in co beef
nd pork: Contribution of individual phenolics to the antioxidant activity of the extract. Food Chem. 2009;116(4):892–7. https://doi.org/10.1016/j.foodchem.2009.03.053

El-Nashi HB, Abdel Fattah AFAK, Abdel Rahman NR, Abd El-Razik MM. (2015). Quality characteristics of beef sausage containing pomegranate peels during refrigerated storage. J Agric Sci. 2015;60(2):403–12. https://doi.org/10.1016/j.aoas.2015.10.002

Garcia-Lomillo J, González-SanJosé ML, Skibsted LH, Sisse J. (2016) Effect of skin wine pomace and sulfite on protein oxidation in beef patties during high oxygen atmosphere storage. Food Bioprocess Technol. 2016;9(3):532–42.

García-Lomillo J, Gonzalez-San José ML, Del Pino-García R, Ortega-Heras M, Muniz-Rodríguez P. (2017) Antioxidant effect of seasonings derived from wine pomace on lipid oxidation in refrigerated and frozen beef patties. LebensmWiss Technol. 2017;77:85–91. https://doi.org/10.1016/j.lwt.2016.11.038

Gómez I, Beriain MJ, Mendizabal JA, Realini C, Purroy A. (2016). Shelf life of ground beef enriched with omega-3 and/or conjugated linoleic acid and use of grape seed extract to I nhibit lipid oxidation. Food SciNutr. 2016;4(1):67–79. https://doi.org/10.1002/fsn3.251

Huminiecki L, Horbańczuk JO. (2018). The functional genomic studies of resveratrol in respect to its anti-cancer effects. Biotechnol Adv. 2018;36(6):1699–708. https://doi.org/10.1016/j.biotechadv.2018.02.011

Lin SP, Tsai SY, Lin YL, Kuo SC, Hou YC, Chao PDL. (2008)Biotransformation and pharmacokinetics of 4-(3,4-dihydroxybenzoyloxymethyl)phenyl-O-β-d-glucopyranoside, an antioxidant isolated from *Origanumvulgare*. J Agric Food Chem. 2008;56:2852–6. https://doi.org/10.1021/jf703730e

Liu R, Heiss EH, Sider N, Schinkovitz A, Gröblacher B, Guo D, (2015). Identification and characterization of [6]-shogaol from ginger as inhibitor of vascular smooth muscle cell proliferation. MolNutr Food Res. 2015;59(5):843–52 https://doi.org/10.1002/mnfr.201400791

Lorenzo JM, Pateiro M, Domínguez R, Barba FJ, Putnik P, BursaćKovačević D, (2018). Berries extracts as natural antioxidants in meat products: A review. Food Res Int. 2018;106: 1095–104. https://doi.org/10.1016/j.foodres.2017.12.005

Martin KA, Appel CL. (2010). Polyphenols as dietary supplements: A double-edged sword. Nutr Diet Suppl. 2010;2:1–12.

Naveena BM, Sen AR, Vaithiyanathan S, Babji Y, Kondaiah N. (2008) Comparative efficacy of pomegranate juice, pomegranate rind powder extract and BHT as antioxidants in cooked chicken patties. Meat Sci. 2008;80(4):1304–8. https://doi.org/10.1016/j.meatsci.2008.06.005

NDSR (2019) Nutrient Data Base for Standard Reference USDA.

Owen RW, Mier W, Giacosa A, Hull WE, Spiegelhalder B, Bartsch H. (2000). Phenolic compounds and squalene in olive oils: The concentration and antioxidant potential of total phenols, simple phenols, secoiridoids, lignans and squalene. Food ChemToxicol. 2000;38:647–59. https://doi.org/10.1016/S0278-6915(00)00061-2

Radošević K, SrčekGaurina V, CvjetkoBubalo M, RimacBrnčić S, Takacs K, Radojčić Redovniković I. (2016). Assessment of glucosinolates, antioxidative and antiproliferative activity of broccoli and collard extracts. J Food Compos Anal. 2017; 61:59–66. https://doi.org/10.1016/j.jfca.2017.02.001

Shahidi F, Ambigaipalan P. (2016). Phenolics and polyphenolics in foods, beverages and spices:

Antioxidant activity and health effects – A review. J Funct Foods. 2015;18(Part B): 820–97. https://doi.org/10.1016/j.jff.2015.06.018

Turgut SS, Soyer A, Isikci F. (2016). Effect of pomegranate peel extract on lipid and protein oxidation in beef meatballs during refrigerated storage. Meat Sci. 2016;116:126–32. https://doi.org/10.1016/j.meatsci.2016.02.011

Wang M, Li J, Rangarajan M, Shao Y, LaVoie EJ, Huang TC, *(1998).* Antioxidative phenolic compounds from sage (*Salvia officinalis*). J Agric Food Chem. 1998;46(12):4869–73. https://doi.org/10.1021/jf980614b

Wang L, Waltenberger B, Pferschy-Wenzig EM, Blunder M, Liu X, Malainer (2014) . Natural product agonists of peroxisome proliferator-activated receptor gamma (PPARγ): A review. BiochemPharmacol. 2014;92:73–89. https://doi.org/10.1016/j.bcp.2014.07.018

Wang D, Özen C, Abu-Reidah IM, Chigurupati S, Patra JK, Horbanczuk JO, (2018) Vasculoprotective effects of pomegranate (*Punicagranatum*L.). Front Pharmacol. 2018;9:544. https://doi.org/10.3389/fphar.2018.00544

Zamuz S, López-Pedrouso M, Barba FJ, Lorenzo JM, Domínguez H, Franco D. (2018) Application of hull, bur and leaf chestnut extracts on the shelf-life of beef patties stored under MAP: Evaluation of their impact on physicochemical properties, lipid oxidation, antioxidant, and antimicrobial potential. Food Res Int. 2018;112:263–73. https://doi.org/10.1016/j.foodres.2018.06.053

Zhang X, Meng Q, He L, Zhao L, Ren L. (2016) Effects of garlic extract on color, lipid oxidation and oxidative breakdown products in raw ground beef during refrigerated storage. Ital J Food Sci. 2016;26(1):139–47. https://doi.org/10.14674/1120-1770/ijfs.v467