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# MICROBIOLOGICAL QUALITY AND ORGANOLEPTIC PROPERTY OF MEAT AND FISH PRESERVED WITH OIL FROM *DACRYODES EDULIS* SEED

– Research paper –

Temitope Julianah ONIYIDE[1], Clement Olusola OGIDI[*2], Bamidele Juliet AKINYELE[1]

[1]Department of Microbiology, The Federal University of Technology, PMB 704 Akure, Nigeria
[2]Department of Food Science and Technology, School of Agriculture, Food and Natural Resources, Olusegun Agagu University of Science and Technology, PMB 353, Okitipupa, Nigeria

**Abstract**: The bioactive compounds contributing to aroma and natural antimicrobial potential of oil from *Dacryodes edulis* seed can be harnessed in food industries as food preservatives. This study therefore, reveals the preservative effect and organoleptic property of meat and fish preserved with oil from *D. edulis* seed. Proximate and mineral analysis of oil were carried out using standard methods. Preservative quality of oil on fish and meat was investigated at 4˚C and 37˚C. Organoleptic property of preserved fish and meat was determined using trained panellists. Fat, protein, carbohydrates, crude fibre, ash and moisture content of oil from *D. edulis* seed are 55.7%, 18.7%, 10.8%, 7.1%, 4.6% and 3.1%, respectively. Potassium (106.5 µg/g) and phosphorous (102.5 µg/g) have the relatively highest values compared ($p<0.05$) to other minerals like zinc, iron, calcium, magnesium, and sodium. Better preservative property of oil was observed on fried fish and meat kept at 4˚C with no microbial growth. The highest microbial load (3.95 x $10^6$ cfu/g) occurred in fresh chicken coated with oil from *D. edulis* seed after 7 days of preservation. Fish and meat fried with oil from *D. edulis* seed were well accepted (9.00) than those fried with groundnut oil (3.50). Oil from *D. edulis* seed is an edible oil that can be utilized as alternative vegetable oil with natural preservatives and embedded nutrients.

**Keywords**: meat, fish, preservation, microbial count and seeds

## INTRODUCTION

Chemical preservatives are used to manage food deterioration but such preservatives are known to endanger human life in recent time (Lopez et al., 2021). Nowadays, there are serious concerns towards the side effects of synthetic preservatives and thus, create more focus and search for various natural alternatives products from plants as well as it component as reliable substitute (Sonker *et al*., 2015). Oil from plants and their components can be used as natural antimicrobial agents to reduce microbial activities in foods, minimize enzymatic activities and thereby improving the shelf life of the foods (Bhavaniramya *et al*., 2019). Dauda *et al*. (2018) assessed the preservative potentials of seed oil of soursop (*Annona amuricata*) on plantain and concluded that the ripening and spoilage of the plantain were delayed for about 10 days.

Oil from medicinal plants have pronounced antimicrobial and food preservative properties due to the presence of a variety of bioactive compounds like terpenes terpenoids, carotenoids, coumarins and curcumins, which have been exploited with great significance in the food industries (Pandey *et al*., 2017). Methods of food preservation need to be improved with new source of preservative agents that are reliable and safe to mitigate food spoilage as a step to enhance food security.

Food spoilage render many food products unacceptable to the consumer. Meat and fish contain essential nutrients such as amino acids, vitamins and cofactors, with optimal pH and water activity that influence the growth of spoilage microorganisms (Das *et al*., 2021). Spoilage of fish and meat occurs when they remain unpreserved, in a matter of hours or days and become unappetizing, poisonous, or infectious to man (Burkepile *et al*., 2006). Several food preservation techniques such as freezing, heating, drying, and addition of antimicrobial compounds have been adopted to reduce the occurrence of microorganisms that associated with outbreaks of food borne diseases (Singh, 2018). With the use of different preservation

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* Corresponding author.
E-Mail address: clementogidi@yahoo.com

techniques, some food industries accepted the replacement of chemical preservatives with natural preservatives from plants due to the increased consumers' demand, tasty, aroma, nutritious, natural and easy-to-handle in food products (Anand and Sati, 2013).

*D. edulis* is eaten raw, softened in hot water, fried or even roasted before eaten. It can also be eaten alone or taken alongside maize and serves as a good source of oil, vitamins, minerals and protein (Arisa and Lazarus, 2008, Sofowora, 2008). Oils from vegetable and fruit-seeds are rich in amino acids, triglycerides and can augment common household oils (Ikhuoria and Maliki, 2007). In most cases, after eating, seeds from *D. edulis* fruit are discarded. Oil from *D. edulis* seed can be processed into valuable vegetable oil. Since, it has smoke point (198°C) and flash point (270°C), which means, oil from *D. edulis* seed can be regarded to be good for frying and will not dry out easily. The freezing point (21°C) of the oil explains the fact that the oil is liquid at room temperature (Arisa and Lazarus, 2008). Hitherto, there is little or no information on preservative quality of oil from *D. edulis* seed. Therefore, this study was designed to assess the microbial quality of meat and fish preserved with oil from *D. edulis* seed.

## MATERIALS AND METHODS

### Collection of fruits

*D. edulis* fruits were purchased from the market in Orlu, Imo State, Nigeria. It was transported to Akure, Ondo state. Nigeria. The fruit was authenticated at the Department of Crop, Soil and Pest management, The Federal University of Technology, Akure, Nigeria.

### Source of meat and fish

Fresh meat and fish were purchased at different locations in King's market, Akure, Ondo State, Nigeria. Meats namely; beef (*Bos taurus*), turkey (*Meleagris gallopavo*), pork (*Sus scrofa domesticus*), chicken (*Gallus gallus domesticus*), chevon (*Capra aegagrus hircus*) and different fish like tilapia (*Oreochromis niloticus*), croaker (*Micropogonius undulatus*), mackerel (*Scomber scombrus*), horse mackerel (*Trachurus trachurus*), herrings (*Clupea pallasii*), hake (*Merluccius merluccius*), and blue whiting (*Micromesistius poutassou*) were collected in sterile ice bags and carefully transported to the laboratory for analysis.

### Extraction of oil from seed of *Dacryodes edulis*

Seeds from *D. edulis* fruits was dried at room temperature (37°C) for 6-7 days. Oil was extracted from the crushed seed with *n*-hexane using a Soxhlet extractor. After extraction, the hexane-oil mixture was then evaporated under vacuum using a rotary evaporator at 40°C. The resultant oil was weighed, maintained at room temperature for 7 days until no traces of *n* hexane and stored at 0°C until further analysis

$$\% \text{ Oil yield} = \frac{\text{weight of oil}}{\text{Weight of } D.edulis \text{ seed used}} \text{ X } 100$$

### Proximate and mineral analysis of oil from *Dacryodes edulis* seed

Proximate and mineral analysis of oil from *Dacryodes edulis* seed was determined using standard procedures of the Association of Official Analytical Chemist (2006). Moisture, ash, crude fibre, fat and oil, protein and carbohydrate contents were determined using document number of 925.09, 923.39, 991.43, 922.06 and 960.52. The carbohydrate content was determined by difference in total percentage of moisture, ash, crude fibre, fat, and protein. To determine the mineral contents of the oil, the sample was ashed in a furnace for 5 hours at 600°C, and then refluxed with 20% HCl. The mixture was filtered into a 100 ml standard flask, the filtrate was then made up to the mark with deionized water. Sodium (Na) and potassium (K) of oil was determined using a flame emission photometer. Other metals were determined using atomic absorption spectrometry (AAS).

### Microbial analysis of fresh, preserved fish and meat with oil from *D. edulis* seed

Preservative quality was determined by coating and frying 20.04±3.03 g of fresh fish and meat as well as steamed fish and meat with *Dacryodes edulis* seed oil. Fresh fish and meat served as negative control, while fish and meat coated or fried with groundnut oil served as the positive control. They were all kept in sterile conditions at room temperature (37°C) and low temperature (4°C). Fish and meat were observed daily for seven days. Isolation of microorganisms was carried out on fresh (non-preserved), preserved fish and meat using the methods of Cheesbrough (2006). Briefly, sample (1.0 g) was placed in sterile distilled water and serially diluted. Aliquot of 0.1 ml was transferred on plate containing sterile nutrient agar

and Potato dextrose agar. The plates were incubated for 24 h and 48 h at 32ºC and 25ºC for bacteria and fungi, respectively. Microbial colonies were counted using a colony counter (J-2 Colony Meter PEC MEDICAL USA). Morphological and biochemical tests were carried out according to Cheesbrough (2006) and Fawole and Oso (2007). Identification of microorganisms was done by interpreting the results of biochemical tests using Cowan and Steel (2009).

**Organoleptic property of fish and meat preserved with seed oil**

The sensory evaluation was carried out on fish and meat fried with oil from *Dacryodes edulis* seed. Fish and meat fried with groundnut oil served as the control. The fried fish and meat were rated by five male and five female panellists for taste, colour, aroma and texture on the first and eighth day. The panellists are those who interest in fried meat and fish. Nine (9)-point hedonic scale was used as ranking method: 9- like extremely, 8-like very much, 7- like moderately, 6- like slightly, 5- neither like nor dislike, 4- dislike slightly, 3- dislike moderately, 2- dislike very much, 1- dislike extremely (Camille and Nicholas, 2015). Necessary precautions were taken to prevent carryover taste by ensuring that assessors rinse their mouth with water after each evaluation.

**Statistical Analysis**

Data obtained during the experiment were subjected to one-way analysis of variance (ANOVA). Means were separated with Duncan's New Multiple Range Test (DNMRT) and differences were considered significant at $P \leq 0.05$.

## RESULTS AND DISCUSSION

Oil from plant crops and seeds have multiple health benefits and thus, recognized as functional foods. This study therefore, reveals the preservative potential of oil extracted from *Dacryodes edulis* seeds**.** Table 1 shows the yield and physical parameters of oil extracted from *D. edulis* seed.

Table 1: Yield and physical parameters of oil from *Dacryodes edulis* seed

| Parameter | Properties |
|---|---|
| Percentage yield of oil | 60% |
| Colour of extracted oil | Pale yellow |
| Odour | Very pleasant |

The oil extracted from *Dacryodes edulis* seed was light yellow in colour. Colour is a useful parameter that can be adopted to grade the quality of seed oil (Isaac *et al*., 2014). The yield of oil was 60%, which falls within the ranges (55.16-59%) reported in the studies carried out by Isaac *et al*. (2014), Arisa and Lazarus (2008), Ogunsuyi (2015) and Okafor *et al*. (2017). The high oil concentration of *Dacryodes edulis* may be due to different proposed reasons, which includes orchard location, harvesting time of the fruits, choice of solvent, ecological factors affecting seeds/fruits in different geographical locations and experimental methods adopted. Figure 1 shows the proximate composition of the extracted seed oil. Contents of oil, protein, carbohydrates, crude fibre, ash and moisture in *D. edulis* seed oil are 55.7%, 18.7%, 10.8%, 7.1%, 4.6%, and 3.1%, respectively. The proximate composition of oil from seed revealed carbohydrates as 10.8%, which is known to be a potential source of energy in *Dacryodes edulis* seed oil. Ash content is an indication of the mineral composition of the sample. The ash content of 4.6% was obtained in this study. Fidings of Ogunka-Nnoka *et al*. (2017) reported 2.4% in the oil. The variability of ash content could due to mineral content of the seed oil. The protein content (10.7%) of the seed oil was higher than that of *D. edulis* seed reported by Amadi *et al*. (2017). The protein quantity in the oil suggests that it as an alternative source of amino acids and protein for both man and animal. Oilseed from soybeans, rapeseed (canola), cottonseed, groundnut (peanut), sunflower seed, sesame, cotton, rape, palm tree, safflower, flaxseed and linseed have been regarded as source of oil seed protein (Riaz, 2011). The moisture content (3.1%) of the seed oil was low compared to moisture content (14.26 %) of palm kernel seeds (Onyeike and Acheru, 2002). Udo *et al*. (2016) revealed the proximate and phytochemical of *Dacryodes edulis* exudate and reported low moisture content of 2.7%. The lower moisture content of *D. edulis* seed oil indicated that the oil can be stored for a long period without spoilage since elevated moisture contents renders food materials more susceptible to microbial infestation. Fibre content of 7.1% suggests a possible good bowel movement when consumed. The substantial amount of fibre in the seed oil of *D. edulis* showed that, it can be of help in proper functioning of the digestive system. The fibre content in seeds indicates ability to aid digestion and prevent the absorption of excess cholesterol in the body (Arawande and Borokini,

2010). The fat and oil content (55.7%) was moderately high. This confirms that *Dacryodes edulis* seed oil is a good source of oil, which is very important in diet as it promotes absorption of fat, soluble vitamins and provide high energy nutrient. The proximate composition *D. edulis* seed oil is promising and suggests obtaining commercial quantities for industries, pharmaceutical, cooking and other purposes (Okonkwo and Okafor, 2016). The mineral composition of the extracted seed oil is shown in Figure 2.

The mineral: K, P, Na, Ca, Fe, Zn, and Mg are present in the seed oil. Potassium had the highest value (106.5 µg/g), followed by phosphorous (103.5 µg/g), zinc (78.1 µg/g), iron (72.4 µg/g), calcium (66.2 µg/g), magnesium (64.7 µg/g) and sodium had the lowest concentration with value of 20.6 µg/g. Minerals are important constituents of human diet, they are needed for several physiological and metabolic processes (Bolajoko *et al*., 2017). The oil has higher potassium but lower concentration of sodium, the consumption of oil may reduce the incidence high blood pressure. Reports by Du *et al*. (2014) indicated higher concentration of potassium with lower concentration of sodium present hypertension and cardiovascular diseases. The presence of calcium and iron implies that the seed oil could prevent bone diseases; rickets, osteoporosis, osteomalacia and also enhances the effective use of iron in the system (Lee *et al*., 2021).

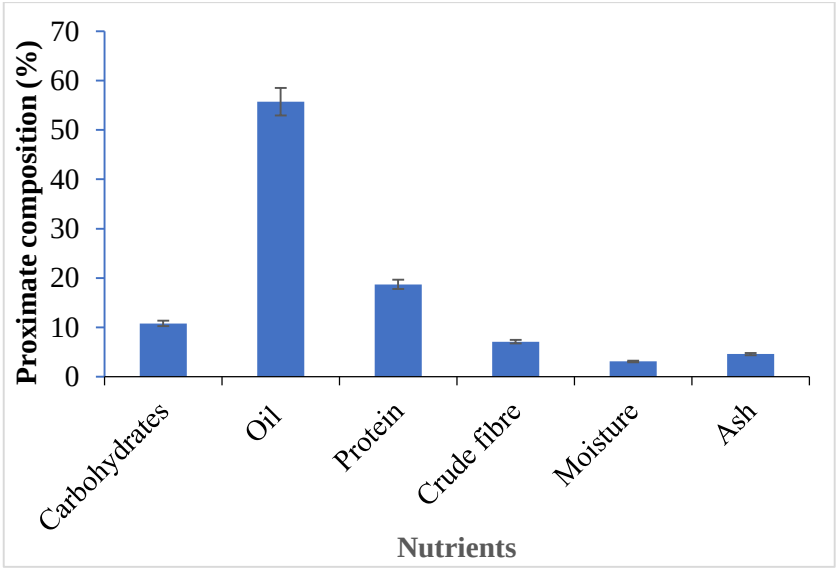



Figure 1. Proximate composition (%) of oil from *D. edulis* seed. Error bar is SD

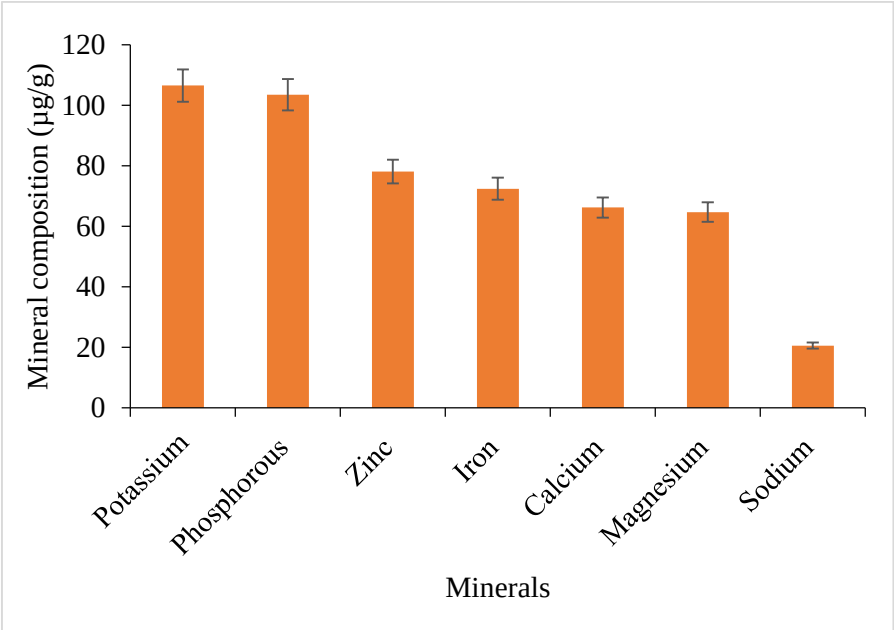



Figure 2. Mineral composition (µg/g) of oil from seed of *D. edulis.* Error bar is SD

Iron is required for biological functions such as proper functioning of the immune system, electron transfer reactions, gene regulation, cell growth and differentiation as well as binding and transport of oxygen (Siddiqui *et al*., 2014). Magnesium is required for the action of more than 300 enzymes in the body, where it participates in several significant physiological functions in the maintenance of good health and glucose homeostasis (Bolajoko *et al*., 2017). Zinc is known to play a crucial role as antioxidants in type 2 diabetic patients where it enhances reduction and neutralization of free radicals (Khan, 2014).

Table 2 shows the total colonies obtained from fresh fish and meat. In fish, the bacterial count (x $10^4$ cfu/g) of 3.56, 3.12, 1.90, 1.86, 0.97, 0.69 and 0.64 was recorded in mackerel, horse mackerel, blue whiting, croaker, hake and tilapia respectively. In meat, the bacterial count (x $10^4$ cfu/g) of 6.12, 5.40, 3.24, 2.48 and 2.37 was recorded in pork, chevon, beef, chicken and turkey respectively. The highest bacterial count was obtained in mackerel (3.56 x $10^4$ cfu/g) and in pork (6.12 x $10^4$ cfu/g), respectively.

Table 2: Microbial load of fish and meat

| Samples | Bacterial load (cfu/g) |
|---|---|
| Fish | |
| Blue whiting | 1.86 x $10^4$ |
| Croaker | 0.97 x $10^4$ |
| Hake | 0.69 x $10^4$ |
| Herrings | 1.90 x $10^4$ |
| Horse mackerel | 3.12 x $10^4$ |
| Mackerel | 3.56 x $10^4$ |
| Tilapia | 0.64 x $10^4$ |
| Meat | |
| Beef | 3.24 x $10^4$ |
| Chicken | 2.48 x $10^4$ |
| Chevon | 5.40 x $10^4$ |
| Pork | 6.12 x $10^4$ |
| Turkey | 2.37 x $10^4$ |

Tables 3 and 4 show occurrence of microorganisms from fish and meat, respectively. *S aureus, B. cereus*, *E. coli* (19.40%) *M. luteus* (14.50%), *S. pyogenes* and *P. aeruginosa* emerged as the most dominating microorganisms in fish and meat. In all microorganisms isolated, the least occurring bacteria were *S. marcescens*, *K. pneumoniae, L. plantarum*, *L. mesenteroides* and *P. vulgaris*. Fish is open to contaminated air in the markets and consumers freely touch it with contaminated hands from time to time when bargaining for prizes. Asides been exposed to contaminated air and hands, the fish are placed in an environment suitable for most microorganisms to thrive (Zhou *et al*., 2010). The low bacterial count of croaker (0.97 ×$10^4$ cfu/g) and hake (0.69 ×$10^4$ cfu/g) ascertained that, there were less exposure to contaminations in the market. These fish are mostly brought out from the deep freezer at the point of sales. This low microbial load could due to the facts that, at lower temperature, enzymatic activities and biochemical changes of lipids and proteins in fish are minimized, which will reduce microbial growth as well as deteriorative changes (Zhou *et al*., 2010). Total viable bacterial count (TVBC) of mackerel (9.97 × $10^5$ cfu/g) and horse mackerel (4.80 × $10^6$ cfu/g) purchased at King's market was recorded in a studies carried out by Bodunde *et al*. (2019). Findings of Ariyawansa *et al*. (2016) reported high microbial count of 2.0 ×$10^2$ to 2.0×$10^8$ cfu/g for fish examined in Negombo, Western province of Sri Lanka. Higher microbial count was obtained from pork (6.12 × $10^4$ cfu/g) than the other meat. Bodunde *et al*. (2019) recorded the TVBC for examined pork as 9.3x $10^5$ cfu/g. The bacterial load on beef, chevon, chicken, turkey and pork could be attributed to hygienic conditions at point of sales where the meat were collected, contamination before, during and after slaughtering. The source of contamination could also come from knives, clothes, air, workers, carts, boxes, and equipment or processing facilities, water used in dressing, apron, bags used in packaging, trays, and unhygienic selling points (Bakhtiary *et al*., 2016). Absence of fungal growth could be because of unfavourable conditions for their colonization due to higher water activity (<0.99) and pH (6-8) of fish and meat. These factors influence better colonization and growth of bacteria than fungi. This conformed to the findings by Thanigaivel and Anandhan (2015) who reported that retail raw meat is highly contaminated with bacteria than fungi. The most predominant bacteria isolated from studied fish are *S. aureus*, *B. cereus* and *E. coli* with occurrence of 31.80%, 28.40% and19.40%, respectively. In meat, *S. aureus, B. cereus*, *M. luteus*, *S. faecalis*, *P. aeruginosa* and *E. coli* appeared in all meat types with occurrence of 27.50%, 16.20%, 14.50%, 12.80%% and 11.10%, respectively. From the studies by Iroha *et al.* (2011) and Imarhiagbe *et al*. (2016), authors reported similar microorganisms in beef, chicken and chevron. Similarly, findings of Kumar *et al*. (2014) isolated *Staphylococcus, Salmonella* spp. and *E. coli* from beef, chevon, mutton, pork, and chicken sold in Karnataka State, India. Kind and number of microorganisms that will be present on or in food will be influenced by the kind and extent of contamination (Imarhiagbe *et al*., 2016).

The growth of contaminated microorganisms as well as their enzymatic activity on fish and meat, produce unpleasant odour, flavour, colour, appearance (Lawrie and Ledward, 2006). This

diminishes their shelf life and quality thereby making them unfit for consumption and therefore, require the use of natural preservatives to suppress the growth of spoilage microorganisms.

Tables 5 and 6 show the microbial load from mackerel and horse mackerel preserved with *D. edulis* seed oil. Fish and meat preserved with groundnut oil has microbial count of 0.15 x$10^6$ cfu/g to 3.97 x$10^6$ cfu/g and 0.07 x$10^6$ cfu/g to 6.04 x$10^6$ cfu/g for fish and meat respectively. Tables 7 and 8 show the microbial load of beef and chicken preserved with oil from *D. edulis* seed and groundnut. The findings reveal that the microbial count from fresh coated samples was higher than steam coated and fried samples. Crops, aromatic and medicinal plants produce essential oils in the form of secondary metabolites that can be used in food industries as antimicrobials and food preservative agents (Pandey et al., 2017). The effectiveness of oil from *D. edulis* seed as a preservative agent on muscle foods was highly appreciated and there was absence of microbial growth on fried fish and meat stored at low temperature (4°C). Findings of Gandotra (2012) and Khanipour *et al*. (2014) attributed to the killing of microorganisms, denaturation of proteins and microbial enzymes to low temperature. Low moisture content in seed oil prevent microbial growth and there was higher consumers acceptance due to appealing aroma, colour, taste contributed by *D. edulis* seed oil to final food products. Edible oil from seeds contain different bioactive compounds; linoleic, tocopherols, carotenoids, phytosterol, beta-carotene, nitrogenous compounds, minerals, vitamins, fatty acids and phenolic compounds (Pachuau et al., 2019 and Mazzocchi et al., 2021), which could be attributed to their bioactivities: antimicrobial, antioxidants, anti- inflammatory preservative quality. Findings from Anthony *et al*. (2003) revealed that oil from *Cymbopogon nardus, C. flexuosus,* and *Ocimum basilicum* and observed that they could significantly increase shelf-life of food up to 21days.

Table 3: Occurrence (%) of microorganisms isolated from different fish

| Bacterial isolates | A | B | C | D | E | F | G | Number of isolates | Occurrencem(%) |
|---|---|---|---|---|---|---|---|---|---|
| *Staphylococcus aureus* | + | + | + | + | + | + | + | 28 | 31.80 |
| *Bacillus cereus* | + | + | + | + | + | + | + | 25 | 28.40 |
| *Escherichia coli* | + | + | + | + | + | + | + | 17 | 19.40 |
| *Streptococcus pyogenes* | - | - | - | - | - | - | + | 5 | 5.70 |
| *Micrococcus luteus* | - | - | + | - | - | - | + | 5 | 5.70 |
| *Enterobacter aerogenes* | - | - | - | - | - | - | + | 3 | 3.40 |
| *Pseudomonas aeruginosa* | - | - | - | - | - | + | + | 3 | 3.40 |
| *Serratia marcescens* | - | - | - | + | - | - | - | 1 | 1.10 |
| *Klebsiella pneumoniae* | - | - | - | + | - | - | - | 1 | 1.10 |

Key: + = present, - = absent, A - Blue whiting (*Micromesistius poutassou*), B - Croaker (*Micropogonius undulatus*), C - Hake (*Merluccius merluccius*), D - Herrings (*Clupea pallasii*), E - Horse mackerel (*Trachurus trachurus*), F - Mackerel (*Scomber scombrus*) and G - Tilapia (*Oreochromis niloticus*)

Table 4: Occurrence (%) of microorganisms from different meat

| Bacterial isolates | A | B | C | D | E | Number of isolates | Occurrence (%) |
|---|---|---|---|---|---|---|---|
| *Staphylococcus aureus* | + | + | + | + | + | 32 | 27.50 |
| *Bacillus cereus* | + | + | + | + | + | 19 | 16.20 |
| *Micrococcus luteus* | + | + | + | + | + | 17 | 14.50 |
| *Streptococcus pyogenes* | + | + | + | + | + | 15 | 12.80 |
| *Pseudomonas aeruginosa* | + | + | + | + | + | 13 | 11.10 |
| *Escherichia coli* | + | + | + | + | + | 8 | 6.80 |
| *Enterobacter aerogenes* | + | - | - | + | - | 6 | 5.10 |
| *Lactobacillus plantarum* | - | - | - | + | - | 3 | 2.60 |
| *Leuconostoc mesenteroides* | - | - | - | + | - | 2 | 1.70 |
| *Proteus vulgaris* | - | - | + | - | - | 2 | 1.70 |

Key: + = present, - = absent, A- Beef (*Bos taurus*), B- Chicken (*Gallus gallus domesticus*), C- Chevon (*Capra aegagrus hircus*), D- Pork (*Sus scrofa domesticus*) and E- Turkey (*Meleagris gallopavo*).

Table 5: Microbial load of mackerel (*Scomber scombrus)* preserved with oil from *D. edulis* seed and groundnut

| Days | **Bacterial load (x$10^6$ cfu/g)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Preserved with *D. edulis* seed oil*** | | | | | **Preserved with Groundnut oil*** | | | | |
| | **A** | **B** | **C** | **D** | **E** | **A** | **B** | **C** | **D** | **E** |
| 1 | 0.91±0.00 | 1.21±0.00 | 0.29±0.00 | 0.12±0.00 | 0.00 | 1.17±0.00 | 1.06±0.01 | 0.41±0.00 | 0.29±0.00 | 0.15±0.00 |
| 2 | 1.89±0.00 | 1.46±0.00 | 0.63±0.00 | 0.19±0.00 | 0.00 | 2.51±0.01 | 1.21±0.00 | 0.65±0.00 | 0.35±0.00 | 0.18±0.00 |
| 3 | 2.17±0.01 | 1.74±0.00 | 0.72±0.00 | 0.22±0.00 | 0.00 | 2.96±0.00 | 1.38±0.00 | 0.68±0.00 | 0.39±0.00 | 0.26±0.00 |
| 4 | 2.37±0.00 | 1.92±0.00 | 0.80±0.00 | 0.29±0.01 | 0.08±0.00 | 3.02±0.00 | 1.56±0.00 | 0.87±0.00 | 0.43±0.00 | 0.33±0.00 |
| 5 | 2.68±0.02 | 1.98±0.00 | 1.00±0.00 | 0.32±0.00 | 0.12±0.00 | 3.48±0.02 | 1.79±0.00 | 0.96±0.00 | 0.64±0.00 | 0.39±0.00 |
| 6 | 2.96±0.30 | 2.18±0.00 | 1.14±0.00 | 0.32±0.00 | 0.18±0.00 | 3.72±0.10 | 1.79±0.00 | 1.84±0.00 | 0.51±0.00 | 0.48±0.00 |
| 7 | 3.47±0.40 | 2.46±0.00 | 1.22±0.00 | 1.02±0.00 | 0.24±0.00 | 3.97±0.11 | 1.90±0.00 | 2.93±0.00 | 0.53±0.00 | 0.59±0.00 |
| | **Fungal load (x$10^5$ sfu/g)** | | | | | | | | | |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.20±0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.50±0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | 0.60±0.00 | 0.00 | 0.30±0.00 | 0.00 | 0.00 | 0.90±0.00 | 0.00 | 0.20±0.00 | 0.00 | 0.40±0.00 |
| 5 | 1.50±0.00 | 0.00 | 0.90±0.00 | 0.00 | 0.00 | 1.80±0.00 | 0.00 | 0.40±0.00 | 0.00 | 0.90±0.00 |
| 6 | 2.10±0.00 | 0.00 | 1.30±0.00 | 0.00 | 0.00 | 2.50±0.00 | 0.00 | 1.00±0.00 | 0.00 | 0.90±0.00 |
| 7 | 2.90±0.00 | 0.00 | 1.50±0.00 | 0.00 | 0.00 | 3.10±0.00 | 0.00 | 1.60±0.00 | 0.00 | 1.30±0.00 |

Key: A= Coated fish with oil stored at 37˚C. B= Coated fish with oil stored at 4˚C, C=Steamed and coated fish with stored at 37˚C, D=Steamed and coated fish with oil stored at 4˚C, E= Fried fish with oil stored at 37˚C and * fish fried with extracted oil or groundnut oil and stored at 4˚C have no microbial growth, 0.00-no microbial growth, Sd< 0.00 indicate <

Table 6: Microbial load of horse mackerel (*Trachurus trachurus)* preserved with oil from *D. edulis* seed and groundnut

| ays | **Bacterial load (x$10^6$ cfu/g)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Preserved with *D. edulis* seed oil*** | | | | | **Preserved with Groundnut oil*** | | | | |
| | **A** | **B** | **C** | **D** | **E** | **A** | **B** | **C** | **D** | **E** |
| 1 | 0.89±0.00 | 0.42±0.30 | 0.36±0.00 | 0.24±0.00 | 0.00 | 1.03±0.01 | 0.64±0.00 | 0.47±0.00 | 0.30±0.00 | 0.32±0.00 |
| 2 | 1.86±0.00 | 0.42±0.00 | 0.39±0.00 | 0.24±0.00 | 0.00 | 2.15±0.00 | 0.69±0.00 | 0.54±0.00 | 0.38±0.00 | 0.41±0.00 |
| 3 | 2.14±0.00 | 0.58±0.00 | 0.48±0.00 | 0.28±0.00 | 0.00 | 2.54±0.00 | 0.85±0.00 | 0.95±0.00 | 0.56±0.00 | 0.59±0.00 |
| 4 | 2.68±0.02 | 0.65±0.10 | 0.82±0.00 | 0.40±0.00 | 0.00 | 2.79±0.00 | 1.09±0.00 | 1.26±0.00 | 0.62±0.00 | 0.59±0.00 |
| 5 | 2.84±0.10 | 0.72±0.01 | 1.04±0.00 | 0.45±0.00 | 0.28±0.00 | 3.14±0.10 | 1.42±0.00 | 1.45±0.20 | 0.71±0.00 | 0.68±0.00 |
| 6 | 3.08±0.01 | 0.85±0.11 | 1.30±0.00 | 0.48±0.00 | 0.37±0.00 | 3.58±0.20 | 1.57±0.00 | 1.64±0.11 | 0.71±0.00 | 0.75±0.00 |
| 7 | 3.39±0.11 | 0.85±0.00 | 1.41±0.00 | 0.59±0.00 | 0.41±0.00 | 3.80±0.30 | 1.64±0.00 | 1.82±0.00 | 0.74±0.00 | 0.88±0.00 |
| | **Fungal load (x$10^5$ sfu/g)** | | | | | | | | | |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.30±0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.60±0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.90±0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.30±0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Key: A= Coated fish with oil stored at 37˚C. B= Coated fish with oil stored at 4˚C, C=Steamed and coated fish with stored at 37˚C, D=Steamed and coated fish with oil stored at 4˚C, E= Fried fish with oil stored at 37˚C and * fish fried with extracted oil or groundnut oil and stored at 4˚C have no microbial growth

Table 7: Microbial load of beef (*Bos taurus)* preserved with oil from *Dacryodes edulis* seed and groundnut

| Days | **Bacterial load (x10$^6$ cfu/g)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Preserved with *D. edulis* seed oil*** | | | | | **Preserved with Groundnut oil*** | | | | |
| | **A** | **B** | **C** | **D** | **E** | **A** | **B** | **C** | **D** | **E** |
| 1 | 0.66±0.01 | 0.45±0.01 | 0.38±0.01 | 0.00 | 0.00 | 1.62±0.00 | 1.05±0.00 | 0.49±0.00 | 0.26±0.00 | 0.00 |
| 2 | 0.64±0.00 | 0.63±0.00 | 0.52±0.00 | 0.25±0.00 | 0.00 | 1.96±0.00 | 1.07±0.01 | 0.98±0.01 | 0.46±0.01 | 0.00 |
| 3 | 1.01±0.00 | 0.84±0.00 | 0.63±0.00 | 0.37±0.00 | 0.00 | 2.03±0.00 | 1.16±0.00 | 1.09±0.00 | 0.46±0.00 | 0.00 |
| 4 | 1.08±0.00 | 0.94±0.01 | 0.75±0.01 | 0.37±0.00 | 0.00 | 2.24±0.00 | 1.14±0.00 | 1.17±0.00 | 0.58±0.00 | 0.00 |
| 5 | 1.31±0.00 | 1.15±0.00 | 0.75±0.00 | 0.32±0.00 | 0.00 | 3.04±0.01 | 1.23±0.01 | 1.21±0.00 | 0.63±0.01 | 0.07±0.01 |
| 6 | 1.72±0.01 | 1.33±0.01 | 0.84±0.00 | 0.42±0.00 | 0.11±0.00 | 5.40±0.00 | 1.44±0.00 | 1.36±0.01 | 0.66±0.00 | 0.18±0.01 |
| 7 | 2.02±0.01 | 1.53±0.00 | 0.89±0.00 | 0.42±0.00 | 0.23±0.00 | 5.96±0.00 | 1.57±0.00 | 1.42±0.00 | 0.72±0.00 | 0.38±0.02 |
| | **Fungal load (x10$^5$ sfu/g)** | | | | | | | | | |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.70±0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | 0.20±0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.90±0.00 | 0.00 | 0.90±0.00 | 0.00 | 0.30±0.02 |
| 5 | 0.40±0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.20±0.00 | 0.00 | 0.90±0.00 | 0.00 | 0.30±0.03 |
| 6 | 0.70±0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.20±0.00 | 0.00 | 1.50±0.00 | 0.00 | 0.50±0.03 |
| 7 | 1.10±0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.30±0.01 | 0.00 | 1.60±0.01 | 0.00 | 0.80±0.03 |

Key: A= Coated fish with oil stored at 37˚C. B= Coated fish with oil stored at 4˚C, C=Steamed and coated fish with stored at 37˚C, D=Steamed and coated fish with oil stored at 4˚C, E= Fried fish with oil stored at 37˚C and *beef fried with extracted oil or groundnut oil and stored at 4˚C have no microbial growth

Table 8: Microbial load ($10^6$ cfu/g)) from chicken (*Gallus gallus domesticus)* preserved with oil from *Dacryodes edulis* seed and groundnut

| Days | **Bacterial load** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Preserved with *D. edulis* seed oil** | | | | | **Preserved with Groundnut oil** | | | | |
| | **A** | **B** | **C** | **D** | **E** | **A** | **B** | **C** | **D** | **E** |
| 1 | 0.95±0.00 | 0.84±0.00 | 0.65±0.00 | 0.14±0.00 | 0.00 | 1.89±0.00 | 1.34±0.00 | 0.74±0.00 | 0.22±0.00 | 0.00 |
| 2 | 1.12±0.02 | 0.93±0.00 | 0.71±0.00 | 0.19±0.00 | 0.00 | 2.04±0.00 | 1.48±0.00 | 0.92±0.00 | 0.22±0.03 | 0.00 |
| 3 | 1.38±0.00 | 0.99±0.00 | 0.78±0.02 | 0.24±0.00 | 0.00 | 2.36±0.00 | 1.54±0.00 | 1.07±0.00 | 0.46±0.00 | 0.16±0.00 |
| 4 | 1.76±0.01 | 1.07±0.10 | 0.92±0.00 | 0.24±0.01 | 0.00 | 2.79±0.10 | 1.67±0.00 | 1.28±0.00 | 0.49±0.00 | 0.19±0.00 |
| 5 | 2.08±0.00 | 1.24±0.20 | 1.06±0.01 | 0.37±0.00 | 0.15±0.00 | 4.15±0.00 | 1.69±0.01 | 1.32±0.00 | 0.55±0.00 | 0.24±0.00 |
| 6 | 3.42±0.07 | 1.24±0.00 | 1.17±0.00 | 0.48±0.00 | 0.24±0.00 | 5.86±0.00 | 1.75±0.00 | 1.49±0.00 | 0.58±0.00 | 0.37±0.00 |
| 7 | 3.95±0.02 | 1.45±0.02 | 1.35±0.02 | 0.55±0.00 | 0.37±0.00 | 6.04±0.20 | 1.89±0.00 | 1.51±0.00 | 0.64±0.02 | 0.43±0.00 |
| | **Fungal load (x$10^5$ sfu/g)** | | | | | | | | | |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.40±0.00 | 0.00 | 0.00 | 0.00 | 0.50±0.00 |
| 6 | 0.20±0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.40±0.00 | 0.00 | 0.00 | 0.00 | 0.80±0.00 |
| 7 | 0.50±0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.60±0.00 | 0.00 | 0.20±0.02 | 0.00 | 1.40±0.03 |

Key: A= Coated meat with oil stored at 37˚C. B= Coated meat with oil stored at 4˚C, C=Steamed and coated meat with oil stored at 37˚C, D=Steamed and coated meat with oil stored at 4˚C, E= Fried meat with oil stored at 37˚C and *chicken fried with extracted oil or groundnut oil and stored at 4˚C have no microbial growth

*Cymbopogon flexuosus* oil is capable of protecting against rotting of *Malus pumilo* fruits for up to 3weeks (Shahi *et al*., 2003). Vegetable oils from plant seeds have pronounced antimicrobial and food preservative properties because they consist of a variety of active constituents (terpenes, terpenoids, carotenoids, saponins and alkaloids) that have great significance in the food industry (Siddeeg and Xia, 2015). The broad spectrum antimicrobial properties in mushroom extracts was attributed to presence of free fatty acids identified by GCMS (Ogidi *et al*., 2015). Hence, the presence of fatty acid such as oleic acid in *Dacryodes edulis* seed oil could be responsible for its preservative effect in food, which can be exploited for preservation of perishable products. Table 9 shows the sensory evaluation of fried fish and meat with *D. edulis* seed oil and groundnut oil. On the first and eighth day, fish and meat fried with extracted oil had higher rating for taste, colour, aroma and texture than those fried with groundnut oil. The organoleptic properties of fried fish and meat with *Dacryodes edulis* seed oil by panelists revealed that, on the first day of preservation, food samples fried with *D. edulis* seed oil showed higher acceptability (9.00 – 8.60) with no significant difference in taste, aroma, colour and texture compared to food samples fried with groundnut oil (7.80 – 6.70). On the eighth day of preservation, the rate of acceptability varied significantly with fish and meat fried with groundnut oil having the lowest acceptability (4.60 – 2.60). Food samples fried with *D. edulis* seed oil retained their higher acceptability rate with only slight differences in taste and colour. Frying is a type of food preservation that imparts unique flavor and texture to foods (Egwim *et al*., 2015). The very high value in texture of food samples fried with *D. edulis* seed oil is an indication that the oil drastically reduced the moisture content of the food samples thereby avoiding the entry of microorganisms to minimum level. Thus, *D. edulis* seed oil is very suitable for frying fish and meat, thus elongating the shelf life of muscle foods. Edible plant oils are reported by the United States Food and Drug Administration to have a Generally Regard As Safe status and are approved as flavour or food additives (Pandey *et al*., 2017).

Table 9: Sensory properties of fish and meat preserved by frying with oil from seed of *Dacryodes edulis* on the first and eighth day

| | | **Fish** | | **Meat** | |
|---|---|---|---|---|---|
| **Properties** | **Day(s)** | **A** | **B** | **C** | **D** |
| Taste | 1 | 8.60±0.22 | 7.80±0.46 | 8.90±0.10 | 8.20±0.32 |
| | 8 | 6.20±0.32 | 2.60±0.37 | 8.40±0.22 | 6.70±0.21 |
| Colour | 1 | 9.00±0.00 | 7.10±0.37 | 9.00±0.00 | 8.60±0.16 |
| | 8 | 8.70±0.15 | 2.70±0.39 | 8.50±0.40 | 6.70±0.33 |
| Aroma | 1 | 8.90±0.10 | 7.10±0.60 | 8.70±0.15 | 8.40±0.16 |
| | 8 | 8.20±0.20 | 4.60±0.65 | 7.90±0.43 | 6.80±0.32 |
| Texture | 1 | 8.70±0.15 | 6.70±0.26 | 9.00±0.00 | 8.80±0.13 |
| | 8 | 9.00±0.00 | 3.50±0.45 | 9.00±0.00 | 6.90±0.40 |

Key: A– Fish fried with extracted oil, B – Fish fried with groundnut oil, C– Meat fried with extracted oil, D – Meat fried with groundnut oil

## CONCLUSIONS

Fish and meat preserved with oil from *D. edulis* reduced the microbial growth when stored at 374$^{o}$C and 4$^{o}$C for days. The preservative of *D. edulis* seed oil confirmed its quality for cooking and most importantly for use in food industries. Organoleptic properties of fish and meat preserved with oil from *D. edulis* seed are preferred by consumers since the quality of preserved fish and meat was retained. *D. edulis* seed oil can be regarded as a good source of edible oil, having good assured quality of maximum preservation. The seed oil can be shelved without deteriorating for longer period. *Dacryodes edulis* seed oil as a rich source of protein, crude fibre, potassium, and phosphorus. *Dacryodes edulis* seed oil can be considered an excellent preservative agent, good taste and nutritious like other common vegetable oils in our markets.

**Conflict of interest**
No conflict of interest

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