ISSN: 2754-4915

Journal of Material Sciences & Manufacturing Research

SCIENTIFIC Research and Community

Review Article

Open Access

Processing of Indigenous Food Materials for Food Preservation and Security: The Case of Avocado (Persea Americana) Fruit

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Received: July 15, 2025; **Accepted:** July 21, 2025; **Published:** July 29, 2025

Introduction

Indigenous food materials encompass materials such as: plants, animals, insects, etc., that are native to a specific region and have been traditionally used for food by the indigenous people of that area. The foods are whole and unprocessed. The include: grain cereals, leafy vegetables, tropical fruits, legumes, starchy stems, wild yams, root tubers, edible insects, etc. These food substances are cultivated spontaneously, following the climatic seasons. The need for cultural preservation, nutritional security, food sovereignty, etc., makes the study of the processing of indigenous food substances remarkable. Ordinarily, they are underutilized and a lot of them are wasted. [AI Overview indigenous food materials] [Indigenous Food - an overview | ScienceDirect Topics] [Food Sovereignty | USFSA) (Nutrition security is more than food security | Nature Food] There are several issues which necessitate studying indigenous food system in general. Some of these considerations are: wars, inflation, climate change, industrialization, etc. These issues need management that will give consumers the right to healthy food always. A well-informed society who chooses local and healthy food is acceptable. Some of the indigenous foods in Nigeria are: fruits, leafy vegetables, cereals, roots and tubers, spices, etc. The benefits of producing and consuming indigenous foods are: access to high nutrition of the foods, medicinal value intake, availability of seeds, affordability, etc. However, some of the local foods are going extinct due to challenges. The unavailability of some indigenous foods in the local areas are due to: urbanisation, extinction of seeds to plant, lack of access to storage facilities, poor weather conditions, unavailable markets for products, etc. [NIGERIA-INDIGENOUS-FOOD-Final.pdf] These are challenges in ensuring food security and food preservation in using the traditional food systems. There are facts on the strength and promise of local traditional food systems to improve health and well-being. [Indigenous Peoples's food systems & well-being] The artificial fermentation of foods by man existed before history. It is the oldest method of preserving perishable foods. Preservation of food by fermentation makes foods available for future. The nutritional value produced by fermentation is of good benefit too. [Nigerian Indigenous Fermented Foods: Processes and Prospects | IntechOpen] This write-up explains the processing, consumption and preservation of Avocado fruit.

Development of innovative food packaging techniques gives safe and high-quality food products that meet growing market needs and consumers' preferences. Advanced food packaging brings indigenous foods into a global spotlight and emphasizes the economic and commercial importance of such foods. The consumption of fermented foods has increased because of the increased health benefits. Appropriate packaging material plays important role in maintaining the therapeutic activity of foods throughout the shelf life. [Packaging and packaging technology for indigenous fermented foods in the tropics: challenges and opportunities - ScienceDirect]

Nigeria is blessed with abundant crops and animals' products. The indigenous foods are diverse and many, both in size and category. If these foods are well processed, they would be used for all groups of people. The technology for processing and preserving indigenous foods are lacking in many cases. This has caused wastage and lack of such foods. Acceptable technology for processing, packaging and preservation of indigenous foods will give abundant food for all. Challenges of food storage faced in Nigeria and many parts of the world have similar cases of contamination. Food storage systems of indigenous people who kept to long-evolved cultures and patterns of living in local ecosystems present a network of knowledge. [Indigenous Peoples' Food Systems: the many dimensions of culture, diversity and environment for nutrition and health] This study gives the approach for processing and preservation of avocado fruits. This would add to national development. [Potentials of Nigerian Indigenous Food Products for Addressing Nutritional Needs of Persons in Internally Displaced Persons' Camps (I. D. P. Camps)]

Food Processing

Food processing is the changing of agricultural products into food or the changing of one form of food into other forms. It is the process of transforming food items into a form that can also be used. It covers the processing of raw materials into food through different physical and chemical processes. Some of the processing methods are: mincing, cooking, canning, liquifying, pickling, macerating, emulsifying, etc. Clean crops and animal products are used to produce attractive, marketable and life-long food products. However, food processing could lower the nutritional value of the food. Some additives used for food preservation might have adverse health effect.

Food Processing has the following Objectives

- The shelf life of the food is prolonged when the food is well processed and preserved.
- Contamination of the food is avoided in storage.
- Good storage and transportation of the processed food are ensured.
- Raw food materials are changed into attractive and marketable products
- Processing and preservation of foods give employment.

Food preservation is a process used to prevent the growth of fungi, bacteria and many other microorganisms from attacking the food. Food preservation methods are: washing, chopping, pasteurizing, freezing, cooking, fermenting, drying, cooling, freezing, heating, pickling, etc. The processes slow down the oxidation of fats that would lead to rancidity and thereby prevent the food from spoiling. [Food Processing - Methods, benefits & Drawbacks of Food Processing] Food processing uses methods to ensure the preservation of food substances to extend their shelf-life. Processing of food enables it to last for weeks, months and years. It is also a method used to turn food into another food products. Many changes are made on the food when it is being processed for preservation. Chemical substances which are not harmful could be added to the food for preservation. Foods such as: tomato, meat, fish, onion, vegetable, milk, etc., are used. Methods of food processing are:

- **Fermentation:** This is the breakdown of sugar by bacteria, yeast and other microorganisms, with certain enzymes under anaerobic conditions. Therefore, for fermentation to take place, oxygen is not needed. Fermentation is used in the production of beverages such as wine, beer and also in the processing and preservation of other food substances such as yoghurt, dry sausage, etc.
- **Drying:** This is one of the oldest methods known in processing of food substances for preservation. This method is based on the removal of water or moisture present in the food. A moisturized environment is a medium for culturing bacteria and other harmful microorganisms that could attack the foods. The removal of water extends the shelf life of the food product. Drying can be done by application of hot air or subjection to high temperatures, etc. Food products that can be dried are fish, meat, tomatoes, plantain and many others.
- **Freezing:** This is one of the commonest methods of food processing. The market demand for frozen products is high. Freezing of food increases the shelf life by inhibiting or stopping the growth of bacteria and other micro-organisms. A refrigerator is used to get frozen products. Also, subjecting food to cool air using liquid Nitrogen at the temperature range of -123.33°C to -206.67°C in a cold room freezes the food products.
- **Pasteurization:** This method is used for milk. The food product is subjected to treatment under mild heat of about 72°C for about 16 seconds and it is cooled to about 4°C afterwards. This process deactivates the microorganisms. It has minimal effect on the nutritive value of the food product. Apart from dairy products such as milk, pasteurization is also used for other food products as canned food, juice and alcoholic beverages.
- **Smoking:** This is a method of processing food for preservation. The food is exposed to smoke generated from the burning of wood. The heat from the burning wood kills the microbes present in the food product. Foods processed using this method include meat, fish, cheese etc.
- **Incorporation of Additives:** Food additives are some chemical substances that help in the processing and preservation of food to retain its freshness, appearance and taste. They are added to maintain the quality of the food and also increase the shelf life. Fats and oil turn rancid without additives and so antioxidants are added to prevent this and reduce the growth of micro-organisms.
- Importance of food processing
- It makes food products edible. Most food crops such as: grains, wheat, corn, beans, etc., are not edible in their natural state. Processing techniques are used to make them edible for human consumption without changing their nutritive value.
- Food products are also processed to extend their shelf life and to preserve them.
- Processing of food enhances the quality of the food. Components such as: Vitamin D and other nutrients are added. Also, reducing of fat level, salt or sugar in the food are achieved. However, components like fibre, minerals and vitamins could be lost due to excessive freezing or heating of the food product.
- Well processed and packaged food products are easier to transport to various places without stress. [What Is Food Processing? 6 Methods And 5 Importance of Food Processing | Example NG]

Avocado

Avocado is native to Central America. It is grown in warm temperate and subtropical climates throughout the world. The pulp of this fruit contains about 60% oil, 7% skin, and about 2% seed. The lipid content is monounsaturated fatty acids and it is associated with cardiovascular health system and anti-inflammatory properties [1,2].

Food Values of Avocado Fruits; The Oil Extract

Avocado oil has nutritional and technological characteristics. There are no international regulations on the quality of the oil. The parameters used is as stated for olive oil by the Codex Alimentarius or the International Olive Oil Council. The quality of avocado oil depends on the quality and maturity of the fruit and the extraction technique in relation to temperature, solvents and conservation. Classification for avocado oil is based on its extraction method and fruit quality. Avocado oil of high quality, described as extra virgin is produced from high-quality fruit and is extracted with mechanical methods, using a temperature below 50°C and without the use of chemical solvents. Virgin avocado oil is produced with fruit of lower quality than that for extra virgin. The fruit may have areas of rot and physical changes and are extracted by mechanical methods using a temperature below 50°C and without the use of chemical solvents. Pure avocado oil is produced from fruits where the quality is not considered. The oil is bleached and deodorized and infused with natural flavour of herbs or other fruits. Mixed avocado oil is combined with olive, macademia and other oils. Crude oil from avocado is a slightly amber-colored fatty liquid, produced by physical extraction of the pulp and the seed of the fruit (Persea americana). Edible avocado oil is a product with about 98.5% refined avocado oil.

Avocado has a high humidity of 70 to 80%. The pulp is dried at about 60°C under vacuum. The parameters assessed for quality are acidity index, peroxide value, iodine value, amount of oleic acid, refractive index, electrical conductivity, content of carotenoids, chlorophyll, phenolic compounds, antioxidant activity, oxidative stability, etc. The bioactive compounds are not destroyed when the avocado pulp is dried at 60°C with air ventilation and mechanical pressing. Higher antioxidant activities and vitamin E content are

contained in oil extracted from pulp that is dried with hot air [1,2].

Extraction Methods for Avocado Oil

Cold Pressed Method

This method involves grinding of the pulp which results in the breaking of the parenchyma cells. The oil carriers (idioblastic cells) are maintained. The oil production increases when the pulp is beaten at 45.5°C for 2 hours. There is high concentration of tocopherol, squalene, campesterol, cycloartenol acetate and a relatively low yield of the oil when the extraction method is compared to that of Soxhlet extraction method. Drying by lyophilization give oil yield with high concentration of antioxidants and other bioactive compounds [1,2].

Ultrasound-Assisted Aqueous Extraction Method (UAAE)

In this method, cavitation forces generated by acoustic waves are applied to open the cell walls of the oil-containing cells. Emulsion is formed which facilitates the extraction. The method is carried out using ultrasonic bath or ultrasonic horn transducer. The frequency conditioning of: 0.4MHz, 0.6MHz, 2MHz, etc., for 5 mins of 90kJ/kg of avocado puree will increase oil extraction and reduce the beating time [1,2].

Supercritical CO_2 Method

This method uses supercritical fluids. Extraction is done at a pressure of 400 bar and a temperature above its critical point of 31.1°C. Supercritical CO_2 is not harmful. The method gives a high performance. Ethanol is used as a co-solvent to extract the residual oil, which is enriched in tocopherols. Generally, the quality of the oil is determined in terms of free fatty acid titration, peroxide index, iodine index, saponification, and specific gravity, etc., according to the American Oil Chemists' Society (AOCS) standards. Oils extracted by supercritical CO_2 gives low acidity index, low oxidation of unsaturated fatty acids and higher iodine index when compared with the other methods [1,2].

CO_2 Subcritical Method: Extraction with subcritical CO_2 works with the same principle as supercritical CO_2 extraction but with a temperature below 31.1°C and a pressure of 72.9 bar.

Enzymatic Extraction: The extraction is done by centrifugation with the incorporation of enzymes. Such enzymes are: pectinases, α-amylase, proteases and cellulase. The oil yield depends on the concentration and type of enzyme used, the reaction time and percentage of water used. This method improves the oil in comparison with the performance of a non-enzymatic centrifugation.

Solvent Extraction: Soxhlet extraction method gives the most reproducible results [1].

Conservation of Avocado Oil: Conservation of oils increases the useful life (shelf life) of the product. Physical techniques such as: the electric field method, the oxidative stability method, etc., are used. Electric field with the capacity: 9 kV cm−1, 720 Hz, 5 and 25 mins, allows the polyphenol oxidase enzyme present in the avocado pulp to be inactivated, preserving the components present in the avocado oil. The changes in the quality of the refined oil analyzed in terms of acidity index, peroxides and iodine value are minimal. The electric field method is an alternative to the addition of synthetic antioxidants [1-3].

The oxidative stability is ensured by finding the antioxidant activity which reduces ferric ion. The ferric-reducing antioxidant power (FRAP) analysis considers the reducing ability of antioxidants in reducing Fe3+-2,4,6-tripyridyl-s-triazine complex at the absorbance of 593nm [1-3].

Analytical Techniques for the Assay and Quantification of Avocado Oil: The components in avocado oil, such as: fatty acids and phytosterols are quantified by gas chromatography, coupled with a flame ionization detector (GC-FID). Techniques, such as ultra-high-performance liquid chromatography (UHPLC), coupled with mass spectrometry (UHPLC-MS) or a photodiode array detector (UHPLC-PDA), as well as inductively coupled plasma mass spectrometry (ICP-MS), are used for the identification and quantification of analytes, such as polyphenols, squalene and minerals, respectively. The qualitative determination of the components present in avocado oil could be done using 13C nuclear magnetic resonance spectroscopy (NMR), for the identification of major components, such as: fatty acids. H Nuclear Molecules 2019, 24, 2172 7 of 21 magnetic resonance spectroscopy (1H-NMR) was used for the detection of the minor components present in other vegetable oils. FTIR combined with multivariate calibrations is used to detect and quantify the adulteration of avocado oil in binary mixtures with palm oil and canola oil. The adulteration of avocado oil with soybean oil or grape seed oil can be determined using mid-infrared spectroscopy. Organophosphorus pesticides in samples of commercial avocado oil are determined using atmospheric pressure microwave-assisted liquid–liquid extraction (APMAE), with solid-phase extraction or low-temperature precipitation. Spectroscopic techniques focused on determining the adulteration of avocado oil with the presence of other types of vegetable oil [1-3].

Applications of Avocado Oil: It is used for the production of healthy foods that could maintain their nutritional properties over time. Avocado oil is used for direct consumption. It has fatty acids, vitamins, antioxidants, etc. It is also used for industrial purposes in: emulsions productions, due to its physical and chemical stability, as well as the high bioavailability of its lipid components, etc [1-3].

Composition of Avocado Oil: Avocado oil has a thermal stability of about 176°C. It has a lower concentration of total phenolic compounds when compared with olive oil, although the antioxidant activity of avocado oil is similar to that of olive oil. The presence of compounds with nutritional interest, such as unsaturated fatty acids as well as compounds with biological activity, such as tocopherols, tocotrienols, phytosterols, carotenoids, and polyphenols, have made the studies on avocado oil necessary, for enhancing good health. Avocado oil is characterized as a monounsaturated oil, with polyunsaturated fatty acids, similar to olive oil. It contains other bioactive compounds, present in the unsaponifiable fraction, such as tocopherols, polyphenols, and a remarkable proportion of phytosterols. This oil has stability at high temperatures. These characteristics show that avocado oil has properties that are useful for technological applications too. [1-3]

Avocado Seed Oil: Avocado seed is made up of a large number of extractable polyphenols, which have attracted attention due to their high antioxidant capacity. It was found that, with a higher power of the ultrasound (0–104 W) and increase of the temperature (20–60°C), the polyphenol content and antioxidant capacity were increased. It has a high fatty acid profile in linoleic acid and linolenic acid. The antioxidant activity, is low. it is higher in the saponifiable fraction than in the unsaponifiable fraction, which is attributed to the presence of polyphenols and steroids. The quality parameters, such as: acidity, peroxide, saponification,

iodine, and specific gravity indexes, are similar to those for extra virgin olive oil. The composition of oil from the pulp and seed are different in the lipid content. The parameters of oil quality such as: refractive index, gravity, peroxide index, etc., are similar for both oils. The iodine, acid index, and saponification index were higher in seed oil than in pulp oil. The seed oil has a greater variety of fatty acids than pulp oil. Also, the fatty acid profile for the pulp is more concentrated in monounsaturated fatty acids than that of seed, and conversely, the seed oil is much more concentrated in polyunsaturated fatty acids than pulp oil [1].

Literature Review

Avocado fruit is rich in monounsaturated fat and contains high amount of important lipid-soluble compounds such as: vitamin E, β-sitosterol and carotenoids. The consumption of avocado fruit is related to its potential benefits. The increase of avocado production, short time of maturation and easy oxidation of avocado fruit, promote the production of oil from avocado fruit [2]. Avocado has high lipid content. It contains antioxidants and phytochemicals such as: carotenoids, chlorophylls, polyphenols, tocopherols, and phytosterols. It contains dietary fiber, vitamin C, and Potassium, etc. Avocado consumption promotes cardio vascular health. It supports healthy aging. Avocado seed contains about 2% oil. Most commercial avocado oil is extracted from the flesh (pulp). Among the total lipids' content, more than 95% is neutral lipids and 87% are triglyceride. The fatty acid composition depends on the species, ripening stage, geographical growth, location and the extraction method. Avocado oil has monounsaturated fatty acid (oleic acid) similar to that of olive oil. [2] Both palmitic acid (saturated fatty acid) and linoleic acid (polyunsaturated fatty acid) are in avocado oil. Carotenoids (lutein), tocopherols (vitamin E) and phytosterols (β-sitosterol) are the most important lipid-soluble compounds, which are in avocado oil. Lutein is good for the improvement of eye due to diseases from age-related macular degeneration and cataracts. Phytosterols reduces serum total cholesterol and LDL-cholesterol by competing with cholesterol in the intestine for uptake in hypercholesterolemic people. High concentration of chlorophylls is found in virgin/crude avocado oil. It contributes to the appearance (emerald-green colour) and health profile of the avocado oil. The concentration of pigments such as: chlorophylls, carotenoids, etc., increases in the oil with increase in the proportion of avocado skin added to pulp during oil extraction [1,2].

Extraction Methods

Crude oil is generated by techniques of centrifugation, pressing, solvent extraction, etc. Pretreatment of the fruits affects the oil extraction yield. Lipids are in the avocado mesocarp. The mesocarp is composed of the parenchyma cells and idioblasts. The parenchyma cells contain well distributed oil emulsion while the idioblast has one large oil sac. The idioblastic oil cell is about the diameter of 75 μm and thicker cellular wall compared to the parenchyma cells. The primary walls of the parenchyma cells can be degraded by the activity of cellulase and polygalacturonase during ripening, but the suberized walls of the idioblastic cells are not affected due to the immunity from the activity of its enzymes. Extraction processes coupled with mechanical, enzymatic and thermal pretreatments are used to rupture the structure of the cell walls in order to increase the release of oil from the cellular bodies and enhance oil extraction [1-3].

Aqueous Separation: Aqueous extraction is a traditional process used to recover oil from plant resources. Aqueous separation of avocado oil is done by enzymatic or mechanical infiltration of the tissue cells containing lipids followed by centrifugation or pressing to separate the oil from the oil-water emulsion. There are: enzymatically assisted centrifugation separation, mechanically assisted centrifugation separation and mechanically assisted hot water separation methods [1-3].

Pressing Extraction: This refers to oil extraction by pressing or squeezing of oily materials with screw press or hydraulic press. Pressing technology is used to squeeze oil from oilseed materials such as sesame which have relatively high oil content [2]. Compared with some oilseeds, avocado pulp has high moisture content (about 77%). Its cellular contents are different too. The water content of fruit pulp affects the oil production from it. There is need for pretreatment preparation of avocado pulp before the generation of oil from it.

Some of the Pretreatment Methods are:

- Slicing and sun drying of avocado pulp
- Microwave-oven drying
- Addition of solid additives to enhance the oil production. Oven-drying and sun-drying to 4%-5% water content may produce poor oil quality. Microwave-oven drying process reduces the drying time. Addition of solid additives reduces moisture and increases viscosity to increase the oil production. Appropriate heating is used for the extrusion process [1,2,3].

Solvent Extraction: Organic solvent extraction is used to separate oil from sources. The avocado fruit is sliced, dried and grounded and the oil is extracted with organic solvents. Solvents such as Hexane, Acetone, etc., are used. Supercritical fluid extraction could be used for such separations too. Supercritical Carbon dioxide is a green solvent and it has biological safety with no solvent residue in the final product [1]. Avocado pulp could be dried in air circulation oven at 40°C and 60°C and in vacuum oven at 60°C. The acidity, peroxide value, iodine, refractive indices; phenolic compounds; carotenoids; chlorophyll; tocopherols; antioxidant activity; fatty acid profiles; ratio between hypocholesterolemic and hypercholesterolemic fatty acids (h/H); atherogenic and thrombogenic indices, would be checked. Avocado fruit is nutritionally complete. It is widespread. Due to the functional properties and nutritional values, research of avocado fruit, seed, leaves and oil has increased. The benefits are associated with health protective effects. The reduction of the risk of coronary heart disease, plasma reduction of low-density lipoproteins without affecting high-density lipoproteins, as well as the prevention of cataract, diabetes and prostate cancer, lipid-lowering effect, hypotensive effect, cardio-protective property, diabetes management, anti-arthritic property, periodontal disease management, skin and wound healing and enhancement of nutrients absorption are considered. The fruit has a high potential for oil extraction. The main compounds associated with the beneficial effects of avocado oil are mono unsaturated fatty acids, phytosterols and other bioactive compounds with antioxidant potential [1]. The different varieties of avocado have fruits with variable chemical compositions.

Avocado pulp oil is registered as a high-value edible oil. It is rich in mono-unsaturated fatty acid. About 60-80% of the mesocarp's dry weight is oil. The oil is stable and contains high concentration of mono-unsaturated compounds, carotenoids, minerals and vitamins such as: vitamin A, D, E, K, omega-3 fatty acids. It is used in foods, cosmetics, carrier oils in flavours, etc. Avocado trees are widely cultivated in tropical and subtropical regions of the world. Generally, fats and oils (lipids) are the third principal constituents of food. They are important sources of energy. They are used for

cooking, seasoning, binding, emulsifying and preservations. At room temperature, oils are liquids. Oils are extracted from plants. They are fatty acid esters of the trihydric alkanol (propane 1,2,3 triol). Oils are insoluble in water but soluble in organic solvents. Vegetable oils are extracted from plant seeds, nuts, fruits, etc. Plants such as: soybean, cotton seed, corn, peanut, sunflower, olive, coconut, linseeds, tung, castor, avocado pear, etc., are sources of vegetable oils. Oils have lower densities than water. Oils are extracted from their sources by [1,4,5].

- Chemical extraction, using solvent extraction
- Physical extraction, using mechanical milling, squeezing, etc.

The oils generated from the different sources differ in their physical and chemical properties. They contain different amounts of mixed esters. Unsaturated oils contain one or more double bonds in the hydrocarbon chain. Bad fats and oils contain little unsaturated fatty acids; hydrogenation of such oils is limited. Good fats and oils are mono-unsaturated and poly-unsaturated. They lower the risk of heart diseases and stroke. Mono-unsaturated oils are found in olive, peanut, almonds, macademia, cashew, avocado, etc [4,5].

Conclusion

Nature has enhanced life with unlimited food sources. These food materials differ from one climate to the other, one season to the other and one locality to the other. The abundance of indigenous food materials in nature and the geographical and seasonal effects plus the human needs to have the benefits of these foods at all times necessitate the studies on indigenous foods. This write-up enlisted the processing of avocado (persea americana) fruit [6].

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