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J. Nat. Prod. Plant Resour**., 2013, 3 (3):7-11**
(http://scholarsresearchlibrary.com/archive.html)

ISSN : 2231 – 3184
CODEN (USA): JNPPB7

Comparative studies on the relative biopreservative efficiencies of major tropical vegetable oils on industrial tomato (*Lycopersicum esculentum*) paste in storage

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ABSTRACT

The biopreservative efficiencies of ten major edible and industrial vegetable oils on stored tomato paste were compared in this study. These oils were groundnut oil, cotton seed oil, soybean oil, olive oil, palm oil, palm kernel oil, sesame seed oil, coconut oil, castor oil and chilli oil, castor oil was the only industrial oil. 2.5mls of each of these oils were used to preserve 3mls of the canned tomato paste, incubated at room temperature and observed for over two and half weeks. The results showed that coconut oil, chilli oil, castor oil, sesame seed oil and palm oil were more efficient in preserving stored tomato paste. The groundnut oil, soyabean oil and cottonseed oil were less efficient. The olive oil and palm kernel oil were not good preservatives as microbial growths were observed after 168hrs (1week) of incubative preservation. The result of this study showed that coconut oil, chilli oil, castor oil, sesame seed oil and palm oil were clearly superior within the trial duration. Organisms found associated with the spoilage of the industrial tomato paste included fungi such as Aspergillus flavus, A. fumigatus, A. niger and Fusarium spp and bacteria such as Bacillus coagulans, B. stearothermophilus and Proteus spp.

Keywords: biopreservatives, vegetable oils, antimicrobial, industrial oil, spoilage organism

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INTRODUCTION

The tomato (*Lycopersicum esculentum*) is a member of the Solanaceae or nightshade family, as are its close cousins: tobacco, chilli pepper, potato and eggplant. The tomato though commonly classified as a vegetable is really a fruit. They are either bilocular or multilocular. Most cultivated varieties except cherry tomatoes have four or five locules, which are surrounded by the pericarp, which includes the inner wall, columella, the radial wall, septa and the outer wall. The pericarp and the placenta comprise the fleshy tissue of the tomato [1]. Tomato plants grow best in well-drained, fertile, slightly acidic (pH 6.2 to 6.8) loamy soils. Most tomato varieties have red fruit due to the red carotenoid lycopene [2]. Because of its medicinal importance, namely prevention of heart diseases and prostate cancer [3] and the treatment of high blood pressure and fresh taste as for salad, tomatoes are now eaten freely throughout the world. One medium size of fresh tomato provides 47% of the recommended daily allowance (RDA) of Vitamin C and 22% of the RDA of Vitamin A [4]. Tomatoes are also high in potassium and are cholesterol free. The tomato has an acidic property that is used to bring out other flavors. This same acidity makes tomato especially easy to preserve in home canning as tomato sauce or paste [5]. Tomato belongs to the group of perishable fruits due largely to its high water content and therefore is easily subjected to spoilage by both bacteria and fungi. Therefore it is usually processed into pastes and sealed in silvexlines glossy paper containers, bottles and cans with the addition of various types of preservatives with sodium benzoate being the commonest [4].

Botanical biopreservatives are a wide range of natural products from both plants and microorganisms which can be useful in extending the shelf life of foods, reducing or eliminating survival of pathogenic microorganisms and increasing overall quality of food products [6]. Antimicrobial botanicals which have the potential to be used as biopreservatives can be divided into several useful categories including phenolics, polyphenols, quinines, flavones, flavonoids, flavanols, tannins, coumarins, terpenoids, alkaloids, lecitins, and polypeptides [7]. The essential oil (*quinta essential*) fraction of botanicals is often the most inhibitory chemical fraction to growth and survival of microorganisms. Essential oils are highly enriched with terpenoids with approximately 30% of essential oils which have been examined are inhibitory to bacteria and more than 60% of its derivatives have shown to be inhibitory to fungi [8].

Although numerous studies have been done *in vitro* to evaluate the antimicrobial activity of botanicals, only a few studies have been done with food products. Similarly, edible oils have found uses in foods such as oleomargarines and butter substitutes especially in bakery, salad dressings and preparations. Non-food uses are in candles, soaps, paints and varnishes, as well as in lubrications and fuel in internal combustion engines [9]. There have been few, if any, reports on their uses as food biopreservatives. Vegetable oils belong to the group referred to as lipids. They are a structurally diverse group of chemicals that are essential for the structure and function of living cells. They are often classified on the basis of their solubility, saponifiability, saturation or insaturation, aromatic or nonaromatic, cyclic or acyclic structures, to mention a few [10]. Lipidomics is an emerging technology that will provide enormous information on the complete characteristics present in diverse samples with respect to fats, oils, hormones and pigments as well as non-protein membrane components. Lipids also function in signaling and defense, a characteristic control system in plants comparable to immunology in animals.

Plant storage lipids are a highly reduced form of carbon, which is available as an energy source for seeds during germination and early seeding development. Storage lipids found in oil producing (oleaginous) crops are also a source of edible oils for human consumption. They are the major storage lipids found in plants generally as are triacylglycerols. Fatty acids represent the most abundant form of reduced carbon chains available in living things. They have a diverse range of dietary and industrial uses and are a major commercial resource. The world production level of vegetable edible oil was over 100 million metric in 2006 with soybean, oil palm, rapeseed and sunflower being the four most important crops. These oils are primarily saturated types. Most vegetable oils are used directly for human dietary purposes. Thus the use of vegetable oils as a biopreservative is considered safe and cheap. In this present work, comparative studies on the relative biopreservative efficiencies of 10 different vegetable oils on stored tomato paste was carried out. The main objective of this investigation is to confirm local practices through research and to rank the selected oil for good biopreservation.

MATERIALS AND METHODS

Sample collection

Ten different vegetable oils (one drying oil type, four semi-drying oil types and five non-drying oil types) were used in this study. Nine of the ten oils namely: groundnut oil, cotton seed oil, soybean oil, olive oil, palm oil, sesame seed oil, coconut oil, castor oil and chilli oil used were purchased at Shoprite supermarket, Lagos, Nigeria, while palm kernel oil was purchased from a local market in Ibadan, Nigeria. DeRica, a popular brand of tomato paste which is widely consumed in Nigeria was chosen for this study and it was purchased at shoprite supermarket, Lagos, Nigeria.

Sample preparation and microbial isolation

The ten vegetable oils: groundnut oil, coconut oil, chilli oil, castor oil, sesame seed oil, soybean oil, cotton seed oil, palm kernel oil, olive oil and palm oil were labeled A to J respectively. The canned DeRica tomato paste was aseptically opened using a sterile tin cutter in an inoculating hood. 3 mL of the tomato paste was measured into each of the sterilized test tube labeled A to J and 2.5 mL of each of the labeled vegetable oils was added to the corresponding test tubes, thus allowing the tomato paste to be submerged in the oil. The test tubes were in duplicate for each oil. These were incubated at room temperature and microbial isolation was carried out every 24hrs. Observations and records were taken every day. Growth pattern in each test tube were isolated and characterized using the taxonomic schemes and descriptions by Buchanan and Gibbons [11] and Sutton *et al*. [12]. Each of the vegetable oils and the canned tomato paste were separately cultured as control (this was done so as to check if these products came sterile from their various manufacturers.

RESULTS

Table 1 show the result obtained from the incubated test tubes. All the ten vegetable oils bio-preserved the tomato paste for 6 days as the first microbial isolation was after 144hrs (6 days) from the first day of incubation. Groundnut oil, soybean oil, palm kernel oil and olive oil had the least (6 days for others and 7 days for olive oil) bio-preservative efficiencies while coconut oil, chilli oil, castor oil, sesame seed oil, and palm oil showed better preservative efficiencies. However, coconut oil and palm oil had the best bio-preservative efficiency of 15 days.

Table 1: Result of incubated tomato paste using ten vegetable oils

Specimen	Presence or absence of microbial growth	Time interval (hrs)	Bacteria	Fungi
A	+	144	-	+
B	+	360	-	+
C	+	198	-	+
D	+	198	+	+
E	+	212	+	+
F	+	144	-	+
G	+	224	+	-
H	+	144	+	+
I	+	168	+	+
J	+	360	+	+
K	+	72	+	+
L	-	-	-	-

A-Groundnut oil, B-coconut oil, C-Chilli oil, D-Castor oil, E-Sesame seed oil, F-Soyabean oil, G-Cotton seed oil, H-Palm kernel oil, I-Olive oil, J-Palm oil, K-tomato paste alone, L- vegetable oils alone. + present, - absent

No growth was observed from the plates containing the vegetable oils only while the plate with tomato paste only showed growth after 72hrs. Fungi isolates include *Aspergillus niger*, *A. flavus*, *A. fumigatus* and *Fusarium spp*, while bacterial isolates include *Bacillus coagulans*, *B. stearothermophilus* and *Proteus spp*. *A. flavus* has the highest occurrence (65%) followed by *A. niger* (30%) and *Fusarium spp* has the least occurrence among the fungi isolates (fig 1) while *B. coagulans* has the highest occurrence (50%) followed by *B. stearothermophilus* (38%) and *Proteus spp* has the least occurrence (fig 2). Groundnut oil, coconut oil, soybean oil and chilli oil inhibited bacterial growth as only fungi isolates were obtained throughout the period of the study. However, only cotton seed oil completely inhibited fungi growth throughout the period of this study.

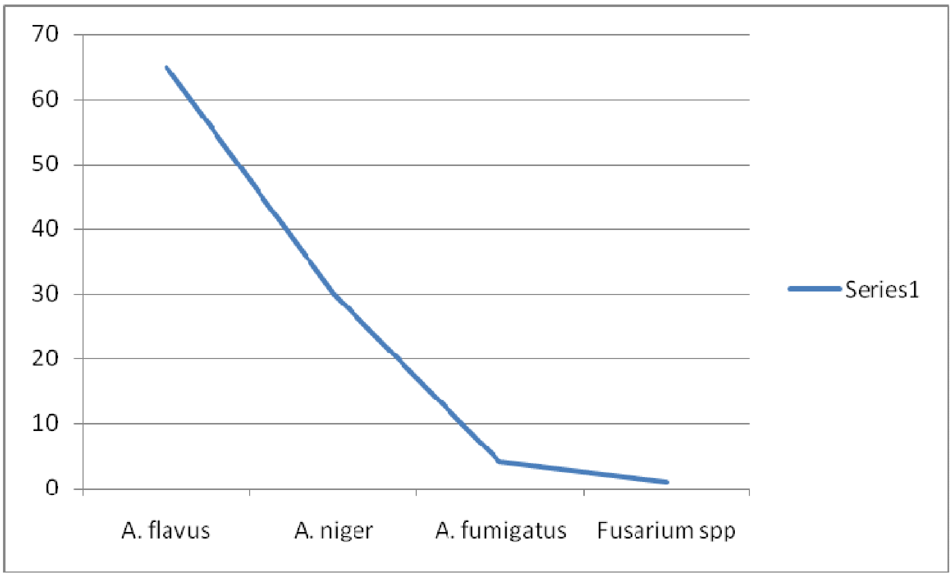

Figure 1: The percentage occurrence of fungi spoilage organisms.

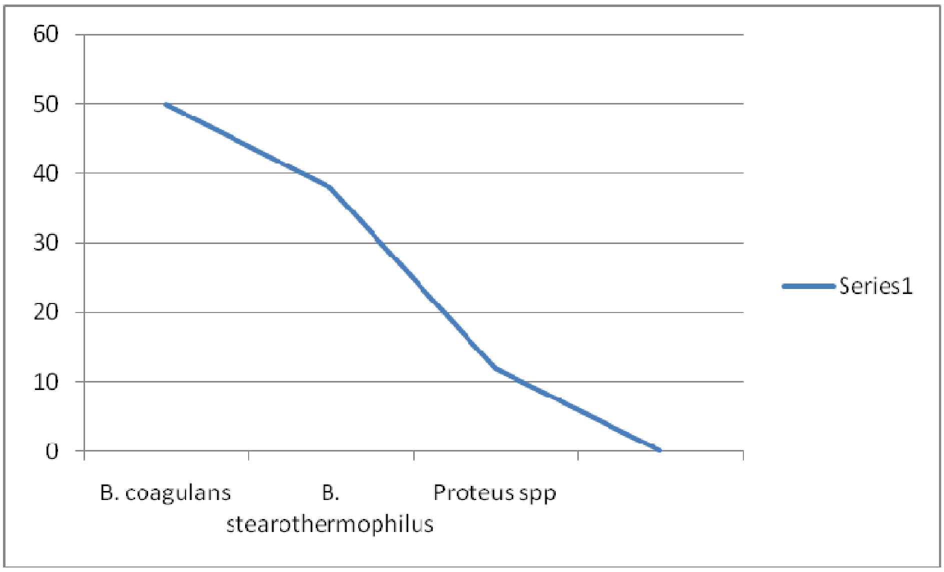

Figure 2: The percentage occurrence of bacteria spoilage organisms.

DISCUSSION

Both the tomato paste (vegetable) and the vegetable fatty oils used in this investigation were plant products produced industrially. This is therefore one of the classical and rare case when a food is acting as a bio-preservative for another food. For convenience, foods for human consumption have been classified into eight main groups; four each are of plant and animal origins [13]. Those from plants, which are the focus of this report, include cereals and products, sugars and products, vegetables and products, fruits and products. By extension, this list also includes spices, flavor materials nutmeats and edible fungi to mention a few. Accordingly, ten methods of food preservation have been recognized for the purposes of discussion namely asepsis, microbial removal, anaerobiosis, thermal therapy (high and low temperatures), desiccations or drying, use of chemicals, irradiation, high pressure and finally combinations of these [13].The closest, among all the listed, methods of preservation relevant to this investigation is the application of anaerobiosis or use of a chemical, in this case the vegetable fatty oil which is considered to have provided anaerobic environment may also be acting as a chemical.

The use of vegetable fatty oil as a food preservative is not very popular. In fact few cases exit, such as is found in salted vegetable fatty oils in canned fish packs commonly called sardines. Canned tomato pastes are foods that have been industrially preserved by heat-processing them in an evacuated sealed container can, however, when opened and not completely consumed domestically, a new preservation process has to be used to ensure its sustained quality over time. When any vegetable fatty oil is used as a preservative its method and mode of action is principally based on maintenance of anaerobic conditions which is characteristic of hemetically sealed, evacuated containers [13]. Anaerobic condition may also be provided by a replacement of the air by either CO_2 or by an inert gas such as nitrogen which ensures anaerobiosis [14]. Civilization has brought a lot of changes with respect to how food items can be stored or preserved. Our forbears stored food through some traditional means like digging buckets of sand for carrots, apples and peas were stacked in baskets while meat was left either salted, sundried, or in a smoked house. Today, the emphasis is on processed foods and the use of freezers (refrigerator) in storing these foods until they are needed. Proper storage of foods helps to preserve the nutrients, flavors, texture and appearance. Enzymes and certain microorganisms such as bacteria and fungi cause food spoilage. Many of these microbes could also be poisonous and can cause illness or even death. An attempt was made in this study to compare the relative efficiency of vegetable oils to preserve the tomato paste which is a common and regular food in human diet. The major objectives of this study were to establish an alternative method of tomato preservation in the absence of or lack of refrigeration facilities most especially in rural areas. It has been established through this investigation that different vegetables oils have different capabilities. The best preservative oils were coconut oil, chilli oil, castor oil, sesame seed oil and palm oil and the poorest preservative oils were soybean oil, cotton seed oil, palm kernel oil, olive oil and the groundnut oil. Studies have shown that coconut oil and castor oil contain lauric acid [15] and do not become rancid because of their low proportion of unsaturated fatty acids and high melting point, hence they are considered as good preservatives. Palm oil and sesame seed oil belong to the group of oils containing oleic acid while chilli oil contains linoleic acid. Among the poorest preservative oils, olive oil and groundnut oil contain oleic acid, cotton seed oil contains linoleic acid, soybean oil contains linolenic acid while palm kernel oil contains lauric acid. The mechanism of action for the antimicrobial activity of botanical preservatives is not fully understood [6]. However, terpenoids and phenolics (which are contained in these oils) are thought to exert inhibitory action against microorganisms by membrane disruption. Simple phenolics and flavonoids appear to inhibit growth of microbes by binding to biochemicals essential for metabolism [8]. The causal organisms were fungi and bacteria. The fungi isolated from this substrate were *A. flavus*, *A. fumigatus*, *A. niger* and *Fusarium spp*. Aspergillus spp has been associated with rots in crops of economic importance such as peanuts, palm kernels, grapes, onions and crops with pods. Some of this species are less likely to cause human disease, but if after large amounts of spores are inhaled, a serious lung disease, aspergillosis can occur [16]. Organisms isolated from the spoilt tomato paste are in accordance with previous report where *B. coagulans* and *B. stearothermophilus* were identified as spoilage organisms of tomato fruit and where enzymes of *A. flavus*, and *A. fumigatus* were found to be responsible for the deterioration of tomato fruit [17]. Botanical bio-preservatives such as the group of vegetable oils are only one example of an array of naturally occurring antimicrobial systems. Other sources may include microbial products (e.g. bacteriocins), animal products, and various enzymes to mention a few. On the safety and quality assurance of foods involved in the preservative integrity of the product, the Nigerian experience and indeed the West African sub region has exploited the palm oil more than any other oil involved in this investigation. In conclusion, coconut oil, chilli oil, castor oil, sesame seed oil and palm oil in decending order are more efficient in preserving stored tomato paste.

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