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Production and Quality Evaluation of Vinegar from Tamarind (*Tamarindus indica* L.) Fruit Pulp

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ABSTRACT

Vinegar is a liquid consisting mainly of acetic acid (CH_3COOH) and water. The acetic acid is produced by the fermentation of ethanol by acetic acid bacteria. This study aimed to produce vinegar from tamarind fruit pulp and evaluation of its quality. Samples of tamarind fruit were collected from different sites in Sudan: Gedaref (GT), Damazin (DT) and Obeid (OT). The vinegar yields from 1 kg tamarind pulp from (GT), (DT) and (KT) were 300, 200, 260 ml, respectively. The physical characteristics of tamarind fruit pulp and its seeds were determined. The average fruit length, width and weight were 14.28± 0.31mm, 11.06± 1.1mm and 12.33± 0.7g, respectively The production of vinegar was carried out at three stages. The concentration of acetic acid of the produced vinegar from (GT), (DT) and (OT) were equivalent to (16.2%), (19%) and (17.7%), and pH values of these samples were found to be (2.2), (1.9) and (2.0), respectively. The study recommends the efficient industrial use of tamarind fruit in many products such as vinegar.

Key words: Vinegar, tamarind, acetic acid, ethanol.

INTRODUCTION

Tamarind (*Tamarindus indica* L.) is a versatile fruit, which can be used for many purposes. The fruit pulp is edible. The hard green pulp of a young fruit is considered by many to be too sour, but is often used as a component of savory dishes, as a pickling agent. The ripened fruit is considered the more palatable, as it becomes sweeter and less sour (acidic) as it matures. It is used in desserts as a jam, blended into juices or sweetened drinks, sorbets, ice creams and all manner of snacks.

Tamarind pulp has been used for many medicinal purposes and continues to be used by many people in Africa, Asia and America (Gunasena & Hughes, 2000). The pulp is believed to improve loss of appetite and is used as a gargle for sore throats, dressing of wounds (Benthal, 1933; Dalziel, 1937) and is said to aid the restoration of sensation in cases of paralysis. Tamarind is genetically diverse, as reflected primarily in the variability of its fruits in terms of size and taste (sweet or acidic pulp) periods of food scarcity (Aline *et al*., 2008).

Tamarind concentrate can be used to remove tarnish from brass and copper. Tamarind trees are used as ornamental, garden and cash crop plantings.

Vinegar is a liquid consisting mainly of acetic acid (CH_3COOH) and water. The acetic acid is produced by the fermentation of ethanol by acetic acid bacteria. Vinegar is commonly used in food preparation, in particular in pickling processes and other salad dressings. It is an ingredient in sauces such as mustard, ketchup, and mayonnaise. Vinegar is sometimes used while making chutneys. It is often used as a condiment, Marinades often contain vinegar. In terms of its shelf life, vinegar's acidic nature allows it to last indefinitely without the use of refrigeration (http://en. Wikipedia.org/wiki/Vinegar, 2013). Most vinegars are much more than dilute solutions of acetic acid. Depending on the fruit or feed stock they are made from, and the amount of processing, they will contain various amounts of minerals, vitamins, fiber, enzymes and other organic compounds. Minor components in the vinegar even though they are major contributors to the product's flavor and aroma as well as its overall nutrition and health benefits.

Vinegar was thought to be useful for treating infections in ancient times. Hippocrates (460–377 BC) prescribed it for curing pleurisy, fever, ulcers, and constipation; it was used by the ancient Egyptians to kill bacteria (Myers, 2007). The present study aimed to produce vinegar from tamarind fruit pulp and evaluation of its quality.

MATERIALS AND METHODS

Preparation of samples

Tamarind (*Tamarindus indica* l.) fruit samples were obtained from three sites, central Sudan (Damazin), Western Sudan (Obeid), Eastern Sudan (Gedaref), and then transported into sacks to the food laboratory, Department of Food Science and Technology, University of Gezira, Sudan.

The tamarind samples were then cleaned from foreign material. For vinegar production, samples washed, soaked in water for 24 hours, and the seeds were removed from the soak by clearance and filtration.

Physical characteristics of tamarind fruits and seeds

Physical characteristics of tamarind fruits and seeds including fruit length, fruit width, seed length and seed width were measured using a Vernier Caliper: while the fruit weight, pulp weight and seed weight were determined using a sensitive balance. The seed density (g/ml) was determined according to Scann (1971). Each treatment was carried out in triplicates, the means and standard deviations (SD) were calculated for each variable.

Yeast culture preparation

Stock culture of *Saccharomyces cerivisiae* was procured from Ozmaya San company, Turkey. The organism was grown at a temperature of 30^0C and pH 6.5. The incubation period was 48 hours. After incubation the culture was stored at 4^0 C in a refrigerator.

Acetobacter aceti culture preparation

Stock culture of *Acetobacter aceti* was procured from food laboratory Department of food science and technology, University of Gezira. The organism was grown at a temperature of 30^0C

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and pH 6.0. The incubation period was 24 hours. After incubation the culture was stored at 4^0C in a refrigerator.

Production of vinegar

The method described by Paturau (1982) was used for production of vinegar at laboratory level. This method included fermentation, distillation and vinegar production as follows:

Fermentation

One kilogram of tamarind fruits was cleaned from foreign matter, washed and soaked in 6 liter water for 24 hours in stirrer tank, then seeds were removed from the pulp and filtered. The brix and pH were read using the pocket refractometer and pH- meter, respectively. The pH was adjusted to 6.5 using sodium hydroxide (1 N).

One gram of ammonium sulphate, half ml of orthophosophoric acid were added. Then 10g of yeast were added and well shacked. Then closed in steel tank for fermentation at room temperature for 72 hour. Ferment slurry was kept at 10-20°C.

Distillation

Using the distillation unit, the fermented slurry sample was distilled at 78-80°C. The ethanol distillates from this was collected, weighed and analyzed.

Vinegar production

Ten ml of acetic acid were added to the 100ml of ethanol in the flask. Then the flask was closed with a foil paper containing several pores in order to allow oxygen to enter for 72 hours (the oxidation process) at a temperature of 37°C. The produced vinegar was then weighed and analyzed.

Physicochemical properties of ethanol

The refractive index of ethanol was determined using an Abbe bench refractometer according to ICUMSA (1998). The measurement was affected by changes in the temperature. Therefore, the sample of ethanol was cooled to correct temperature (20^0C). The refractometer was adjusted to zero with distilled water. A drop of the sample of juice was placed on refractometer. Then the refractive index was read.

The density (The weight per volume) of ethanol was measured according to Scann (1971) as follows:

The flacon (100 ml) was weighed then filled with ethanol, and weighed again the density of ethanol was calculated as:

$$\text{Density} = \text{weight} / \text{volume}$$

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For the determination of the concentration of processed alcohol refractometrically, series of dilutions for absolute alcohol were prepared in the order of 10%, 20%, 40%, 60%, 80% and 100%. Using the Abbe refractometer, the refractive index of the series dilutions was recorded respectively, and then the curve was plotted. The refractive index of the sample was found using the same instrument. Then from the curve obtained the concentration of the processed alcohol was found.

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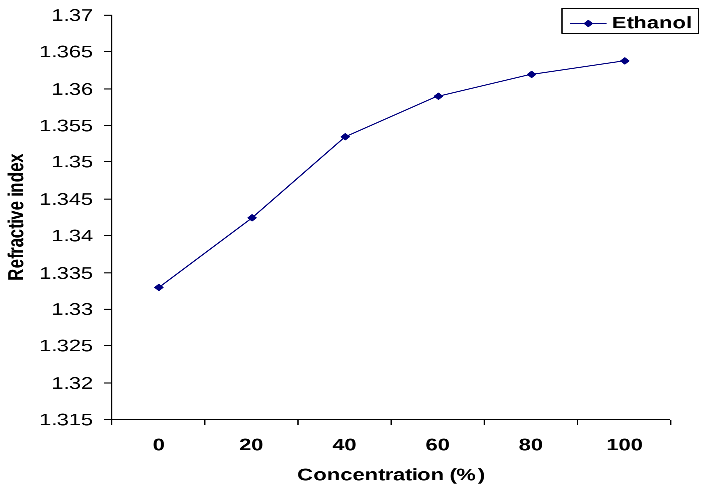

Fig.(1) Ethanol concentration curve

Vinegar analysis

The pH of the vinegar was measured using pH- meter (PHS-3C Digital) at ambient temperature (ICUMSA, 1994) while the concentration of acetic acid in sample of vinegar was determined using titration method and the density of vinegar was measured as described by Scann (1971).

RESULTS AND DISCUSSION

Physical characteristics of tamarind fruits and seeds

Physical characteristics of tamarind fruits and seeds are show in Table (1). The average fruit length, width and weight were 14.28± 0.31mm, 11.06± 1.1mm and 12.33± 0.7g, respectively. However, the fruit length was greater than that determined by Adeola *et. al*. (2012) and less than that determined by Karpoora *et al*. (2013) who reported a range of 10.59-12.64 mm and an average of 17.97 mm, respectively. On the other hand, Adeola *et. al*. (2012) reported a range of 8.84-10.87 mm for fruit width which was less than the value determined in the present study, moreover, Karpoora *et al*. (2013) determined a higher value (17.97 mm) in local tamarind variety in India. The average number of seeds per pod was 9 ± 0.1. The average pulp weight was found to be 54.58± 1.3g per 100g raw fruit material. The average density of tamarind seed was 3.66 ± 0.1 (g/ml) which was greater than that of Kapoora *et. al*. (2013) who reported a value of 0.60 (g/ml).

Table (1) Physical characteristics of tamarind fruits

Parameters	G.T	D.T	O.T	Mean ± SD
Fruit length (mm)	14.52	12.21	16.11	14.28± 0.31

Fruit width (mm)	9.4	10.3	13.5	11.06± 1.1
Weight of fruit (g)	12.61	12.4	11.9	12.33± 0.7
Weight of pulp /100g fruit	54.64	55.34 ± 1.4	53.76	54.58± 1.3
Number of seeds per pod	8	10	9	9 ± 0.1
Density of seeds (g/ml)	3.5	3.8	3.7	3.66 ± 0.1

G.T = Gedaref tamarind; D.T = Damazin tamarind; O.T = Obeid tamarind.

Physicochemical properties of ethanol

Table (2) shows the different physicochemical properties of the produced ethanol. The concentration of ethanol produced from Gedaref, Damazin and Obeid tamarind were 78%, 75% and 80%, respectively**.** The density of ethanol that produced from Gedaref, Damazin and Obeid were

found to be 1.5319, 1.5328 and 1.4371 g/ml, receptively. The density values was higher than the value reported by Eltayeb, (2002) which was 0.94908 g/ml at 30°C, and also greater than the value 0.807 g/ml reported by Gasm Alla (2008), and also greater than the standard density value which was 0.789 g/ml at 15°C (San, 2000). The refractive index value of ethanol which produced from Gedaref, Damazin and Obeid were found to be 1.3362, 1.3354 and 1.3344, receptively. These were slightly lower than the value 1.3638 of the absolute ethanol.

Table (2) Physicochemical properties of ethanol produced from fermentation of tamarind.

Character	G.T	D.T	O.T
Refractive index	1.3362 ± 0.0006	1.3354± 0.0001	1.3344± 0.0002
Density (g/cm^3)	1.5319 ± 0.0001	1.5328± 0.00005	1.4371± 0.0005
Concentration(%)	78	75	80

G.T = Gedaref tamarind; D.T = Damazin tamarind; O.T = Obeid tamarind.

Physicochemical properties of vinegar

The volume of the produced vinegar from Gedaref, Damazin and Obeid tamarind were 300, 260 and 200 ml/kg of tamarind. Table (3) shows some of the physicochemical characteristics of the examined vinegar after production. The vinegar produced from Gedaref, Damazin and Obeid contained 16.2, 19 and 17.7% acetic acid, respectively. The concentration of acetic acid was in agreement to value reported by the US Food and drug administration. Code of federal regulations available at: (http://www.fda.gov/org/compliance-ref/cpg fod/cpg 525 - 825.html). It has been reported that the amount of acetic acid in vinegar can vary, typically between 4 to 6% for table vinegar, but up to three times higher (18%) for pickling vinegar, however, typical white distilled vinegar is at least 4% acidity and not more than 7%. Cider and wine vinegars are typically slightly more acidic (http://www.versatile vinegar.org/faqs.html, 2007).

Acetic acid in vinegar imparts the sour taste, it also possesses cleaning and antiseptic or germ killing properties. The term "pH" is derived from "potential hydrogen" and refers to the amount of hydrogen ions present in solution. Mathematically, pH is equal to the negative logarithm (base 10) of the hydrogen ion concentration in moles per liter, so if the pH of a solution decreases by 1 pH unit then its hydrogen ion concentration increases by ten times. Pure water has a pH of 7 and is neutral whereas anything with a pH less than 7 is acidic and anything with a pH greater than 7 is basic. The pH of vinegar depends upon how much acid is present, but most commercial distilled white vinegars contain 5% acetic acid and have a pH of about 2.4. The pH of vinegar depends on the concentration of acetic acid. The pH value of produced vinegar from Gedaref, Damazin and Obeid tamarind were found to be 2.17, 1.89 and 1.97, receptively, which were less than the pH value of trade vinegar which was 2.42. However, the most commercial distilled white vinegars contain 5% acetic acid and have a pH of about 2.4 (http://www.apple-cider-vinegar-benefits.com/properties-of-vinegar.html).

The density, or mass per unit volume, of a solution is used in many analytical calculations and can be measured with a hydrometer. For a typical commercial vinegar with a 5% acetic acid content, the density is about 1.01 g/ml. the pH and density, depend on how much acetic acid is present.

The density of produced vinegar from Gedaref and Obeid tamarind were 0.94 and 0.95 g/ml, which were slightly lower than both the standard value 0.96 g/ml and the house hold vinegar used for cooking (1.05 g/ml) (http://en,wikipedia.org/wiki/vinegar, 2013). The density of vinegar from Damazin was found to be 0.96 g/ml, which is similar to standard value 0.96 g/ml, and lower than the house hold vinegar used for cooking (1.05 g/ml)

Table (3) Physicochemical properties of vinegar.

Character	G.T.V	D.T.V	O.T.V
Concentration of acetic acid (%)	16.17 ± 0.19	19.02 ± 0.19	17.73 ± 0.24
Density (g/cm^3)	0.94 ± 0.01	0.96 ± 0.01	0.95 ± 0.01
Refractive index	1.35 ± 0.00	1.35 ±0.001	1.34 ± 0.00
pH	2.17 ± 0.02	1.89 ±0.003	1.97 ± 0.00

G.T.V = Gadaref tamarind vinegar; D.T.V = Damazin tamarind vinegar.
O.T.V = Obeid tamarind vinegar.

CONCLUSION

The goal of the present study was production of vinegar from tamarind fruit pulp and evaluation of it's quality. The resulting low pH value of tamarind inhibits the growth of food spoilage bacteria, most of which are acid sensitive; in addition, other bacteria cannot successfully grow like *staphylococci*, *salmonella*, *coliform* and. *E. coli*.

The volume of vinegar prepared from tamarind fruit pulp from Gedaref, Damazin and Kordofan were equivalent to 300, 200 and 260 ml per kg of tamarind.

Tamarind pulp have great potentialities to be used industrially in many products such as concentrates, pickles, confections, powdered….etc. It is recommended to use tamarind fruit to produce vinegar which should not be packed in plastic containers, for its acidic properties which may lead to serious problems to consumers.

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