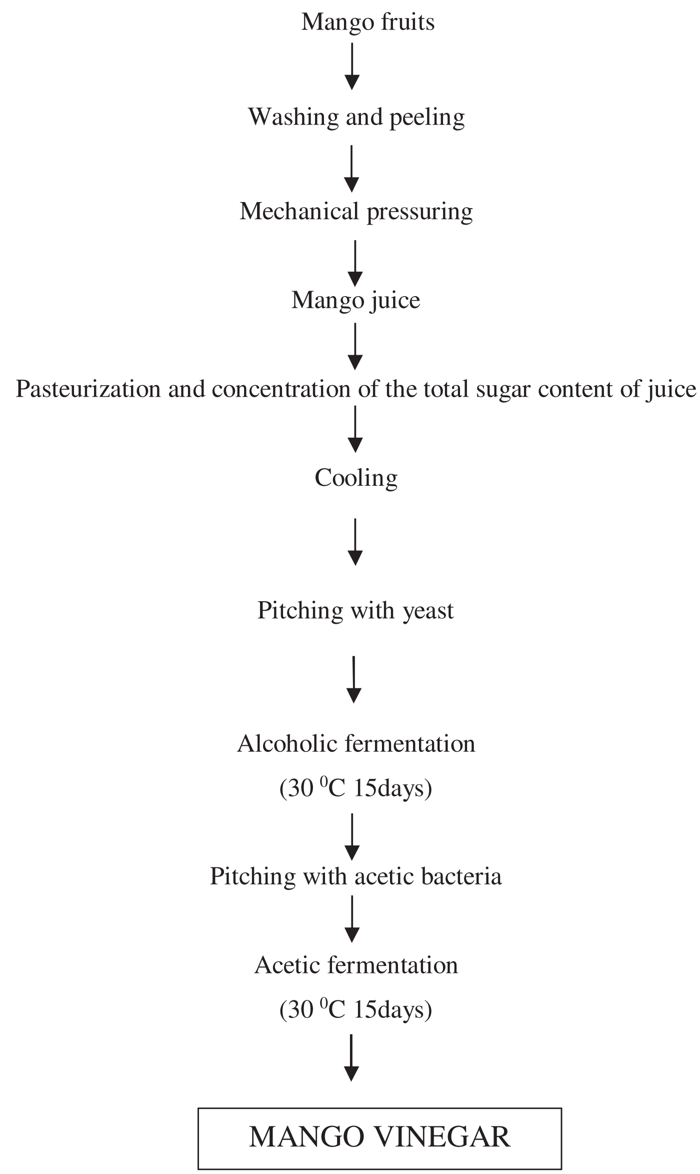
cogent food & agriculture



FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Production and quality evaluation of vinegar from mango

Abiodun Omowonuola Adebayo-Oyetoro, Elizabeth Adenubi, Oladeinde Olatunde Ogundipe, Bolanle Olayinka Bankole and Samuel Ayofemi Olalekan Adeyeye

Cogent Food & Agriculture (2017), 3: 1278193 cogent food & agriculture

FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Production and quality evaluation of vinegar from mango

Abiodun Omowonuola Adebayo-Oyetoro[1]*, Elizabeth Adenubi[1], Oladeinde Olatunde Ogundipe[1], Bolanle Olayinka Bankole[1] and Samuel Ayofemi Olalekan Adeyeye[2]

Received: 25 October 2016
Accepted: 28 December 2016
First Published: 09 January 2017

*Corresponding author: Abiodun Omowonuola Adebayo-Oyetoro, Yaba College of Technology, Department of Food Technology, P.M.B 2011, Yaba, Lagos State, Nigeria
E-mails: wonunext@gmail.com, abiodun.oyetoro@yabatech.edu.ng

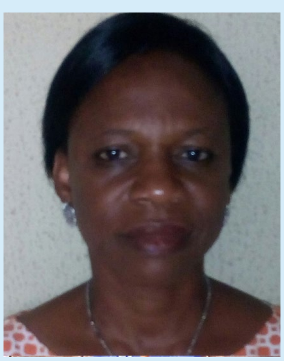
Reviewing editor:
Fatih Yildiz, Middle East Technical University, Turkey

Additional information is available at the end of the article

Abstract: Post-harvest losses of fruits and vegetables are very critical in developing countries and processing excess fruits into vinegar which can be used for preservation of some foods and snacks is a helpful strategy in reducing these losses. This study was carried out to evaluate production and quality of vinegar from mango. Mango was processed into mango juice which was used for vinegar production. The mango juice was divided into two batches; the first batch was supplemented with 20% sugar for primary fermentation while the second batch was not supplemented with sugar. *Saccharomyces cerevisae* was then added to the juice in the two batches for primary fermentation. This was done for 15 days after which acetic acid bacteria was added and then allowed to ferment for 15 days to form vinegar. Analyses carried out on the product include colour and physico-chemical properties while sensory evaluation was carried on the cake product preserved with the vinegar. Results showed that pH, alcoholic content and garlic acid were 4.02, 6.17 and 0.513 g/ml respectively. The results of sensory evaluation revealed that the cake preserved with the vinegar was unacceptable to the panellists. Hence, the vinegar produced cannot be used for cake preservation.

Subjects: Environment & Agriculture; Bioscience; Food Science & Technology

Keywords: vinegar; *Saccharomyces cerevisae*; fermentation; acetobacter



Abiodun Omowonuola Adebayo-Oyetoro

ABOUT THE AUTHORS

Abiodun Omowonuola Adebayo-Oyetoro is a dynamic, enthusiastic professional and hardworking specialist in Food Quality Control and Nutrition. She is a senior lecturer in the Department of Food Technology, Yaba College of Technology, Lagos, Nigeria. Her PhD in Food Quality Control and Assurance was from the department of Food Science and Technology, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. Her area of focus has been general product development, food safety and assurance with reference to raw agricultural materials and finished products. Hence, this study was undertaking to promote the use of local raw material and reduce postharvest losses associated with mango. She has attended several trainings, conferences and workshops both nationally and internationally on Food Safety, Quality, Nutrition, HACCP Certification and holds several awards. She is a member of many professional bodies including The Nutrition Society (UK, Nigeria), Nigerian Institute of Food science and Technology among others.

PUBLIC INTEREST STATEMENT

Vinegar an age long food preservative is important for its many culinary uses in food industry. It is used to promote food safety and wellness worldwide as an integral part of many food products. These include but are not limited to sauces, ketchup and mayonnaise. It has a unique sour and tart flavour that distinguishes it in food during preservation. Mango is abundantly available in many tropical countries including Nigeria and undergoes lot of postharvest food losses. To reduce this, biotransformation potential of mango into vinegar was explored and its quality was evaluated for selected attributes. Physicochemical properties such as specific gravity, pH, titratable acidity among others were evaluated. Colour and sensory evaluation were also determined as an index of acceptability. Vinegar produced compared favourably with imported vinegar products and provides a good opportunity to save scarce foreign exchange and promote sustainable economic development in Nigeria and other developing countries.

1. Introduction

Mangoes have been cultivated in South Asia for thousands of years and reached East Asia between the fifth and fourth centuries BC. By the 10th century AD, cultivation had begun in East Africa. Mangoes are generally sweet, although the taste and texture of the flesh varies across cultivars; some have a soft, pulpy texture similar to an overripe plum, while others are firmer, like a cantaloupe or avocado, and some may have a fibrous texture. The skin of unripe, pickled, or cooked mango can be consumed, but has the potential to cause contact dermatitis of the lips or tongue, gingiva in susceptible people. Mangoes are used in preserves such as *moramba, amchur* (dried and powdered unripe mango), and pickles, including a spicy mustard-oil pickle and alcohol mango are used to make juices, smoothies, ice cream, fruit bars etc. (Singh et al., 2004).

Vinegar traditionally has been used as a food preservative, whether naturally produced during fermentation or intentionally added; vinegar retards microbial growth and contributes sensory properties to a number of foods. The wide diversity of products containing vinegar (sauces, ketchup, mayonnaise, etc.) and the current fall in wine consumption have favoured an increase in vinegar production (de Ory, Romero, & Cantero, 2002). Vinegar is described as a sour and sharp liquid used as condiment and for preservation of food. It is produced by double fermentation of a carbohydrate-containing solution with agricultural origin.

All over the world there are several different types of vinegar based on widely varying raw materials, such as grapes, rice, apples, different berries, grains, whey and honey (Solieri & Giudici, 2009). In 2005, balsamic vinegar, made of grapes, had the largest world market share with about one third, while the cider vinegar share was 7%. Other ingredients that are permitted in the vinegar, apart from the raw material of agricultural origin, are fruit juices, sugars, honey, whey, plant parts or extracts adding flavour, and salts. Additionally, some food additives are permitted and include specified antioxidants, colours, flavour and flavour enhancers, stabilizers and processing aids, as bacterial nutrients, and also agents for clarification.

According to FDA (Food and Drug Administration, USA), vinegar as a sour solution, contains not less than 4 g of acetic acid in 100 cubic centimetres that is produced through alcohol and successively acetic fermentation of sugary and starchy substrates. Earlier processes used for making vinegar were the Orleans process (which is also called the generator process) and the submerged culture process. The quick process and submerged culture process were developed and are used for commercial vinegar production today. Further processing of vinegar, following substrate conversion to acetic acid may include filtration, clarification, distillation and pasteurization before it is bottled.

In Nigeria and many developing countries of the world, mangoes and many other fruits are produced in large quantities, larger percentage are wasted annually, causing serious disposal problem. Mangoes being highly perishable and with poor infrastructures to preserve them all year round, therefore, efforts should be put in place to reduce wastage and make the fruits available to consumer. Meanwhile, vinegar is commonly produced from fruits like pineapple, apple, banana, strawberry, chocolate, etc. but mango fruits have not used for vinegar production.

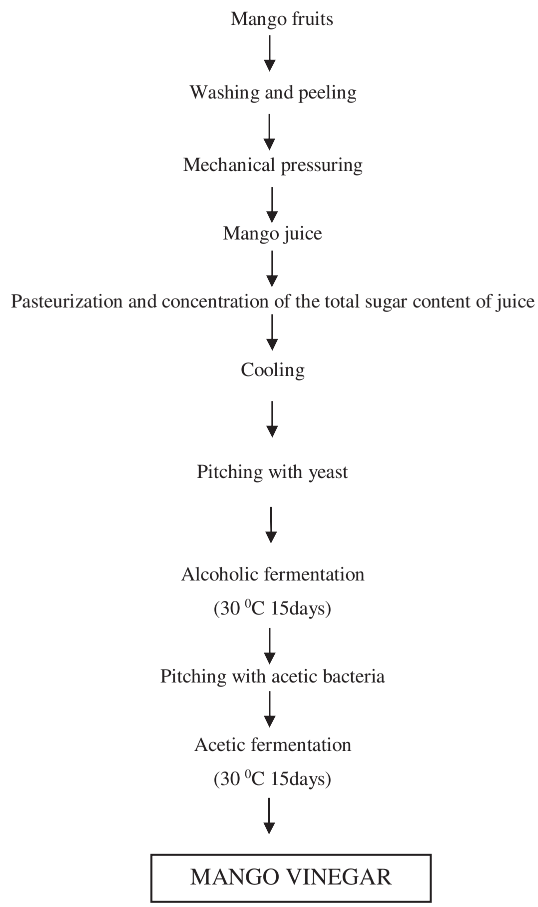
Therefore, this study was carried out to produce and assess the quality of vinegar produced from mango fruits. This will help to reduce high rate of post-harvest losses associated with mango fruits and also provide information on diversification and utilization of mango fruits.

2. Materials and method

Sources of materials: The mangoes used were Sherry variety obtained from Ketu market, Lagos State, Nigeria. The yeast strain *Saccharomyces cerevisiae* that was used for alcoholic fermentation was purchased from Iyana Ipaja market, Lagos State, Nigeria. It was used as described by the manufacturer's instructions.

Figure 1. Diagram of mango vinegar.

Source: Beltran et al. (2002).



Production of mango vinegar: The mango vinegar was produced by the method of Beltran et al. (2002) with modification as shown in Figure 1. It was carried out in two successive stages which are: alcoholic fermentation at 30°C for 2 weeks and acetic fermentation at 30°C for 2 weeks using the acetic bacteria isolated from wine. The mango fruits were washed to eliminate the dirt followed by peeling. Juice was obtained from the peeled mangoes by mechanic pressure.

Preparation of cake: Cake was prepared by the method of Kiin-Kabari and Banigo (2015) with modification. Half the flour was mixed with all the fat for about 2 min to obtain creamy dough, before adding the remaining composite flour and other ingredients. The baking powder was dissolved in water and also added to the mixture. Eggs were dispersed in little water and added to the mixture. About ¾ of the estimated water and vinegar was added and the mixing carried out for another one minute. More water was added gradually and mixing continued until the dough was soft and greasy when touched. The dough was moulded into rolls, shaped and baked in the oven at 200°C for 10 min.

The juice was heated at 80°C in order to prevent microbial contaminations and to concentrate the sugar until 20 °Brix was obtained. After cooling at room temperature, the bottles were sealed with 2 ml of 10^6 Cfu yeast for 2 weeks to allow alcoholic fermentation.

2.1. Chemical analysis

2.1.1. pH

The pH was determined according to Association of Analytical Chemists (2000). Ten g of the vinegar was weighed into a beaker, mixed thoroughly in 100 ml of distilled water and centrifuged for 20 mins at 200 rpm. The supernatant was then decanted and the pH was determined with a standard pH meter.

2.1.2. Titratable acidity

The content of acid in the vinegar was analyzed by titration with automatic titration equipment (Radiometer Copenhagen). Each of the samples was measured in triplicate. The titration was made with 0.1 M NaOH until pH end point is 8.4 and the acidity was calculated as acetic acid in vinegar (Association of Analytical Chemists [AOAC], 2000).

2.1.3. Total phenol

Analysis of total phenol was done spectrophotometrically using Folin-ciocalteaus method. The phenol of the sample was analyzed in triplicate. Phenol extraction was made of 2 ml sample and 8 ml 50% ethanol with addition of 50 ml H_3PO_4 in 15 ml centrifuge tubes.The extraction was made overnight on a vibrating plate at 200 rpm, and then centrifuge for 10 min at 4,500 rpm (Gao, Björk, & Trajkovski, 2000). The mixture was left for 24 h before measuring the absorbance at 765 nm using a UV-VIS scanning spectrophotometer (Shimadzu). Each cuvette was read two times and the absorbance was compared to a standard curve of Gallic acid equivalents (GAE)/L.

2.2. Physical analysis

2.2.1. Specific gravity

The specific gravity was measured with a hydrometer for a quick estimation of alcohol in the vinegar. The reading was carried out three times on each sample. These were compared with values on the conversion table specified by Proulx and Nichols (2003).

2.2.2. Colour

Colour was determined by modified method of AOAC (2000) using photometric color index. Colour parameters (lightness L*, a* and b*) of mango vinegar was determined with a Minolta Chroma Meter CR-210b and compared a white ceramic plate used as standard.

2.2.3. Sensory evaluation

The final vinegar was evaluated by 20-man panellists; males and females of 25–45 years of age, including students and staff of Yaba College of Technology. The panellists were selected for participation on the basis of their preference. The evaluations took place in the mid- morning between 10:00 and 11:30 am This was conducted at room temperature of 22–24°C under white light. The mango vinegar was evaluated for their appearance, taste and general acceptability. The results were analysed using Analysis of Variance (ANOVA) (Akinjayeju, 2009).

3. Results and discussion

3.1. Physico-chemical analysis

The results on Table 1 showed that there was no significant different ($p \leq 0.05$) in the titratable acidity which shows that the vinegar produced with *Acetobacteracetic* has good fermentation attributes, which enhance total acidity and minimize cost of production. Acetic acid takes into account that other acids are present in vinegar at negligible quantities. Total acidity has been shown to be a good indicator of acetic acid concentration in vinegar (Oka, Saito, Yasuhara, & Sugimoto, 2004). However, the titratable acidity showed that the degrees of acidity across the two samples were equal due to the fact that there was maximum cellular growth and sufficient biomass density to start the acetification process at the beginning of acetic acid fermentation.

The specific gravity of vinegar from mango juice supplemented with sugar (SMV) was higher when compared with vinegar from mango juice without sugar supplementation (FTV). It has been reported that the specific gravity of vinegar from any fruit range from 1.000 to 1.060 which means that the vinegar produced from SMV and FTY was of good quality. The concentration of brix in the samples implies that there was a better utilization of sugar in SMV than FTV which means that the presence of fermentable sugars in mango fruit makes it an ideal substrate for alcoholic fermentation of fruit juice and subsequent secondary fermentation into vinegar (Dias, Schwan, Freire, & Serôdio, 2007). SMV has the

Table 1. Result of physicochemical analysis

Parameters	SMV	FTV
Specific gravity (g/l)	1.049 ± 0.10[a]	1.007 ± 0.17[b]
Brix(%)	12.14 ± 0.26[a]	1.080 ± 1.55[b]
Alcohol content (%)	6.17 ± 0.36[a]	1.01 ± 0.16[b]
Titratable acidity (g/l)	0.25 ± 0.05[a]	0.25 ± 0.05[a]
Total phenollic (gallic acid) (g/ml)	0.513[a]	0.513[a]
pH	4.02 ± 0.10[a]	4.25 ± 0.11[a]

Notes: Values with the same letter within the row are not significantly different at $p < 0.05$; Letters between same column has same significant difference; SMV: vinegar from mango juice supplemented with sugar, FTV: vinegar from mango juice without sugar supplementation.

highest concentration of alcohol while sample FTV has the least alcohol concentration which may be as a result of added sugar (Nielson, 2002). During the alcoholic fermentation, ethanol production may be proportional to the concentration of sugar juice. The rapid and significant changes in alcohol during acetic acid fermentation may be due to oxidation of ethanol by dehydrogenises during the acetic fermentation, which constitute the second stage of vinegar production (Frébortová, Matsushita, & Adachi, 1997). As for the total phenol, gallic acid is used as a standard for determining phenol content of vinegar which determines the flavonoid which shows that the colour change indicated a presence of phenolic group. Gallic acid increased with ageing in the vinegar and as a result, high concentration is an indication of very aged vinegars (García-Parrilla, González, Heredia, & Troncoso, 1997).

The pH of SMV during the secondary fermentation was observed to have increased slightly from 3.98 to 4.02. This slight increase in acidity provided optimal growth conditions to initiate acetification. The increase in pH can be attributed to accumulation of acetic acid and other organic acids such as tartaric and propionic acid which are important for the development of flavour and aroma (Byarugaba-Bazirake, Byarugaba, Tumuslime, & Kimono, 2014). The table shows that the degree of acidity in sample FTV after the first 24 h was high relative to samples SMV and UMI respectively as a result of its complete fermentation. However, after 15 days, it was observed that the degree of acidity in sample SMV increase with a slight difference of 0.02. However, at 30 days the acidity in sample SMV raised to 4.02 which maybe as a result of complete fermentation.

3.2. Colour

Table 2 showed the results obtained from colour analysis of the samples which revealed that there was no significant different in the lightness compare to colour observed. It was observed that the lightness is higher in sample FTV compare to SMV. Also the SMV result shows that the colour changed from green to blue and for FTV the colour changed from green to black which can be due to the presence of phenolic group or the degree of acetification (Morales, Tesfaye, García-Parrilla, & Casas, 2001).

Table 2. Result of sensory evaluation

Parameters	FTV	SMV
Colour	7.7 + 0.46[a]	6.8 + 0.13[a]
Taste	6.8 + 0.94[a]	6.1 + 0.83[a]
Aroma/flavour	6.0 + 1.47[a]	5.3 + 1.30[a]
Mouth feel	6.5 + 1.12[a]	4.9 + 1.51[b]
Thickness	7.0 + 1.09[a]	7.0 + 1.00[a]
Overall acceptability	6.9 + 0.83[a]	6.4 + 1.68[a]

Notes: Values with the same letter within the row are not significantly different at $p < 0.05$; Letters between same column has same significant difference; SMV: vinegar from mango juice supplemented with sugar, FTV: vinegar from mango juice without sugar supplementation.

4. Sensory evaluation

The organoleptic evaluation showed that sample SMV has a high level of brightness with average mean of 6.1 while brilliant and sharp colour was observed in sample FTV. FTV was also acceptable because it has good appearance, taste, aroma and good mouth feel. Thus, sample FTV had highest acceptance value among the panellists with an average mean value of 6.7. The cake prepared with the vinegar was also assessed for consumer acceptability. The results of sensory evaluation revealed that the cake preserved with the vinegar was unacceptable to the panellists. Hence, the vinegar produced cannot be used for cake preservation.

5. Conclusion

This study revealed that the process used to produce mango vinegar from mango juice was very effective and efficient. The vinegar produce has an acidic strength of 25% which is similar to the industrial vinegar. The vinegar produced from mango fruits also has good physico-chemical properties when compared with the industrial one which compared favourably with previous studies. The mango vinegar has effect on consumer's acceptability unlike the industrial vinegar which was generally accepted. Finally, the mango vinegar produced is shelf stable for 7 month which has little effect on the product so mango vinegar can be produced from mango fruits but may not be suitable for preservation of cake unless the process is upgraded.

6. Recommendations

Vinegar making is very popular nowadays and it is very helpful in food processing and preservatives. It is also one of the important ingredient of cooking food and other delicacies. Thus, many people have continued to experiment different fruits for the production of vinegar to have better quantity and quality. The type of bacteria used and concentration of sugar in the fruits had added impacted on the quality of vinegar produced. There should be further study on utilization of other lesser fruits in vinegar production in Nigeria to enhance food security by reducing losses of mango fruits and other fruits during their seasons.

Funding
The authors received no direct funding for this research.

Competing Interests
The authors declare no competing interest.

Author details
Abiodun Omowonuola Adebayo-Oyetoro[1]
E-mails: wonunext@gmail.com, abiodun.oyetoro@yabatech.edu.ng
Elizabeth Adenubi[1]
E-mail: lizadenubi@yahoo.com
Oladeinde Olatunde Ogundipe[1]
E-mail: deindeogundipe@yahoo.com
Bolanle Olayinka Bankole[1]
E-mail: bobankole@yahoo.com
Samuel Ayofemi Olalekan Adeyeye[2]
E-mail: saadeyeye@yahoo.com
ORCID ID: http://orcid.org/0000-0001-7519-4231
[1] Department of Food Technology, Yaba College of Technology, P.M.B 2011, Yaba, Lagos State, Nigeria.
[2] Department of Food Science & Technology, Mountain Top University, Prayer City, Ogun State, Nigeria.

Citation information
Cite this article as: Production and quality evaluation of vinegar from mango, Abiodun Omowonuola Adebayo-Oyetoro, Elizabeth Adenubi, Oladeinde Olatunde Ogundipe, Bolanle Olayinka Bankole & Samuel Ayofemi Olalekan Adeyeye, *Cogent Food & Agriculture* (2017), 3: 1278193.

Cover image
Source: Beltran et al. (2002).

References

Akinjayeju, O. (2009). *Quality control for the food industry: A stastistical approach* (p. 89). Lagos: Concept Publications.
Association of Analytical Chemists [AOAC]. (2000). *Official methods of analysis* (17th ed.). Washington, DC: Author.
Beltran, G., Torija, M. J., Novo, M., Ferrer, N., Poblet, M., Guillamón, J.M., … Mas, A. (2002). Analysis of yeast populations during alcoholic fermentation: A six year follow-up study. *Systematic and Applied Microbiology, 25*, 287–293. http://dx.doi.org/10.1078/0723-2020-00097
Byarugaba-Bazirake, G. W., Byarugaba, W., Tumuslime, M., & Kimono, D. A. (2014). The technology of producing banana wine vinegar from starch of banana peels. *African Journal of Food Science and Technology, 5*, 1–5.
de Ory, I., Romero, L. E., & Cantero, D. (2002). Optimum starting up protocol of a pilot plant scale acetifier for vinegar production. *Journal of Food Engineering, 52*, 31–37. http://dx.doi.org/10.1016/S0260-8774(01)00082-6
Dias, D. R., Schwan, R. F., Freire E. S, & Serôdio R. D. (2007). Elaboration of a fruit wine from cocoa (Theobroma cacao L.) pulp. *International Journal of Food Science and Technology, 42*, 319–329. http://dx.doi.org/10.1111/ifs.2007.42.issue-3
Frébortová, J., Matsushita, K., & Adachi, O. (1997). Effect of growth substrates on formation of alcohol dehydrogenase in Acetobacter methanolicus and Acetobacter aceti. *Journal of Fermentation Bioengineering, 83*, 21–25. http://dx.doi.org/10.1016/S0922-338X(97)87321-7

Gao, X., Björk, L., & Trajkovski, V. (2000). Evaluation of antioxidant activities of rosehip ethanol extracts in different test systems. *Journal of the Science of Food and Agriculture, 80*, 2021–2027. http://dx.doi.org/10.1002/(ISSN)1097-0010

García-Parrilla, M. C., González, G. A., Heredia, F. J., & Troncoso, A. M. (1997). Differentiation of wine vinegars based on phenolic composition. *Journal of Agricultural and Food Chemistry, 45*, 3487–3492. http://dx.doi.org/10.1021/jf970091s

Kiin-Kabari, D. B., & Banigo, E. B. (2015). Quality characteristics of cakes prepared from wheat and unripe plantain flour blends enriched with bambara groundnut protein concentrate. *European Journal of Food Science and Technology, 3*(3), 1–10.

Morales, M. L., Tesfaye, W., García-Parrilla, M. C., & Casas, J. A. (2001). Sherry wine vinegar: Physicochemical changes during the acetification process. *Journal of the Science of Food and Agriculture, 81*, 611–619. http://dx.doi.org/10.1002/jsfa.v81:7

Nielson S.S (2002). *Introduction to the chemical analysis of foods* (pp. 81–206). New Delhi: CBS Publishers.

Oka, K., Saito, F., Yasuhara, T., & Sugimoto, A. (2004). A study of cross-reactions between mango contact allergens and urushiol. *Contact Dermatitis, 51*, 292–296. http://dx.doi.org/10.1111/cod.2004.51.issue-5-6

Proulx, A., & Nichols, L. (2003). *Cider, making, using and enjoying sweet and hard cider* (3rd ed.). North Adam, MA: Storey Publishing.

Singh, U. P., Singh, D. P., Singh, M., Maurya, S., Srivastava, J. S., Singh, R. B., & Singh, S. P. (2004). Characterization of phenolic compounds in some Indian mango cultivars. *International Journal of Food Sciences and Nutrition, 55*, 163–169. http://dx.doi.org/10.1080/09637480410001666441

Solieri, L., & Giudici, P. (2009). *Vinegars of the World* (pp. 17–39). Milan. Springer-Verlag. http://dx.doi.org/10.1007/978-88-470-0866-3