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Diversified sericulture products: Mulberry fruit wine and wine vinegar

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Abstract

This study explored the production of diversified sericulture products, wine and wine vinegar utilizing mulberry fruits that were analyzed and evaluated. The mulberry fruit wine had sweet, alcohol-like odor while the mulberry wine vinegar had light pungent odor and both possessed dark purple color. The wine's chemical properties - pH, total acidity, volatile acids, ethanol and methanol were within the Philippine standards so with wine vinegar that included pH, total acidity and ash content except for the total solids attributed to the accumulated impurities which could be corrected through filtration. Sensory evaluation of the wine was described as "Good" in terms of appearance, aftertaste, aroma & bouquet, taste and texture while the wine vinegar was generally "Liked" in terms of appearance, color, texture, flavor, taste and acceptance. It implied that mulberry fruit wine and wine vinegar are potential and viable sericulture diversified products which can be adopted as source of additional income for sericulture farmers along with cocoon production and in sustaining and accelerating the development of sericulture industry.

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Introduction

It was signified by Archarya, *et al.* (2015) that the remarkable phases of agricultural growth and revolution include inductive, stimulative and simulative. Inductive stage entails intensive crop production catering agricultural inputs to grow and produce particular crop and the possibility of attaining production within the shortest possible time specifically in treating famine. The second phase involves the conversion and transformation of green revolution to silvery agriculture that entails the value-addition process, a quantum jump to generate a dynamic market for agricultural products. The simulative stage is characterized with future projections, digitized configuration and precision production. It is the period of optimum utilization of value addition focusing on branding, market segments, and value chain management regardless of geographic, temporal and spatial considerations. This further signifies entrepreneurial considerations gearing towards volume of golden production brought about by diversification of products mass-produced or manufactured and offered as available commodity in the market.

Diversification results to increasing commercialization to support the development of the agricultural sector in various ways (Hoq, *et al.*, 2012). In addition, the study of Starcher (2016) confirmed that farming operations such as the small ones could offer diversified or value-added products along with the usual produce in order to sustain their business beyond five years.

Sericulture is an agro-based industry comprised of mulberry cultivation and silkworm rearing to produce cocoons, which are processed into raw silk which eventually encompasses great measure of interdependent technologies resulting to numerous products and wastes. These scenarios propose opportunity to yield innovative and novel commercial products with a high use value. According to Buhroo, *et al.* (2018), mulberry leaves are utilized to feed the silkworm larvae, however, mulberry is also appreciated for its fruit that may be consumed (fresh, in juice, alcoholic drink or as preserves), as a delicious vegetable (young leaves and stems), for its medicinal properties in infusions (mulberry leaf tea). These present diversification practices to the conventional sericulture producing various novel products to be offered to the market.

According to Tanase, *et al.* (2006), Romania initiated researches in the utilization of sericulture by-products. It included the use of mulberry fruits in food and sweet products industry. Mulberry fruit wine is an alcoholic beverage produced through fermentation, the final product; the wine itself is bright in color, rich in nutrition constituents, and full-blooded. The anthocyanin content is five times that of ordinary red wine, while its resveratrol is two times and can be compared favorably with red wine (Liu Xueming, *et al.*, 2006) while mulberry fruit wine vinegar is a result of a double fermentation, alcoholic and acetous or acetification of any sugar substrate (Albert Mas, *et al.*, 2014), and is typically produced from mulberry fruit wine. The yeast strain, *Saccharomyces cerevisiae* in wine and wine vinegar-production makes an impact to the product and brings magnificent effects on the flavor during fermentation that included the content of ethanol, sugars, tannins, esters, methanol and volatile acids as results of the study of Suman Vikas Bhat, *et al.* (2014).

It confirmed in modern studies that mulberry fruits contain abundant glucose, sucrose, fructose, carotene, vitamins, oxysuccinic acid, succinic acid, tartrate and mineral calcium, phosphorus, iron, copper, zinc, etc. (Fang Lian, *et al.*, 2015). The study by Liang, *et al.* (2012) on chemical composition, nutritional value, and antioxidant activities of eight mulberry cultivars from China revealed that the mulberry fruit juice contains 70.0 – 87.4%, the crude protein contents were 1.62-5.24% and the crude fat contents from 1.23 – 2.23%. The major fatty acids in mulberry fruits were linoleic acid ($C_{18:2}$) and palmitic acid (C16:0), 26.40 – 74.77% and 9.29 – 22.26% respectively. Mulberry fruit is also good source of minerals and the potassium content.

Cocoon production remains the primary income-generating aspect of sericulture, providing gainful employment of sericulture farmers in the Philippines. However, additional income may be attributed through diversification that includes the manufacture of mulberry wine and wine vinegar, consequently, mulberry fruits are explored into the production of such and are able to determine their physico-chemical properties and establish sensory evaluation, hence, this study.

This endeavor covered the production and determination of the physico-chemical properties of diversified products using mulberry fruits. Specifically, this study had determined the physico-chemical properties and sensory evaluation of mulberry fruit wine and wine vinegar.

Materials and methods

The study was conducted at the Sericulture Research and Development Institute (SRDI), Bacnotan, La Union, Philippines. Mulberry fruits were gathered from the mulberry plantations along the institute while the wine yeast *Saccharomyces cerevisiae* was bought commercially as Lalvin EC-1118 wine yeast. Prior to the making of mulberry fruit wine and wine vinegar, the working area and equipment were sanitized to prevent contaminations. The mulberry fruits were washed with 10% metabisulfite solution and busted to obtain the juice. Water and white table sugar were added with continuous mixing and adjustments were made through the addition of water and/or sugar to obtain the desired specific gravity using the wine hydrometer. The mixture made from crushed mulberry fruits containing the skin and seeds was called must. It was kept in cool, dry place and readied for primary fermentation. The wine yeast was prepared according to the directions provided on the label and added after 24 hours after the must preparation.

Secondary fermentation was prepared after two weeks, when the desired specific gravity had attained. From the primary fermenter, the wine juice was siphoned into the glass carboy with water seal, and again kept in cool, dry place in a span of six weeks. Racking and stabilizing the wine were done every after a week.

The initial batch of wine prepared was subjected to physico-chemical analyses that included the parameters: color, odor, total acidity, volatile acids, ethanol and methanol components by the Department of Science and Technology (DOST), Metro Manila, Philippines.

The production of mulberry fruit wine vinegar was similar to that of producing wine; however, brown table sugar was used and aged for six weeks. The initial batch produced was analyzed by DOST in terms of color, odor, pH, total acidity, ash content and total solids.

The sensory evaluation of the diversified products was conducted at the Mid La Union Campus of the Don Mariano Marcos Memorial State University, La Union, Philippines by trained panelists. There were twelve (12) evaluators composed of seven (7) females and five (5) males and by which most of them had ages ranging from 18-29, college graduate. There were only two (2) classified as non-alcoholic drinker and the others were occasional drinker.

The descriptive method was used with the aid of the tool, American Wine Society Evaluation Form. The American Wine Society uses the 20 point evaluation scale developed at the University of California at Davis. The Davis system was developed by Dr. Maynard A. Amerine, Professor of Enology at the University of California at Davis, and his staff in 1959 as a method of rating the large number of experimental wines that were being produced at the university. It incorporated Appearance, Aroma, Buoquet, Taste, Aftertaste and Overall Impressions and assigned a number of points for each given area of evaluation.

The American Wine Society Evaluation Form (Kraft, n.d.) described the parameters accordingly. The Appearance of wine characterizes the clarity (refers to the cloudiness or sediment in a wine) and colour as the primary factors evaluated. The Aroma and Buoquet pertains to the smell that the wine acquires from the fruit and from fermentation. The Taste is the general term for the total impression a wine gives in the mouth, also refers to the primary tastes found in wine: sweet, sour and bitter while Aftertaste is the taste left in the mouth when one swallows which is a synonym for length or finish. The longer the Aftertaste lingers in the mouth (assuming it is a pleasant taste), the finer the quality of the wine.

Results and discussion

A. Production and Physicochemical Properties of Mulberry Fruit Wine and Wine Vinegar

The physical properties of the mulberry fruit wine are presented in Table 1. Five kilograms of ripe mulberry fruits were utilized and it approximately produced 23 liters of wine. It has dark purple color and a sweet, alcohol-like odor as observed.

The anthocyanin of the mulberry fruits attributed to the final color of the mulberry wine. Anthocyanin is the natural pigment from the mulberry fruit extract and has a potential medical and other commercial values (Chuanguang Qin, *et al.*, 2009).

Table 1. Physical Properties of Mulberry Fruit Wine.

Wine Sample	Physical Properties		
	Yield	Color	Odor
Mulberry Fruit Wine (5 kg fruits)	23 liters	Dark Purple	Sweet, Alcohol-like

The chemical properties of the mulberry fruit wine are shown in Table 2. Philippine standards attribute the pH, total acid, volatile acid, ethyl and methanol contents as parameters in determining chemical properties of fruit wine. The pH was determined using the pH meter (PH-009 I model) with a pH value of 3.8 and it is within the Philippine standard for fruit wines ranging from 3 to 4 (FDA, 2010). Winemakers use pH as a way to measure ripeness in relation to acidity.

Dias *et al.* (2017) described that low pH values in wines provide better stability and make wines taste tart and crisp, while higher pH wines are more susceptible to bacterial growth. Most wine pHs fall around 3 or 4; about 3 to 3.4 is desirable to white wines while about 3.3 to 3.6 is best for reds.

Table 2. Chemical Properties of Mulberry Fruit Wine.

Wine Sample	Chemical Properties				
	pH	Total Acidity	Volatile Acids	Ethanol/ Propanol	Methanol
Philippine Standard	3-4	0.6 – 0.9	Not more than 0.14	7 - 24	None
Pure Mulberry Fruit Wine	3.8	0.6	0.053	8.93	Not Detected

Total acidity (TA) content of wine is the concentration of organic acids in mulberry fruits such as malic acid, citric acid, tartaric, oxalic and fumuric acid (Koyuncu, 2004). This would make wine too tart or too sour for consumption. A low TA results in flat tasting wine which is more susceptible to infection and spoilage by microorganisms.

The total acidity (TA) of the mulberry fruit wine is 0.6 and is within the Philippine standards , 0.6 – 0.7 (FDA, 2010).

Volatile acid (VA) is a measure of the wine's volatile (or gaseous) acids. Volatile compounds are by-products of alcoholic fermentation from mulberry fruits and responsible for the quality of wine aroma (Velic, *et al.*, 2018). The primary volatile acid in wine is acetic acid, which is also the primary acid associated with the smell and taste of vinegar. High VA is undesirable in wine and would turn the wine into vinegar. The standard volatile acid of not more than 0.14 has been achieved by the produced mulberry fruit wine with a value of 0.053.

The actual type of alcohol created by the yeasts is ethyl alcohol, or ethanol. Fiscal and Chave (2016) reiterated that wine is chemically composed of two main ingredients, water, and ethanol. Ethanol in wine is important because ethanol is indispensable for the aging, stability and organoleptic characteristics of wine and it gives health benefits.

The mulberry fruit wine has 8.93% of ethanol, within the Philippine standard (7-24%) and has not been detected with methanol. Some countries or regions had regulations regarding fruit wine standards, Europe, 1.2 – 14%; Brazil, 4-14%; USA, less than 14%, 14-24% dessert fruit wine; and UK, 4-22% (Dias, *et al.*, 2017).

Table 3 presents the physical properties of mulberry fruit wine vinegar that included the yield, color and odor. Five kilograms of mulberry fruits were used and approximately 23 liters of wine vinegar were produced. It had the color, dark purple with a light pungent odor. The color is also attributed to the anthocyanin contents of the mulberry fruits.

Table 3. Physical Properties of Mulberry Fruit Wine Vinegar.

Vinegar Sample	Physical Properties		
	Yield	Color	Odor
Mulberry Fruit Wine Vinegar (5 kg mulberry fruits)	23 liters	Dark Purple	Light Pungent Odor

The chemical properties of the mulberry fruit wine vinegar are shown in Table 4 such as total acidity, volatile acid, alkalinity of soluble ash, ash content, volatile acidity and non volatile acidity which are chemical parameters provided by the Philippine standards. The pH value of 3.2 is within the Philippine standard for vinegar (FDA, 2013).

Table 4. Chemical Properties of Mulberry Fruit Wine Vinegar.

Vinegar Sample	Chemical Properties			
	pH	Total Acidity	Ash Content	Total Solids % w/w
Philippine Standard	Not less than 4	0.6% - 0.9%	0.4%	Not less than 2.2%
Mulberry Fruit Wine Vinegar	4	0.834	0.112	3.09

The total acid determined is more on acetic acid, which is responsible for the sour taste. The total acidity is 0.834% that is within the standard, 0.6% - 0.9%. The ash content equivalent to 0.112 is also within the standard, 0.4%. The Total Solids have a value of 3.09%, against the Philippine standard, 2.2% (%w/w). The high total solids in mulberry wine vinegar had been attributed by the presence of impurities and could be corrected through filtration.

B. Sensory Evaluation

Sensory evaluation was used to screen the sensory properties of the diversified products related to consumer's acceptance. It was an important step for any beverage characterization (Dias, *et al.*, 2017).

Fig. 1 illustrates Sensory Evaluation of Mulberry Fruit Wine that made used of the American Wine Chart from American Wine Society (Kraft, n.d.) in terms of Appearance and Aftertaste. It could be gleaned from Fig. 1 that the Appearance of the mulberry fruit wine is described as Excellent and the Aftertaste as Good by all othe twelve (12) evaluators.

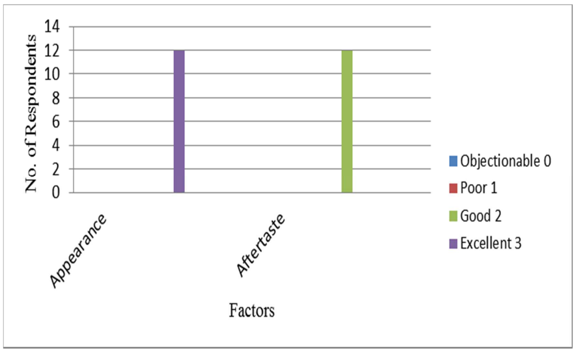

Fig. 1. Sensory Evaluation of Mulberry Fruit Wine in terms of Appearance and Aftertaste.

The sensory evaluation of mulberry fruit wine in terms of Aroma & Bouquet and Taste & Texture is presented in Fig. 2. All of the evaluators described the Aroma & Buoquet, and Taste & Texture as Good. These attributes had been determined due to production compounds produced by the mulberry fruit during fermentation, bottling and aging (Velic, 2018).

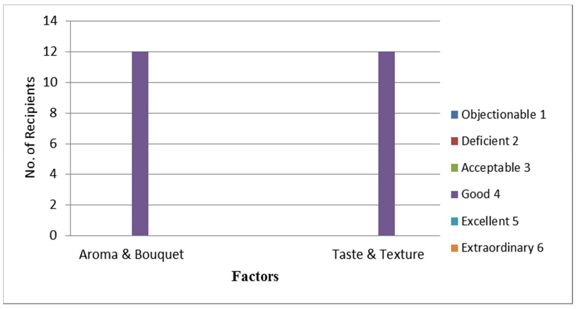

Fig. 2. Sensory Evaluation of Mulberry Fruit Wine in terms Aroma & Bouquet and Taste & Texture.

Moreover the overall impression of the mulberry fruit wine is Good and this is presented in Fig. 3. These results imply that the mulberry fruit had been well-appreciated by the evaluators.

Fig.3. The Over-all Impression of the Evaluators on the Mulberry Fruit Wine.

In Fig. 4, it illustrates the sensory evaluation on the mulberry fruit wine vinegar. It can be noted that the Appearance has been liked by eleven (11) evaluators; Color, nine (9); Texture, eleven (11); Flavor, eight (8), Taste, seven (7) and Acceptance, nine (9). From these results, the mulberry fruit wine vinegar has good qualities and attributes.

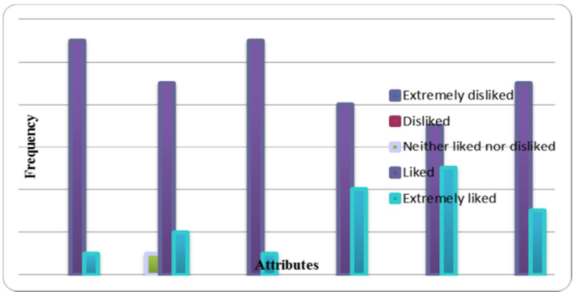

Fig. 4. Sensory Evaluation on the Mulberry Fruit Wine Vinegar.

Conclusion

Product diversification in sericulture such as the production of mulberry fruit wine and wine vinegar are potential commodities to be manufactured, viable for consumption and offer a niche in the market. Along with cocoon production, sericulture farmers may opt to venture in sericulture diversification particularly in producing mulberry fruit wine and wine vinegar to augment their income. This also offers an avenue to sustain and accelerate the development of sericulture industry in the Philippines.

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