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Studies on Various Technical Parameters Affecting Production of Wine from Lucuma, *Pouteria lucuma*

Minh Phuoc Nguyen
Faculty of Biotechnology, Ho Chi Minh City Open University, Ho Chi Minh City, Vietnam PO. Box: 335 Zip Code: 22888

ABSTRACT

Lucuma (*Pouteria lucuma*) is an important fruit in Vietnam. The fruit pulp exhibits an intense yellow colour and characteristic aroma. It is rich in carotenoids; minerals, vitamins, dietary fibres, triterpenes, phenolic compounds with significant pharmaceutical values. Possible spoilage occurred in the ripen lucuma fruit would be due to inappropriate storage condition. Wine is an alcoholic beverage made by fermenting fruit. In order to diversify this valuable fruit into value-added product like wine, purpose of the current research penetrated on the investigation of lucuma pulp fermentation under several technical variables such as sugar addition (4%, 6%, 8%, 10%, 12%), yeast inoculation (0.3%, 0.4%, 0.5%, 0.6%, 0.7%), fermentation temperature (30°C, 33°C, 35°C, 37°C, 40°C) in the primary fermentation; numerous clarifying agents (gelatin, chitosan, casein, wheat gluten) in the secondary fermentation or aging. Results revealed that sugar added at 8%, yeast inoculated at 0.6%, fermentation temperature conducted at 35oC in the initial must were significantly affected to the ethanol, residual soluble solid and organoleptic property of wine. Chitosan showed the best clarifying effectiveness in fining step to control haze turbidity in lucuma wine. From this research, consumers had more chance to inherit a functional food drink come from natural source.

KEY WORDS: *LUCUMA* WINE, YEAST INOCULATION, SUGAR ADDITION, FERMENTATION TEMPERATURE, CHITOSAN, ETHANOL, RESIDUAL SOLUBLE SOLID, ORGANOLEPTIC PROPERTY

INTRODUCTION

Lucuma (*Pouteria lucuma*) is a tropical fruit belonging to Sapotaceae family (Marianela et al., 2019). Its pulp has an intense yellow colour, sweet pleasant taste and characteristic aroma. Its sweet taste is utilized as a natural food sweetener (Banasiak, 2003). This fruit has a low moisture content compared to other fruits, however protein and reducing sugar contents are high (Erazo et al., 1999; Brizzolari et al., 2019). It's a rich source of carotenoids; minerals, vitamins, dietary fibres, triterpenes, phenolic compounds with variety of functional benefits (Rojo et al., 2010; Fuentealba et al., 2016; Albena et al., 2019).

Lucuma has been successfully processed in the production of ice cream, juices, cakes, biscuits, yogurt, chocolate, baby food and pies (Dini, 2011). It has been reported to treat antihyperglycemia and antihypertension (Marcia et al., 2009). Extracted lucuma nut oil can accelerate wound healing properties (Leonel et al., 2010). Lucuma fruit has been classified as one of super fruits (Mukta et al., 2017).

Fermentation is a relatively efficient, low-energy preservation process. Fruit wines are undistilled alcoholic

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beverages undergoing a period of fermentation and aging. During fermentation, yeast interacts with sugars in the juice to create ethanol, commonly known as ethyl alcohol and carbon dioxide as a by-product. They contain 8–11% alcohol and 2–3% sugar. The nutritive value of wine is increased due to the release of amino acids and other nutrients from yeast during fermentation (Pazhani et al., 2017).

After fermentation was completed, the wine is separated from the sediment by racking or using fining agents. At least 6 months should be allowed for aging. This aging enhanced the taste, aroma, and preservative properties of the wine (Van and Tromp, 1982). There are not many researches mentioned to processing of *Pouteria lucuma* fruit into wine. Hence, the purpose of this research focused on the identification of main technical variables such as sugar addition, yeast inoculation, fermentation temperature in the primary fermentation; numerous clarifying agents such as gelatin, chitosan, casein, wheat gluten in the secondary fermentation or aging influencing to the wine quality making from Pouteria lucuma pulp.

MATERIAL AND METHODS

Lucuma fruits were naturally collected from Soc Trang province, Vietnam. After collecting, they must be moved to laboratory quickly for experiments. They were washed under tap water to remove foreign matters. They were set on stainless tray to drip the remaining water. After that, they were opened by sharp knife to collect their pulp. Sugar and Saccharomyces cerevisiae were added into lucuma pulp in different ratio for the primary fermentation at different temperature in 4 weeks. The aging would be continued in fining by treating with different clarifying agents for 6 weeks at 9.5°C.

Effect of sugar addition in the main fermentation: *Pouteria lucuma* pulp was mixed with sugar addition at various ratio: 4%, 6%, 8%, 10%, 12% with Saccharomyces cerevisiae 0.3%. After 4 weeks of fermentation at 30°C, we examined the residual soluble dry matter (oBrix), ethanol (%v/v), and organoleptic attribute (sensory score) in wine.

Effect of yeast inculate in the main fermentation: *Pouteria lucuma* pulp supplemented 8% sugar combined with Saccharomyces cerevisiae was inoculated at various ratio (0.3%, 0.4%, 0.5%, 0.6%, 0.7%). After 4 weeks of fermentation at 30°C, we examined the residual soluble dry matter (oBrix), ethanol (%v/v), and organoleptic attribute (sensory score) in wine.

Effect of temperature in the main fermentation: *Pouteria lucuma* pulp supplemented 8% sugar combined with Saccharomyces cerevisiae was inoculated at 0.6% in various temperature (30°C, 33°C, 35°C, 37°C, 40°C). After 4 weeks of fermentation, we examined the residual soluble dry matter (oBrix), ethanol (%v/v), and organoleptic attribute (sensory score) in wine.

Effect of clarifying agent in the aging to wine quality: *Pouteria lucuma* wine was stored at 9.5oC for 6 weeks as aging with the supporting of numerous fining agents such as gelatin, chitosan, casein, wheat gluten at 0.2%. We monitored organoleptic attribute (sensory score) in wine.

Chemical and sensory analysis: Soluble solid (oBrix) was examined by hand-held refractometer. Ethanol (%v/v) in wine was measured by spectrophotometer. Sensory score was evaluated by a group of 13 panelists using 9 point-Hedonic scale.

Statistical analysis: The experiments were run in triplicate with three different lots of samples. The data were presented as mean ± standard deviation. Statistical analysis was performed by the Statgraphics Centurion version XVI.

RESULTS AND DISCUSSION

Effect of sugar addition in the main fermentation: Sugar is one of the most common substrate of fermentation to produce ethanol, lactic acid, and carbon dioxide (Giri et al., 2013). Sugar is an essential precursor nutrient affecting to the wine flavor, aroma taste and quality of fruit wine. It shows a correlation to the degree of fermentation (Xiao et al., 2017). Higher sugar concentration inhibits the growth of microorganisms (Pino et al., 2015). Sugar may need to be added to spur the fermentation process in the event that the fruit does not contain enough natural sugar to ferment on its own in the presence of yeast (Pazhani et al., 2017).

Table 1. Effect of sugar addition on the main fermentation

Parameter	Sugar addition (%)				
	4	6	8	10	12
Residual soluble solid (oBrix)	2.79 ± 0.02^{d}	3.39 ± 0.03^{cd}	4.04 ± 0.00^{c}	6.97±0.02b	8.43 ± 0.01^{a}
Ethanol (%v/v)	3.11 ± 0.00^{d}	4.65 ± 0.01^{c}	7.09 ± 0.00^{a}	5.72 ± 0.03^{b}	4.03 ± 0.00^{cd}
Sensory score	4.09 ± 0.03^{c}	5.25 ± 0.02^{b}	6.14 ± 0.01^{a}	5.68 ± 0.00^{ab}	4.83 ± 0.03^{bc}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

In the present research, *Pouteria lucuma* pulp was mixed with sugar at various ratios: 4%, 6%, 8%, 10%, 12% with Saccharomyces cerevisiae 0.3% at 30°C. The results are presented in table 1. We could clearly see that 10% of sugar addition was appropriate for wine making to obtain the best wine quality.

Effect of yeast inoculate on the main fermentation: Saccharomyces sp. is important in food fermentation as its ability to reproduce much faster (Pazhani et al., 2017). Yeast primarily requires sugars, water, and warmth to stay alive. Yeast flourishes in habitat where sugar exists. The alcoholic fermentation of fruit must is initiated by a complex yeast community comprising a high proportion of oxidative and weakly fermentative yeasts (Bahareh et al., 2017). In pure fermentation, the ability of inoculated Saccharomyces cerevisiae to suppress the wild microflora is one of the most important feature determining the starter ability to dominate the process (Maurizio et al., 2016).

The inoculation of musts using selected Saccharomyces strains does not ensure their dominance at the end of fermentation (Capece et al., 2010). In our current study, *Pouteria lucuma* pulp was inoculated with Saccharomyces cerevisiae at different ratios (0.3%, 0.4%, 0.5%, 0.6%, 0.7%). Our results were presented in table 2. We could clearly see that 0.6% of yeast was suitable for wine making to obtain the best wine quality.

Table 2. Effect of yeast inoculate on primary fermentation

Parameter	Yeast ratio (%)				
	0.3	0.4	0.5	0.6	0.7
Soluble dry matter (oBrix)	4.04±0.00[a]	3.71±0.02[ab]	3.01±0.01[b]	2.62±0.03[bc]	2.31±0.00[c]
Ethanol (%v/v)	7.09±0.00[b]	7.42±0.01[ab]	7.68±0.02[ab]	7.81±0.00[a]	7.90±0.03[a]
Sensory score	6.14±0.01[b]	6.39±0.03[ab]	6.67±0.00[ab]	6.79±0.01[a]	6.82±0.00[a]

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α= 5%).

Effect of temperature in the main fermentation: A lower temperature is preferred as it increases the formation of esters, other aromatic compounds, and alcohol itself. This causes the wine easier to clear and less susceptible to bacterial infection (Akubor et al., 2013). Temperature control during alcoholic fermentation is essential to promote yeast growth, extract flavors and colors from the skins, allow accumulation of desirable by-products, and limit undue rise in temperature that might kill the yeast cells. The low temperature and slow fermentation favor the retention of volatile compounds. High temperature is necessary to extract the pigment from the fruit skins (Fleet, 2013). In our research, *Pouteria lucuma* pulp supplemented 8% sugar combined with Saccharomyces cerevisiae inoculated at 0.6% in various temperature (30°C, 33°C, 35°C, 37°C, 40°C). Our results were presented in table 3. We could clearly see that fermentation should be conducted at 35°C to obtain the best wine quality.

Table 3. Effect of temperature on the main fermentation

Parameter	Temperature (oC)				
	30	33	35	37	40
Soluble dry matter (oBrix)	2.62±0.03[ab]	2.11±0.01[b]	1.63±0.00[c]	1.98±0.03[bc]	2.97±0.01[a]
Ethanol (%v/v)	7.81±0.00[bc]	8.03±0.02[b]	8.37±0.01[a]	8.23±0.00[ab]	7.54±0.02[c]
Sensory score	6.79±0.01[c]	7.42±0.03[b]	7.81±0.02[a]	7.60±0.01[ab]	.01±0.00b[c]

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α= 5%).

Effect of clarifying agent in the aging to wine quality: The clarifying agents bound the target components to form insoluble aggregates that were subsequently removed from the wine (Matteo et al., 2019). Gelatin preferentially removed high molecular weight tannins (Sarni et al., 1999; Maury et al., 2001; Smith et al., 2015). The gluten preparations were reported to remove highly galloylated tannins in similar quantities as gelatin, while gelatin was more effective in removing total tannins (Maury et al., 2003). Gluten used as fining agent had less impact on the color and anthocyanin content of red wines (González et al., 2014). Fining the red wines with gluten had a small impact on proanthocyanidins (Granato et al., 2014).

Casein was much more effective at low addition rates (Marchal et al., 2002). Being nontoxic and biodegaradable, chitosan may be used as an alternative agent for clarification. Chitosan has been reported to prevent protein haze by the partial precipitation of excess proteinaceous matter (Ricardo et al., 2012). Chitosan as a clarifying agent complexes with protein, polyphenols, and others insoluble solids inducing flocculation and sedimentation thus resulting in removal of these potential haze precursors (Soto et al., 1989). In our research, *Pouteria lucuma* wine was preserved at 9.5oC for 6 weeks as the aging with the supporting of different fining agent such as gelatin, chitosan, casein, wheat gluten at 0.2% (see table 4). Our results revealed that chitosan was superior to other fining agents. One study compared the effectiveness of gelatin and kaolin in clarifying wine variously produced from locally available fruits (pawpaw, pineapple, cashew and banana). Gelatin was a better clarifier than kaolin (Awe, 2018).

Wheat gluten was used as clarifying agent of musts and white wines (Richard et al., 2002). One study compared gluten to gelatin for clarification of young red wines (Iturmendi et al., 2010). Gluten and gelatin were similar in reducing turbidity, but gluten had the advantage of producing less lees and reduced the content of polyphenolic material less than gelatin did. According to Noriega et al. (2010) wine treated with gluten had residual wine post-filtration turbidity that was lower than that achieved using gelatin. Gluten was very fast in lowering wine turbidity upon application (Granato et al., 2018). Gluten showed a similar clarification ability to that of casein while it produced a lower amount of lees (Fernandes et al., 2015). Some residues can be present in gluten fined wines (Simonato et al., 2011; Cattaneo et al., 2003).

Table 4. Effect of clarifying agents on the secondary fermentation to wine quality

Parameter		Fining agent 0.2%		
	Gelatin	Chitosan	Casein	Wheat gluten
Sensory score	8.24±0.02[ab]	8.87±0.04[a]	7.95±0.03[b]	8.41±0.030[ab]

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α= 5%).

CONCLUSION

Fermentation diversified new products of fruits with modified physicochemical and sensory qualities, especially flavor and nutritional constituents. Lucuma is most common in the form of flour. It's a good source of biologically active substances especially beta-carotene, having an excellent antioxidant activity with antihyperglycaemic characteristics. Lucuma could be considered as a good substitute for rational nutrition because its powder is a good source of beneficial nutrients with various therapeutic advantages. Our research demonstrated that ripen lucuma fruit could be exploited for wine fermentation. From this approach, the commercial value of this lucuma fruit would be improved respectively.

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