



International Journal of Multidisciplinary Research and Development



IJMIRD 2014; 1(5): 94-98
www.allsubjectjournal.com
Received: 10-09-2014
Accepted: 23-09-2014
e-ISSN: 2349-4182
p-ISSN: 2349-5979

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Various factors influencing to red dragon fruit (*Hylocereus polyrhizus*) wine fermentation

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Abstract

Red dragon fruit (*Hylocereus polyrhizus*) or pitaya is well known in the fruit market as an excellent source of antioxidants and for its high content of nutrients, particularly potassium, as well as dietary fibre. Fermented products are one of the popular functional food choices due to their good functional and nutritional properties. The research aimed to investigate different factors influencing on the production of dragon fruit wine. We have successfully determined nutritional components in red dragon fruit. Main technical factors influencing to wine fermentation include ratio of mixture (dragon fruit pulp/grape: 9/1); soluble dry matter 22°Brix; pH 4.0 fermentation; *Saccharomyces cerevisiae* yeast ratio 8%, yeast density 2.1.107 (cells/ml); fermentation time 10 days; ethanol 12.77%; sensory score 17.2.

Keywords: *Hylocereus polyrhizus*, *Saccharomyces cerevisiae*, wine, fermentation

1. Introduction

Hylocereus polyrhizus, red pitaya, or dragon fruit is a member of the Cactaceae family from the subfamily "Cactoidea" (Raveh *et al.*, 1993) with red purple colored flesh and black seeds. Dragon fruit has obtained attention during last few years among the people in society, mostly in Asian countries, due to its color, nutritional value, and other features (Hoa *et al.*, 2006; Harivaindaran *et al.*, 2008). It represents a significant source of antioxidants which is a value added characteristic to any food crop (Rebecca *et al.*, 2012). The red layer of the fruit has rich sources of vitamins e.g. B1, B2, B3, and C, minerals e.g. potassium, sodium, calcium, iron, and phosphorus, and nutrients e.g. fat, protein, carbohydrate, flavonoid, crude fiber, thiamin, phytoalbumin, niacin, pyridoxine, kobalamin, glucose, betacyanins, phenolic, carotene, and polyphenol (Le Bellec *et al.*, 2006).

Moreover, this fruit has relatively high antioxidant activity in comparison with other subtropical fruits (Davis, 2007). Betalins, for the first time, extracted from red beet (*Beta vulgaris*) and is used largely for food coloring additives and the extract includes red and yellow pigments, namely betacyanins and betaxanthins, respectively. Betalins were assumed to be flavonoids, however, the evidence determines that it contains nitrogen and may not alter the color reversibly in an identical way as an anthocyanin do to pH. Betacyanin is the main component (95%) of the red pigments in the extract. In addition, dragon fruit peel includes betacyanin that can make contribution to produce beauty and health products (Ding *et al.*, 2009). In Caryophyllales family, the betalins are placed in same group to anthocyanin pigments (Cai *et al.*, 2005; Hoa *et al.*, 2006; Strack *et al.*, 2003). Due to unfavorable earthy flavor of geosmin and pyrazine derivatives as well as possibilities of carcinogenic nitrosamines in red beet, there is a high demand to replace this source (Esquivel *et al.*, 2007). Since dragon peel contains betalins and lacks the disadvantages of beetroot, it can be replaced as a new red dye.

Frequent consumption of red dragon fruit has been reported to improve overall digestive system, reduce cholesterol and prevent constipation. However, fresh dragon fruit can only last a maximum of 14 days at 10°C and 5 days at room temperature. The flesh of dragon fruit, according to a study Luders and McMahon (Luders, L., & McMahon, G., 2006), can be mixed with milk, soft drink, ice cream, jellies, and marmalades. Nazli Moshfeghi *et al.* (2013) introduce dragon fruit coloring powder named (DFCP) as a natural food additive using dragon fruit albedo. M. Z. Islam *et al.*, (2012) studied on the processing and preservation of dragon fruit (*Hylocereus undatus*) jelly.

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Consequently, it is desirable to process fresh fruit into fermented liquid dragon fruit in order to avoid waste and increase its marketability (Bellec *et al.*, 2006). The consumption of these fermented dragon fruit drinks is claimed improve overall body functions (Chew, 2009). The protective health effects was strongly believed to be due to its bioactive compounds since these compounds are commonly found in plant based diets. Extensive studies have been done on cereals, legumes, nuts, oil, vegetables, fruits, tea and red wine to identify their bioactive compounds as well as their associated health benefits such as antioxidant, anti-carcinogen, cholesterol reducing as well as remitting other chronic diseases (Kris-Etherton *et al.*, 2002).

One of the products introduced in recent years is the fermented dragon fruit drink. However, there are only limited published studies on fermented dragon fruit drink. Foong *et al.*, (2012) focused on the bioactive compounds (fatty acids, phytosterols, betacyanins and acetic acid) and other aspects (physical, microbiological, chemical and nutritional properties) of fermented liquid dragon fruit (*Hylocereus polyrhizus*).

Purpose of our research is to find out main factors influencing to dragon fruit (pitaya) wine fermentation such as the chemical compositions in fresh pitaya, ratio of mixture (pitaya/grape); soluble dry matter; pH fermentation; *Saccharomyces cerevisiae* yeast ratio; yeast density; fermentation time. Indicators which are expressed for wine fermentation are ethanol formation and sensory score.

2. Material & Method

2.1 Material

Red dragon fruit (pitaya) is purchased in Mekong river delta, Vietnam. Grape is originated from Binh Thuan province, Vietnam. *Saccharomyces cerevisiae* is supplied from Pasteur Institute HCM City, Vietnam.



Fig 1: Red dragon fruit



Fig 2: Grape



Fig 3: *Saccharomyces cerevisiae*

2.2 Fermentation protocol

2.2.1 Dragon fruit and grape

We select these fruits at technical ripe maturity; without damage, insect and foreign matter.

2.2.2 Treatment

Dragon fruits after being selected, removed foreign matter as well as rotten/ bruise/ damaged ones will come to skinning, pressing, filtrating, steaming at 100°C in 3-4 minutes and cooling. Grape fruits are removed foreign matter as well as rotten/ bruise/ damaged. Then they are pressed to get juice.

2.2.3 Mixing, adjusting composition

Dragon fruit juice after being cooled and grape after being filtered will be mixed together in differents ratios (10/0; 9/1; 8/2; 7/3; 6/4). Then this mixture is supplemented by sugar to get 22°Brix (equivalent to 220 g/l); adjusted to pH=4 by Na₂CO₃; supplemented Nitrogen elements by ammonium phosphate as well as vitamin B1 etc.

2.2.4 Fermentation

The fermentation batch will be inoculated by *Saccharomyces cerevisiae* (proliferated in 24 hours in advance) at ratio 8%. Fermentation is performed at 25 ÷ 30 °C in 10 days.

2.2.5 Treatment after fermentation

After fermentation, we conduct the yeast removal, clearance (by adding pectinase), preservation, filtering and bottling.

2.3 Research method

2.3.1 Determine chemical composition in raw material

Dragon fruit and grape are analysed chemical compositions such as moisture content (%), titratable acidity (%), soluble dry matter (%), mineral (%).

2.3.2 Determine yeast density during proliferation

Prepare the yeast proliferation batch and number yeast cells at different intervals: 0, 4, 8, 12, 16, 20, 24, 28, 32, 36 hours.

2.3.3 Factors influencing to pitaya fruit wine fermentation

2.3.3.1 Effect of ratio pitaya/grape

Prepare 5 samples with different ratios of pitaya/grape: 10/0; 9/1; 8/2; 7/3; 6/4. Fermentation is executed in the following conditions: sugar concentration 22° Brix (220g/l); yeast supplementation 10%; pH 3.5 ÷ 4.0; normal temperature 25-30 °C. After fermentation, we conduct yeast and deposit removal; evaluate ethanol content and sensory characteristics so that we draw out the appropriate ratio of pitaya/grape.

2.3.3.2 Effect of sugar concentration

Prepare 5 samples with different ratios of sugar concentration: 16° Brix; 18° Brix; 20° Brix; 22° Brix; 24° Brix that are equivalent to 160, 180, 200, 220, 240 g/l. Fermentation is executed in the following conditions: ratio of pitaya/grape=9/1, yeast supplementation 10%; pH 3.5-4.0; normal temperature 25-30°C. After fermentation, we conduct yeast and deposit removal; evaluate ethanol content and sensory characteristics so that we draw out the appropriate sugar concentration.

2.3.3.3 Effect of pH fermentation

Prepare 5 samples with different ratios of pH 3.0; 3.5; 4.0; 4.5; 5.0. Fermentation is executed in the following conditions: of pitaya/grape=9/1; yeast supplementation 10%; sugar concentration 22°Brix; normal temperature 25-30°C. After fermentation, we conduct yeast and deposit removal; evaluate ethanol content and sensory characteristics so that we draw out the appropriate pH value.

2.3.3.4 Effect of yeast inoculum

Prepare 5 samples with different yeast ratios of inoculum: 5%; 6%; 7%; 8%, 9%. Fermentation is executed in the following conditions: of pitaya/grape=9/1; sugar concentration 22°Brix; pH 4.0; normal temperature 25-30°C. After fermentation, we conduct yeast and deposit removal; evaluate ethanol content and sensory characteristics so that we draw out the appropriate yeast inoculum.

2.3.3.5 Effect of fermentation time

Prepare 5 samples with different fermentation times 4; 6; 8; 10; 12 days. Fermentation is executed in the following conditions: of pitaya/grape=9/1; sugar concentration 22°Brix; pH 4.0; yeast ratio 8%; normal temperature 25-30°C. After fermentation, we conduct yeast and deposit removal; evaluate ethanol content and sensory characteristics so that we draw out the appropriate fermentation time.

2.4 Testing method

- Moisture content: drying to basic weight at 105°C
- Ash: burning at 550°C
- Titrable acidity: titration
- °Brix: by refractometer
- Ethanol: by distillation
- Sensory characteristics: taste, aroma, color

2.5 Statistical analysis

All data are processed by Excel 2003.

3. Result & Discussion

3.1 Composition of pitaya fruit and grape

Table 1: Composition of Pitaya Fruit and Grape

Description	Moisture (%)	Soluble dry matter (%)	Mineral (%)	Acidity (%)
Pitaya	85.83	14.17	0.447	6.939
Grape	87.73	12.27	0.484	5.009

Moisture content in these materials are quite high so they are ideal source to get juice for fermentation. Moreover, sugar content in these materials are also high so they are suitable for fermentation (sugar supplementation). In contrast, mineral in these materials is quite low so it's necessary to add more mineral into fermentation so that we can get the moderate taste of wine. High acidity in these materials is favourable for preservation and taste feeling.

3.2 Yeast density in proliferation

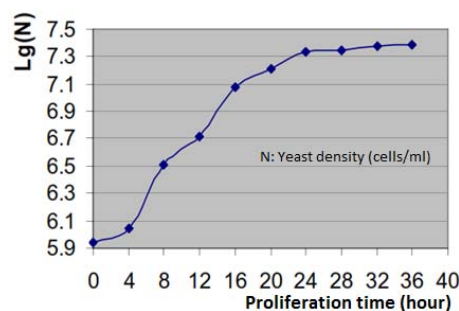


Fig 4: Growth curve of yeast during proliferation

At 24 hours of proliferation, yeast has the best density and fermentation capability.

3.3 Effect of ratio dragon fruit/ grape to ethanol formation and sensory score during wine fermentation

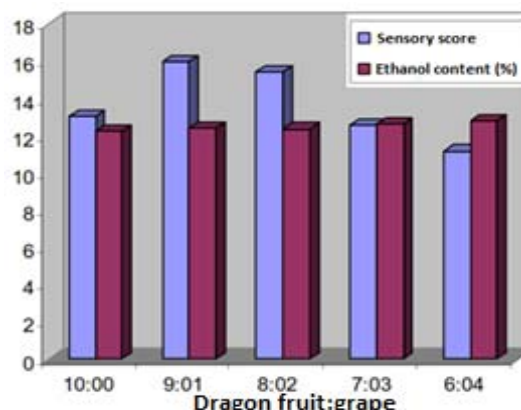


Fig 5: Effect of ratio dragon fruit/ grape to ethanol formation and sensory score

From figure 5, at high ratio of pitaya/grape 10/0 and 9/1, wine has high ethanol content and sensory score. Control sample (100% pitaya) has sensory score 13.04 and ethanol 12.25%. Sample (9 pitaya/1 grape) has the sensory score 16.00 and ethanol 12.44%. Sample (8 pitaya/2 grape) has

the sensory score 15.44 and ethanol 12.38%. Sample (7 pitaya/3 grape) has the sensory score 12.56 and ethanol 12.64%. Sample (6 pitaya/4 grape) has the sensory score 11.20 and ethanol 12.84%. From above data, we can see dragon fruit is a ideal source for wine fermentation with high ethanol content. We decide to choose ratio pitaya/grape: 9/1 for wine fermentation.

3.4 Effect of sugar content to ethanol formation and sensory score during wine fermentation

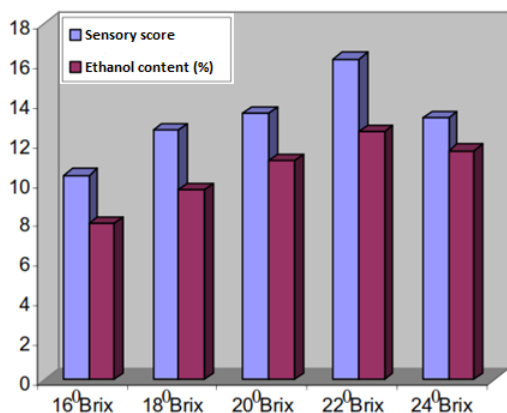


Fig 6: Effect of sugar supplementation to ethanol formation and sensory score

In sugar concentration (16-22)^oBrix, wine has high sensory score and ethanol concentration. At 16^oBrix, wine has sensory score 10.36 and ethanol 7.89%. At 18^oBrix, wine has sensory score 12.64 and ethanol 9.64%. At 20^oBrix, wine has sensory score 13.52 and ethanol 11.08%. At 22^oBrix, wine has sensory score 16.24 and ethanol 12.57%. However, if we continue increasing sugar content to 24^oBrix, sensory score and ethanol content will be decreased to 13.28 and 11.59% respectively. So we choose 22^oBrix for wine fermentation.

3.5 Effect of pH to ethanol formation and sensory score during wine fermentation

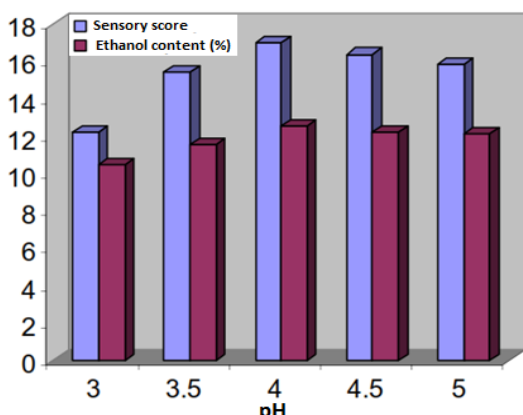


Fig 7: Effect of pH to ethanol formation and sensory score of wine

At pH 3-4, wine has high sensory score and ethanol content. At pH 3.0, wine has sensory score 10.36 and ethanol content 7.89. At pH 3.5, wine has sensory score 12.64 and ethanol content 9.64. At pH 4.0, wine has sensory score 13.52 and ethanol content 11.08. However, if

we continue increasing pH 4.5 to 5.0, sensory score and ethanol content will be decreased. At pH 4.5, wine has sensory score 16.24 and ethanol content 12.57%. At pH 5.0, wine has sensory score 13.28 and ethanol content 11.59. So we can see the strong effect of pH to yeast growth. Initial pH value is very important. We decide to choose pH 4.0 for wine fermentation

3.6 Effect of yeast supplementation to ethanol formation and sensory score during wine fermentation

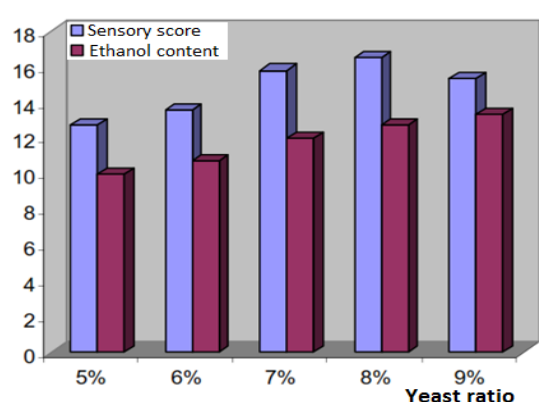


Fig 8: Effect of yeast supplementation to ethanol formation and sensory score in wine fermentation

At yeast ratio 5-8%, wine has high sensory score and ethanol content. At yeast ratio 5%, wine has sensory score 12.8 and ethanol content 10.03. At yeast ratio 6%, wine has sensory score 13.6 and ethanol content 10.75. At yeast ratio 7%, wine has sensory score 15.84 and ethanol content 11.99. At yeast ratio 8%, wine has sensory score 16.56 and ethanol content 12.77. At yeast ratio 9%, wine has sensory score 15.36 and ethanol content 13.36. So we choose 8% yeast for wine fermentation.

3.7 Effect of fermentation time to ethanol formation and sensory score during wine fermentation

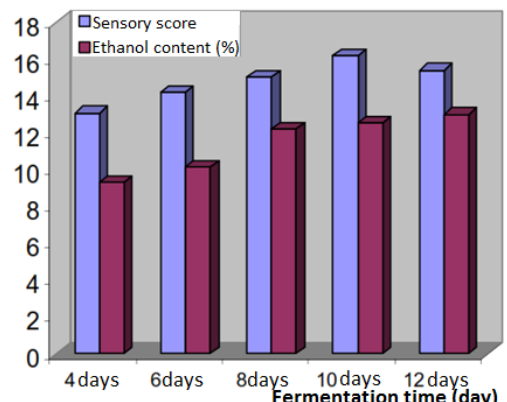


Fig 9: Effect of fermentation time to ethanol formation and sensory score during wine fermentation

At fermentation time from 4 to 10 days, wine has high sensory score and ethanol content. At 4th day, wine has sensory score 13.12 and ethanol content 9.32%. At 6th day, wine has sensory score 14.24 and ethanol content 10.16%. At 8th day, wine has sensory score 15.04 and ethanol

content 12.25%. At 10th day, wine has sensory score 16.24 and ethanol content 12.57%. At 12th day, wine has sensory score 14.00 and ethanol content 13.03%. So we decide to stop fermentation at 10th day.

3.8 Dragon fruit wine quality

Table 2: Dragon fruit wine quality

Parameter	Average score without important factor	Important factor	Average score with important factor	Ethanol (%V)
Color and clearance	3.52	0.8	17.2	12.77
Aroma	5.28	1.2		
Taste	8.4	2.0		

According to Vietnamese standard for wine TCVN 3215–79, dragon fruit wine has good quality.

3.9 Production cost for dragon fruit wine fermentation

Table 3: Overall cost for 1 litre of dragon fruit wine

No	Description	Unit	Unit cost (VND)	Quantity	Amount (VND)
1	Dragon fruit	Kg	15,000	1	15,000
2	Grape	Kg	14,000	0.15	2,100
3	Sugar	Kg	9,000	0.06	540
4	Yeast	ml	10	80	800
5	Others				2,000
Total (VND)					20,440

4. Conclusion

Vietnam has tropical climate and trend for growing dragon fruit that is considerable and it is one of the main producers of *Hylocereus Undatus* (red dragon) in South East Asia and the trend of production has been increased during past few decades. Dragon fruit is an edible fruit with water-soluble fiber and has high source of vitamin C. We have successfully found out some major technical factors influencing to dragon fruit fermentation. Further researches are recommended (1) pectinase enzyme to deposit particle; (2) fermentation temperature; (3) oxygen bubbling.

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