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Technical Variables of Wine Fermentation from Tamarind (*Tamarindus indica*)

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Abstract.

Tamarind is valued highly for its fruits, especially the pulp which is used for a wide variety of domestic and industrial purposes. The most outstanding characteristic of tamarind is its sweet acidic taste, the acid due to mostly tartaric acid**.** They are very nutritious foods contain fatty acids, vitamins, phytosterols and other phytochemicals. There is limited study mentioning to processing of this nutritional fruit. Therefore we explored a wine fermentation from tamarind by focusing on the effect of different parameters such as pectinase concentration and time of treatment for juice extraction, yeast inculate for wine fermentation, and secondary fermentation to wine quality**.** Our results proved that 0.25% pectinase was used for juice extraction in 35 minutes, 1.5% *sacchromyces cerevisiae* was used for the main fermentation at 11^{o}C in 10 days, and 3 weeks of sencondary fermentation in dark bottle at 9^{o}C was applied to get a pleasant Tamarind quality.

Keywords: *Tamarind, wine, fermentation, sacchromyces cerevisiae, pectinase*

1. INTRODUCTION

The tamarind is a long-lived, medium-growth, bushy tree, which attains a maximum crown height of 12 to 18 meters (39 to 59 ft). Tamarind is well adapted to semi-arid tropical conditions, although it does well in many humid tropical areas of the world with seasonal high rainfall (Emmanuel Uchenna Uzukwu et al., 2016). Leaves are evergreen, bright green in color, elliptical ovular, arrangement is alternate, of the pinnately compound type, with pinnate venation and less than 5 cm (2.0 in) in length. The fruit is an indehiscent legume, sometimes called a pod, 12 to 15 cm (4.7 to 5.9 in) in length, with a hard, brown shell. The fruit has a fleshy, juicy, acidulous pulp. It is mature when the flesh is colored brown or reddish-brown (T Sravanthi et al., 2017). When fully ripened, the shells are brittle and easily broken. The pulp dehydrates to a sticky paste enclosed by a few coarse stands of fibre. The pods may contain from 1 to 12 large, flat, glossy brown, obviate seeds embedded in the brown, edible pulp (Emmanuel Uchenna Uzukwu et al., 2016). Tamarind (*Tamarindus indica*) is highly valued for its pulp. Tamarind fruit pulp has a sweet acidic taste due to a combination of high contents of tartaric acid and reducing sugars. Two species of tamarind occur, the so-called sweet and sour tamarind. The pulp is used for seasoning, in prepared foods, to flavour confections, curries and sauces, and as a major ingredient in juices and other beverages ((Ajayi et al., 2006). The pulp is used to flavour preserves and chutney to make meat sauce. Candy can be made by mixing the pulp with dry sugar and moulding it into desired shapes (Sadik HA, 2010). Commercial tamarind-based drinks are available from many countries. The pulp constitutes 30-50% of the ripe fruit. Tamarind fruit pulp is eaten fresh and often made into a juice, infusion or brine (El-Siddig et al., 1999), and can also be processed into jam and sweets. Vitamin B content is quite high; carotene and vitamin C contents are low. Air-dried and powdered plant material was screened for the presence of saponins, tannins, alkaloids, flavonoids, triterpenoids, steroids, glycosides, anthraquinones, coumarin, saponins, gum, mucilage, carbohydrates, reducing sugars, starch, protein, and amino acids (Mahran et al.,1998; Sadiq, I. S. et al., 2016; T Sravanthi et al., 2017). The fruit pulp is relatively poor in protein though the fruit is rich in several amino acids (Ishola et al., 1990). Presence of tannins and other dyeing matters in the seed testa make the whole seed unsuitable for consumption, but they become edible after soaking and boiling in water. Tamarind kernel powder is an important sizing material in textile, paper and jute industries. Seeds are gaining importance as an alternative source of proteins, and are besides rich in some essential minerals. Seed pectin can form gels over a wide pH range. Leaves and flowers can be eaten as vegetables, and are prepared in a variety of dishes. They are used to make curries, salads, stews and soups. Tamarind leaves are a fair source of vitamin C and α-carotene; mineral content is high, particularly P, K, Ca and Mg. Anti-oxidant, anti-inflammatory, anti-microbial and anti-fungal activity has been documented from several plant parts. Tamarind is also extensively used in traditional medicine (Emmy De Caluwé et al., 2010).

Tamarind is an underutilized fruit crop and still now there is very limited research available regarding to processing of this fruit into value added product. The production of wine from Tamarindus indica was examined (O. Akoma et al., 2002). Production and microbial evaluation of table wine from tamarind (Tamarindus indica) and soursop (Annona muricata) was verified (Mbaeyi-Nwaoha et al., 2012). The physicochemical properties of tamarind fruit pulp for production of vinegar and to evaluate the quality characteristics of the produced vinegar was examined (Safiya Altuhami Ballal Taha et al., 2016). A research finding was to produce and improve the quality of tamarind wine (Pongkan, S. et al., 2018).

The fruit contained glucose, fructose and arabinose as inverted sugars, besides; it has a lower acidity, therefore, recommends efficient utilization of tamarind fruit into

wine. Therefore, we utilized this fruit as subtrate for wine fermentation. We focused on the effect of different parameters such as pectinase concentration and time of treatment for juice extraction, yeast inculate for wine fermentation, and secondary fermentation to wine quality.

2. MATERIAL & METHOD

2.1 Material

We collected Tamarind in Soc Trang province, Vietnam. They must be cultivated following VietGAP without pesticide and fertilizer residue to ensure food safety. After harvesting, they must be conveyed to laboratory within 8 hours for experiments. Apart from collecting Tamarind, we also used other materials such as pectinase, yeast. Lab utensils and equipments included knife, weight balance, fermentation tank, refractometer, viscometer, flow UV system, pH meter, ethanol meter, buret.

Figure 1. Tamarind *(Tamarindus indica)*

2.2 Research method

2.2.1 Effect of pectinase concentration and time for juice extraction

Tamarind extract was treated with pectinase enzyme with different concentration (0.15, 0.20, 0.25, 0.30%) in different duration (25, 30, 35, 40 minutes). We analyzed the extract recovery (%), viscosity (cP) and turbidity (mJ/cm^2).

2.2.2 Effect of yeast inculate for wine fermentation

Tamarind wort after being treated by pectinase would be inoculated with *Saccharomyces cerevisiae* at different ratio (0.5, 1.0, 1.5, 2.0%). After 10 days of fermentation at 11^{o}C, we analyzed the soluble dry matter (^{o}Brix), ethanol (%v/v), acidity (g/l), and sensory characteristics (score) in wine.

2.2.3 Effect of secondary fermentation to wine quality

We preserved tamarind wine at 9^{o}C in dark bottle by different time (1, 2, 3, 4 weeks) as the secondary fermentation. We monitored soluble dry matted (^{o}Brix), ethanol (% v/v), acidity (g/l), and sensory characteristics (score) in wine.

2.3 Statistical analysis

Data were statistically summarized by Statgraphics.

3. RESULT & DISCUSSION

3.1 Effect of pectinase concentration and time of treatment for juice extraction

The enzymatic liquefaction process not only helped in increasing the overall yield of juice but also upgrading the quality features of the extracted juice leading to sparkling clarity (Sakhale, B. K. et al. 2016). Tamarind extract was treated with pectinase enzyme with different concentration (0.15, 0.20, 0.25, 0.30%) in different duration (25, 30, 35, 40 minutes). Our results were depicted in table 1, 2 and 3. We clearly found that 0.25% pectinase in 35 minutes treatment was optimal for tamarind extraction. So we selected these values for next experiments.

The enzymatic liquefaction of pulp as a function of enzyme concentration, incubation time and hydrolysing temperature is standardized to obtain a desired yield of brilliantly cleared juice (Bhattacharya and Rastogi, 1999).

3.2 Effect of yeast inculate for wine fermentation

Wine is an alcoholic beverage producing by fermentation of yeast, *Saccharomyces cerevisiae* in fruit juice. In general, grape is the most popular fruit for wine production because grape juice is rich of carbon sources, nutrients and enzyme for yeast fermention. Yeast grows and converts sugar in fruit juices into alcohol and carbondioxide (Pongkan, S. et al., 2018). Tamarind wort after being treated by pectinase would be inoculated with *Saccharomyces cerevisiae* at different ratio (0.5, 1.0, 1.5, 2.0%). After 10 days of fermentation at 11^{o}C, we noticed the change of soluble dry matter (^{o}Brix), ethanol (%v/v), acidity (g/l), and sensory characteristics (score) in wine as in table 4, 5, 6 and 7. We found that the approprate yeast inculate should be 1.5% to get the highest wine quality.

Table 1. Extract recovery (%) by diffferent pectinase concentration (%) and time of treatment (minutes)

Pectinase concentration (%)	Extract recovery (%)			
	25 minutes	30 minutes	35 minutes	40 minutes
0.15	48.52±0.02^c	49.73±0.01^d	51.38±0.01^b	51.45±0.03^b
0.20	49.01±0.01^b	49.85±0.00^c	51.65±0.02^{ab}	51.70±0.02^{ab}
0.25	51.49±0.03^{ab}	51.57±0.03^b	51.98±0.01^a	52.02±0.01^a
0.30	51.60±0.00^a	51.78±0.02^a	52.04±0.03^a	52.08±0.02^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%).

Table 2. Viscosity (cP) by diffferent pectinase concentration (%) and time of treatment (minutes)

Pectinase concentration (%)	Viscosity (cP)			
	25 minutes	30 minutes	35 minutes	40 minutes
0.15	1.39±0.02^a	1.30±0.01^a	1.21±0.01^a	1.19±0.01^a
0.20	1.22±0.01^{ab}	1.20±0.03^{ab}	1.15±0.02^{ab}	1.03±0.02^{ab}
0.25	1.09±0.02^{ab}	1.05±0.02^{ab}	0.98±0.00^{ab}	0.85±0.02^{ab}
0.30	0.93±0.03^b	0.86±0.00^b	0.77±0.03^b	0.74±0.03^b

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%).

Table 3. Turbidity (mJ/cm^2) by diffferent pectinase concentration (%) and time of treatment (minutes)

Pectinase concentration (%)	Optical density (mJ/cm^2)			
	25 minutes	30 minutes	35 minutes	40 minutes
0.15	71.32±0.02^{a}	70.88±0.03^{a}	70.54±0.01^{a}	70.29±0.02^{a}
0.20	70.88±0.01^{b}	70.46±0.02^{b}	70.12±0.02^{b}	69.94±0.01^{b}
0.25	69.45±0.03^{bc}	69.23±0.01^{bc}	69.01±0.01^{bc}	68.79±0.03^{bc}
0.30	69.16±0.03^{c}	68.95±0.03^{c}	68.66±0.02^{c}	68.60±0.00^{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%).

Table 4. Effect of yeast ratio to soluble dry matter (^{o}Brix) in wine

Fermentation time (days)	**Soluble dry matter in wine (^{o}Brix)**			
	Yeast ratio 0.5%	Yeast ratio 1.0%	Yeast ratio 1.5%	Yeast ratio 2.0%
1	19.22±0.01^{a}	19.01±0.01^{a}	18.58±0.00^{a}	18.04±0.00^{a}
2	18.47±0.02^{ab}	18.30±0.01^{ab}	18.11±0.02^{ab}	18.02±0.01^{a}
3	17.30±0.00^{b}	17.12±0.03^{b}	17.03±0.01^{b}	16.89±0.03^{ab}
4	16.21±0.02^{bc}	15.94±0.02^{bc}	15.81±0.03^{bc}	15.70±0.02^{b}
5	15.01±0.03^{c}	14.87±0.01^{c}	14.62±0.01^{c}	14.50±0.01^{bc}
6	14.14±0.01^{cd}	14.02±0.00^{cd}	13.94±0.02^{cd}	13.81±0.01^{c}
7	13.31±0.02^{d}	13.01±0.03^{d}	12.92±0.00^{d}	12.85±0.03^{cd}
8	12.19±0.01^{de}	11.93±0.02^{de}	11.74±0.03^{de}	11.62±0.02^{d}
9	11.33±0.03^{e}	11.06±0.01^{e}	10.83±0.01^{e}	10.60±0.00^{de}
10	10.97±0.00^{f}	10.73±0.03^{f}	10.55±0.02^{f}	10.11±0.01^{e}

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%).

Table 5. Effect of yeast ratio to ethanol formation (%v/v) in wine

Fermentation time (days)	**Ethanol in wine (%v/v)**			
	Yeast ratio 0.5%	Yeast ratio 1.0%	Yeast ratio 1.5%	Yeast ratio 2.0%
1	1.16±0.01^{f}	1.32±0.00^{f}	1.89±0.01^{f}	1.95±0.00^{f}
2	1.33±0.00^{e}	1.45±0.01^{e}	1.97±0.03^{e}	2.06±0.02^{e}
3	1.90±0.03^{de}	2.04±0.03^{de}	2.35±0.02^{de}	2.56±0.03^{de}
4	2.25±0.02^{d}	2.43±0.02^{d}	2.79±0.01^{d}	2.85±0.01^{d}
5	2.79±0.00^{cd}	3.04±0.01^{cd}	3.25±0.03^{cd}	3.34±0.00^{cd}
6	3.03±0.01^{c}	3.21±0.02^{c}	3.49±0.00^{c}	3.57±0.02^{c}
7	3.26±0.02^{bc}	3.39±0.01^{bc}	3.61±0.01^{bc}	3.70±0.00^{bc}
8	3.59±0.01^{b}	3.71±0.02^{b}	3.92±0.03^{b}	4.00±0.02^{b}
9	3.83±0.00^{ab}	3.99±0.01^{ab}	4.15±0.02^{ab}	4.24±0.03^{ab}
10	4.01±0.01^{a}	4.20±0.00^{a}	4.36±0.01^{a}	4.40±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%).

Table 6. Effect of yeast ratio to acidity (g/l) in wine

Fermentation time (days)	**Acidity in wine (g/l)**			
	Yeast ratio 0.5%	Yeast ratio 1.0%	Yeast ratio 1.5%	Yeast ratio 2.0%
1	1.42±0.01^{d}	1.49±0.01^{d}	1.58±0.02^{e}	1.65±0.00^{d}
2	1.51±0.02^{cd}	1.55±0.03^{cd}	1.63±0.01^{de}	1.70±0.01^{cd}
3	1.67±0.03^{c}	1.82±0.01^{c}	1.89±0.02^{d}	1.93±0.03^{c}
4	1.79±0.00^{bc}	1.89±0.01^{bc}	1.95±0.03^{cd}	2.00±0.02^{c}
5	1.85±0.01^{bc}	1.91±0.02^{bc}	1.99±0.02^{cd}	2.04±0.01^{c}
6	2.01±0.02^{b}	1.98±0.01^{bc}	2.05±0.01^{c}	2.11±0.03^{bc}
7	2.13±0.01^{ab}	2.19±0.02^{b}	2.24±0.00^{bc}	2.31±0.01^{b}
8	2.24±0.03^{ab}	2.31±0.03^{ab}	2.39±0.03^{b}	2.43±0.02^{ab}
9	2.27±0.00^{a}	2.32±0.01^{ab}	2.45±0.01^{ab}	2.61±0.00^{a}
10	2.30±0.01^{a}	2.39±0.02^{a}	2.49±0.02^{a}	2.68±0.03^{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 different inoculum concentrations indicated that increased the inoculum concentration result in the increased of alcohol content. The result showed that when the concentration of yeast was increased, yeast cells converted more sugar to alcohol. However, at the higher inoculum concentration yeast cells grew not well because of the limited nutrient and were not able to convert more sugar in to it (Pongkan, S. et al., 2018). The results obtained were agreed with the report of Satav and Pethe (2017) who studied wine production from banana fruits. In this study, 10% and 15% inoculum concentration gave similar alcohol content but 10% showed the better taste than 15%.

Table 7. Effect of yeast ratio to soluble dry sensory characteristics (score, 1-5) in wine

Fermentation time (days)	Sensory score of wine (1-5) by different yeast ratio			
	Yeast ratio 0.5%	Yeast ratio 1.0%	Yeast ratio 1.5%	Yeast ratio 2.0%
1	2.31 ± 0.01^{d}	2.58 ± 0.02^{e}	2.89 ± 0.01^{f}	3.02 ± 0.02^{e}
2	2.41 ± 0.02^{cd}	2.71 ± 0.01^{de}	3.14 ± 0.02^{e}	3.15 ± 0.01^{de}
3	2.66 ± 0.03^{cd}	2.95 ± 0.03^{d}	3.66 ± 0.00^{de}	3.70 ± 0.02^{d}
4	2.87 ± 0.01^{c}	3.11 ± 0.00^{cd}	3.87 ± 0.02^{d}	3.98 ± 0.03^{cd}
5	3.01 ± 0.02^{bc}	3.25 ± 0.01^{c}	3.99 ± 0.03^{cd}	4.10 ± 0.01^{c}
6	3.48 ± 0.03^{b}	3.59 ± 0.02^{bc}	4.12 ± 0.00^{c}	4.29 ± 0.02^{bc}
7	3.87 ± 0.00^{ab}	3.76 ± 0.03^{b}	4.35 ± 0.02^{bc}	4.42 ± 0.00^{b}
8	4.01 ± 0.01^{ab}	4.14 ± 0.00^{ab}	4.48 ± 0.03^{b}	4.64 ± 0.02^{ab}
9	4.11 ± 0.03^{a}	4.30 ± 0.01^{a}	4.61 ± 0.01^{ab}	4.74 ± 0.01^{a}
10	4.19 ± 0.02^{a}	4.38 ± 0.02^{a}	4.74 ± 0.00^{a}	4.80 ± 0.03^{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%).

Table 8. Effect of the sencondary fermentation to wine quality

Criteria	Secondary fermentation (weeks)			
	1	2	3	4
Soluble dry matter (^{o}Brix)	10.32 ± 0.02^{a}	10.24 ± 0.02^{ab}	10.12 ± 0.01^{ab}	10.01 ± 0.02^{b}
Ethanol (%v/v)	4.45 ± 0.01^{b}	4.53 ± 0.00^{b}	4.64 ± 0.02^{ab}	4.80 ± 0.01^{a}
Acidity (g/l)	2.50 ± 0.00^{b}	2.52 ± 0.01^{b}	2.53 ± 0.03^{ab}	2.55 ± 0.03^{a}
Sensory score	4.77 ± 0.03^{b}	4.80 ± 0.02^{ab}	4.84 ± 0.00^{ab}	4.87 ± 0.02^{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%).

3.3 Effect of secondary fermentation to wine quality

We preserved tamarind wine at 9^{o}C in dark bottle by different time (1, 2, 3, 4 weeks) as the secondary fermentation. We monitored soluble dry matted (^{o}Brix), ethanol (% v/v), acidity (g/l), and sensory characteristics (score) in wine. Our results were elaborated in table 8. We noted that the longer of the secondary fermentation, the better of wine quality we got. However, there was not significant change of samples being preserved at the 3rd and 4th week so we choosed 3 weeks of secondary fermentation for economy.

A research finding was to produce and improve the quality of tamarind wine. The optimal conditions for production of tamarind wine was 10% inoculum concentration, 5% tamarind juice and 20 °Brix total soluble solid with the 0.67 percentage of alcohol by volume and 3.63 ± 0.10 points from sensory evaluation **(**Pongkan, S. et al., 2018**).**

4. CONCLUSION

Tamarind is a unique sweet/sour flavor of the pulp is popular in cooking and flavouring. Tamarind is a versatile, nutritious fruit with a great variety of uses. Tamarind fruit pulp is used for seasoning, as a food component, to flavour confections, curries and sauces, and is a main component in juices and certain beverages. Tamarind fruit pulp has a sweet acidic taste due to a combination of high contents of tartaric acid and reducing sugars. The pulp is relatively poor in protein and oil, though rich in several amino acids. The tamarind pulp contents high amount of vitamins and minerals. It is a good source of Ca, P, Cu, Mn and Zn, but low in Fe. Vitamin B content is quite high; carotene and vitamin C contents are low. We have successfully utilized Tamarind as substrate for wine fermentation by investigating different parameters such as pectinase concentration and time of treatment for juice extraction, yeast inculate for wine fermentation, and secondary fermentation to wine quality. These results were important because they could help wine makers to arrange proper processing method and storage.

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