DIFFERENT PROCESSING CONDITIONS AFFECT PALM (*THOT NOT*) WINE FERMENTATION

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ABSTRACT

Thot Not (coconut palm) trees are an integral part of the Khmer community in Van Giao Commune, Tinh Bien District, An Giang Province, Vietnam. Palm wine can be obtained from the young inflorescence either male (or) female ones palm wine is alcoholic beverage that are made by fermenting the sugary sap from various palm plants. It is collected by tapping the top of the trunk by felling the palm tree and boring a hole into the trunk it is a cloudy whitish beverage with a sweet alcoholic taste and very short shelf life of only one day, the wine is consumed in a variety of flavors varying foam sweet unfermented to sour, fermented and vinegary there are various products. Palm sap can be fermented (or) processed into an alcoholic beverage it just needs the correct yeasts, temperature and processing conditions. In our research, we investigate three yeast strains and decide to choose two strains Rh and C_1 to get good sensory quality wine. Between Rh and C_1, the first is superior to the later based on both sensory value and fermenting time (14 days for Rh and 18 days for C_1). Althoug the strain C_1 having longer fermenting time, it creates specific flavor and more CO_2 so it's suitable for sparking wine. From yeast strain Sacharomycess cerevisiae, pretreatment 75 ÷ 80^0C in 15 minutes, initial pH 5.0 ÷ 5.5, dry matter 20 ÷ 22% Brix, fermenting temperature 30^0C, palm wine is well fermented to 11.5 – 12.5% alcohol.

Keywords: Palm wine, yeast, pretreatment, processing condition, alcohol.

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1. INTRODUCTION

Palm wine is the fermented sap of various palm trees especially *Palmyra*, silver date palm and coconut palms. The sap should be collected from a growing palm. It is collected by tapping the palm this involves making a small incision in the bark about 15cm from the top of the trunk a clean gourd is tied around the tree to collect the sap which runs into it the sap is collected each day and should be consumed with in 5-12 hours of collection fresh palm juice is a sweet, clear, colorless juice containing 10-12% sugar. The sap is an excellent substrate for microbial growth fermentation starts soon after the sap is collected and withinan hour (or)

two. Becomes reasonably high in alcoholic (upto 4%) if allowed to continue to ferment for more than a day, it starts turning into vinegar [7].

Figure 1. Thot Not palm sap harvest on sunrise and sunset.

Several studies mentioned to processing conditions affect to palm wine production

J.D. Atputharajah et al. (1986) investigated the Microbiology and biochemistry of natural fermentation of coconut palm sap. A total of 166 isolates of yeasts and 39 isolates of bacteria were identified. Seventeen species of yeasts belonging to eight genera were recorded. The largest number of isolates (72%) belonged to genera *Candida, Pichia* and *Saccharomyces. Saccharomyces chevalieri* was the most dominant yeast species and accounted for 35% of the total isolates. Seven genera of bacteria were isolated. The predominant Genera was *Bacillus*. Others included *Enterobacter, Leuconostoc, Micrococcus* and *Lactobacillus*. The major physical, chemical and microbiological changes occurring in the fermenting sap indicated that a natural fermentation of coconut sap consist of an initial lactic acid fermentation, a middle alcoholic fermentation and a final acetic acid fermentation. It also appeared that activities brought about by micro-organisms of early phase helped the activities of the micro-organisms in each of the later phases [6].

Michael O. Eze, A. Uzoechi Ogan (1988) examined sugars of the unfermented sap and the wine from the oil palm, *Elaeis guinensis*, tree. The sugar composition of the unfermented sap from oil palm (*Elaeis guinensis*) trees growing in the plantations of the Nigerian Institute for Oil Palm Research, Benin City, has been determined. While sucrose concentration ranges from 9.59 to 10.59% (w/v) in the pure unfermented sap, that of either glucose or fructose is much less than 1% (w/v) (0.13–0.73% w/v). Raffinose occurs in traces only (0.13–0.35 w/v). These results were derived from our improved methods which eliminate completely, or reduce to a bare minimum, fermentation of the sap during collection. The variation with time of storage of the individual sugars in the sap during fermentation to form palm wine reveals that, as sucrose steadily decreases, fructose reaches a peak at 1.51% (w/v) at the 9th hour, and thereafter declines, while glucose and raffinose remain continuously low; all sugars disappear beyond the 33rd hour. Concomittantly, pH decreases from pH 6.60 at zero time and stabilizes at pH 3.30 after 48 h, while titrable acidity increases continuously up until the 96th hour. These changes account for the variations in the quality of palm wine during storages [8].
T.R Shamala, K.R Sreekantiah (1988) isolated and identified microorganisms that are responsible in fermenting wild date palm (*Phoenix sylvestris*) sap into wine (*toddy*). *accharomyces cerevisiae, Schizosaccharomyces pombe, Acetobacter aceti, Acetobacter rancens, Acetobacter suboxydans, Leuconostoc dextranicum,*

Micrococcus sp., *Pediococcus*sp., *Bacillus* sp. and *Sarcina* sp. were encountered in the freshly tapped sap. A majority of these microorganisms were also isolated from the traditionally fermented fresh toddy samples. In a comparitive study on the fermentation of fresh sap and fresh toddy, certain variations in the growth pattern of these microorganisms were noticed. In addition to this, the amount of ethanol, volatile acid, non-volatile acid and esters produced during these fermentations also varied [16].

T.E. Ayogu et al. (1999) evaluated the performance of a yeast isolate from Nigerian palm wine in wine production from pineapple fruits. *Saccharomyces cerevisiae* species were isolated from the fermenting sap of *Elaesis guineansis* (palm wine) as a source of yeast for wine making from pineapple fruits. One of these isolates was used to pitch a pineapple must prepared as the fermenting medium. A high ethanol yield of 10·2% (v/v) was obtained when compared with a commercial wine yeast (control) which gave 7·4% (v/v), indicative of higher ethanol tolerance by this isolate [15].

Ezeronye OU et al (2001) defined the genetic and physiological variants of yeast selected from palm wine. Genetic screening of 1200-palm wine yeasts lead to the selection of fourteen isolates with various genetic and physiological properties. Nine of the isolates were identified as *Saccharamyces* species, three as Candida species, one as *Schizosaccharomyces* species and one as Kluyveromyces species. Five of the isolates were wild type parents, two were respiratory deficient mutants (rho) and nine were auxotrophic mutants. Four isolates were heterozygous diploid (alphaa) and two were homozygous diploid (aa/alphaalpha) for the mating types were further identified on mating with type loci. Four Mat alpha and four Mat a types were further identified on mating with standard haploid yeast strains. Forty-five percent sporulated on starvation medium producing tetrads. Fifty-two percent of the four-spored asci contained four viable spores. Maximum specific growth rate [micromax] of the fourteen isolates range from 0.13-0.26, five isolates were able to utilize exogenous nitrate for growth. Percentage alcohol production range between 5.8-8.8% for palm wine yeast, 8.5% for bakers' yeast and 10.4% for brewers yeast. The palm wine yeast were more tolerant to exogenous alcohol but had a low alcohol productivity. Hybridization enhanced alcohol productivity and tolerance in the palm wine yeasts [3].

Obire, O (2005) evaluated the activity of *Zymomonas* species in palm-sap obtained from three areas in Edo State, Nigeria. The bacterium *Zymomonas* mobilis was isolated from fresh palm-sap samples from three different locations as to determine the contribution of the bacterial isolate to alcohol production in palm-wine. Carbohydrate (sugar) fermentation, alcohol tolerance, and growth of the bacterium at different pH and temperature values were determined; and a comparison of sugar fermentation by *Z. mobilis* and *Saccharomyces cerevisiae* was also determined. *Z. mobilis* contributes much to the fermentation of palm-wine due to its ability to ferment sucrose, glucose and fructose which are the main sugars in palm-sap. The bacterium reached its maximum density of 2.72×10^7 cells/ml between 12 and 15 hrs after tapping of the palm-sap. *Z. mobilis* is acid and alcohol tolerant being able to grow at pH values between 4.0 and 7.0 and in alcohol concentration of between 2.5% and 15% respectively. *Z. mobilis* was also found to ferment sugars at a faster rate than *Saccharomyces cerevisiae*. Statistical analysis of the data obtained using ANOVA showed that there is no significant difference at $p = 0.05$ level of significance in the growth of isolates of Z. mobilis obtained from the three locations under different pH, alcohol and temperature values [11].

Nwachukwu et al. (2006) carried out on yeasts isolated from palm wines obtained from South Eastern Nigeria. The isolates were characterised for certain attributes necessary for ethanol production. Isolations were made from 600 hour-aged wines. The attributes investigated the included ethanol tolerance and sedimentation rates.The effect of certain locally available supplements on ethanol tolerance was also investigated. Nine strains of *Saccharomyces cerevisiae*, two strains of *S. globosus*, and two strains of *Hanseniaspora uvarum* were isolated in this study. Results of the ethanol tolerance revealed a range of 10-20% (v/v), ethanol tolerance for the isolates. The sedimentation rates varied from 55.5 to 93.1%. Addition of local supplements enhanced ethanol tolerance of the isolates [10]. Amoa-Awua WK et al. (2007) investigated the microbiological and biochemical changes which occur in palm wine during the tapping of felled oil palm trees. Microbiological and biochemical contents of palm wine were determined during the tapping of felled oil palm trees for 5 weeks and also during the storage. *Saccharomyces cerevisiae* dominated the yeast biota and was the only species isolated in the mature samples. *Lactobacillus plantarum* and *Leuconostoc mesenteroides* were the dominated lactic acid bacteria, whilst acetic acid bacteria were isolated only after the third day when levels of alcohol had become substantial. The pH, lactic and acetic acid concentrations during the tapping were among 3.5-4.0%, 0.1-0.3% and 0.2-0.4% respectively, whilst the alcohol contents of samples collected within the day were between 1.4% and 2.82%; palm wine which had accumulated over night, 3.24% to 4.75%; and palm wine held for 24 h, over 7.0% [2].

Ogbulie T. E. et al. (2007) conducted a comparative study on the microbiology and shelf life stability of palm wine from Elaeis guineensis and Raphia hookeri obtained from Okigwe, Nigeria. The microbiological and biochemical changes and shelf life stability of Elaeis guineensis and Raphia hookeri brands of palm wine were determined. R. hookeri brands were found to habour more heterotrophic and coliform population than the E. guineensis, whereas the later haboured more yeast species. Identification tests revealed the isolation of *Bacillus, Lactobacillus, Brevibacterium* and *Staphylococcus* from *E. guineensis* while *Escherichia coli* and Micrococcus species with the exception of Brevibacterium sp. was additionally isolated from *R. hookeri*. Furthermore heterotrophic count and pH were observed to decrease with increased fermentation days. The effect of the preservatives on the sensory properties of palm wine was dependent on the type of preservation used. The level of CO2 as well as the effect of extracts from the plant preservatives on the isolates from the palm wine samples was also carried out. Percentage loss of CO_2 for each successive fermentation day was observed and there was significant difference in the effect of the plant preservatives used [12].

Stringini M et al. (2009) surveyed yeast diversity during tapping and fermentation of palm wine from Cameroon. They have investigated the occurrence of yeast flora during tapping and fermentation of palm wine from Cameroon. The yeast diversity was investigated using both traditional culture-dependent and culture-independent methods. Moreover, to characterize the isolates of the predominant yeast species (*Saccharomyces cerevisiae*) at the strain level, primers specific for delta sequences and minisatellites of genes encoding the cell wall were used. The results confirm the broad quantitative presence of yeast, lactic acid bacteria and acetic acid bacteria during the palm wine tapping process, and highlight a reduced diversity of yeast species using both dependent and independent methods. Together with the predominant species S. cerevisiae, during the tapping of the palm wine the other species found were *Saccharomycodes ludwigii* and *Zygosaccharomyces bailii*. In addition, denaturing gradient gel electrophoresis (DGGE) analysis detected *Hanseniaspora uvarum, Candida parapsilopsis,*

Candida fermentati and Pichia fermentans. In contrast to the progressive simplification of yeast diversity at the species level, the molecular characterization of the *S. cerevisiae* isolates at the strain level showed a wide intraspecies biodiversity during the different steps of the tapping process. Indeed, 15 different biotypes were detected using a combination of three primer pairs, which were well distributed in all of the samples collected during the tapping process, indicating that a multistarter fermentation takes place in this particular natural, semi-continuous fermentation process [14].

A. I. Elijah et al. (2010) investigated the effect of *S. gabonensis* (0.625%) and A. boonei (0.50%) on the kinetics of *Saccharomyces cerevisiae* isolated from palm wine (PW). Concentrations of the preservatives used in this study were optimal concentrations of the preservatives that had preservative effect on fermenting palm sap. The fermentation rate constant, k, of 2.79 × 10-4 $mol^{-1}s^{-1}$ obtained for untreated PW was higher than the k values for PW treated with *A. boonei* (1.7 × 10^{-4} mol-$1s^{-1}$) and *S. gabonensis* (1.1 × $10^{-4}mol^{-1}$ sec^{-1}). Both preservatives enhanced yeast growth. The specific growth rates (µmax) for the yeast were 0.43, 0.76 and 0.88 for the control, samples treated with *A. boonei* and *S. gabonensis*, respectively. However, the sedimentation rate of the yeast was reduced by both preservatives, but *A. boonei* produced the greatest effect [1].

Ghosh, S. et al. (2012) optimized process conditions for palm (Borassus flabelliffer) wine fermentation using Response Surface Methodology. *Saccharomyces cerevisiae* (NCIM 3045) was cultivated in palm juice and different physical parameters such as temperature, pH and time have been varied to maximize the yield of wine. The fermentation process was standardized by statistical methods. Response surface methodology (RSM) based on the 23 factorial central composite design (CCD) was applied to determine the optimum conditions for the maximum yield of ethanol with the variation of temperature and pH. The highest yield of ethanol concentration of was obtained at 32^0C and pH 5.5 after 48 h of fermentation. The model showed that the value of R^2 (0.9973) was high and p- value of interaction of variance was < 0.005. Hence the model can be said to be of high significance. Highest concentration of ethanol obtained by fermentation was found to be 82.3 g/l [4].

Nguyen Van Thanh et al (2012) conducted on the basis of survey selecting of yeast for making high quality palm wine. There are 18 yeast trains were obtained from palm juice at different treatment conditions. The treatment conditions did not affect the ability of yeast isolation. However, the ability of the presence of yeast in palm juice could be affected by harvesting time. Selected yeast train, which was isolated from palm juice harvested in afternoon without treatment, showed the best yeast strain for making palm wine with high alcohol content (13-14% v/v) [9].

Ho Kim Vinh Nghi et al (2013) study on the selection of *Saccharomyces cerevisiae* strains for production of wine from palmyrah palm flower's saps. Palmyrah palm wine was fermented from Palmyrah palm flower's saps, which was a special product of An Giang province. Natural Palmyrah palm wine fermenting process was related to *Saccharomyces cerevisiaes*, lactic acid fermenting bacteria and acetic acid fermenting bacteria. Naturalal uncontrolled fermenting process with multiform microorganisms led to unstableness and easy spoilage of this product quality. This research focused on the selection of *Saccharomyces cerevisiae* strains for wine fermentation from Palmyrah palm flower's saps. Extract from Palmyrah palm flower's saps included total sugar of 108.38 ± 11.74g/l, in which glucose was 30.24 ± 3.95g/l, protein was 1.59 ± 0.35 g/l and minerals were 1.6 ± 0.05g/l. *Saccharomyces*

cerevisiae CNTP 7028 was selected, which was able to achieve 15.3%v/v, furfurol did not appeared, methanol content was low at 0.145g/l [5].

Opara C.C. Ajoku G. and Madumelu N.O. (2013) investigated the palm wine mixed culture fermentation kinetics. Experimental data obtained from literature was used to obtain the growth rates and substrate saturation coefficient using the Monod model. It can be seen that the cell number of *Leuconostoc* spp. has increased to 1978.3 while the experimental value is 1667.0678 at 24hours. The substrate concentration at 24hrs was found to be 4.968g/100g dry matter while its experimental value is 4.348g/100g dry matter [13].

Figure 2. *Saccharomyces cerevisiae* under microscope.

In this our research, Palmyrah palm wine is fermented from Palmyrah palm flower's saps, which was a special product of An Giang province, Vietnam.

2. MATERIALS AND METHODS

Thot Not palm sap collected from Tri Ton distric, An Giang province, Vietnam. Then it has been primarily filtered to remove particles and foreign matters. It should be gently heated, put *Sen* tree bark into its sap, kept 3-4^{0}C during transportation to Lab, preserved in fridge.

Figure 3. Farmers collect Thot Not palm sap in the morning & its fresh palm sap.

Isolation source: utilize 3 brewingyeast sources:
+ From Cooper's brewery, named **C_1**.
+ From Biology Laboratory of Natutral Science University (Vietnam), named **RD.**
+ From VLB university, named **Rh**.

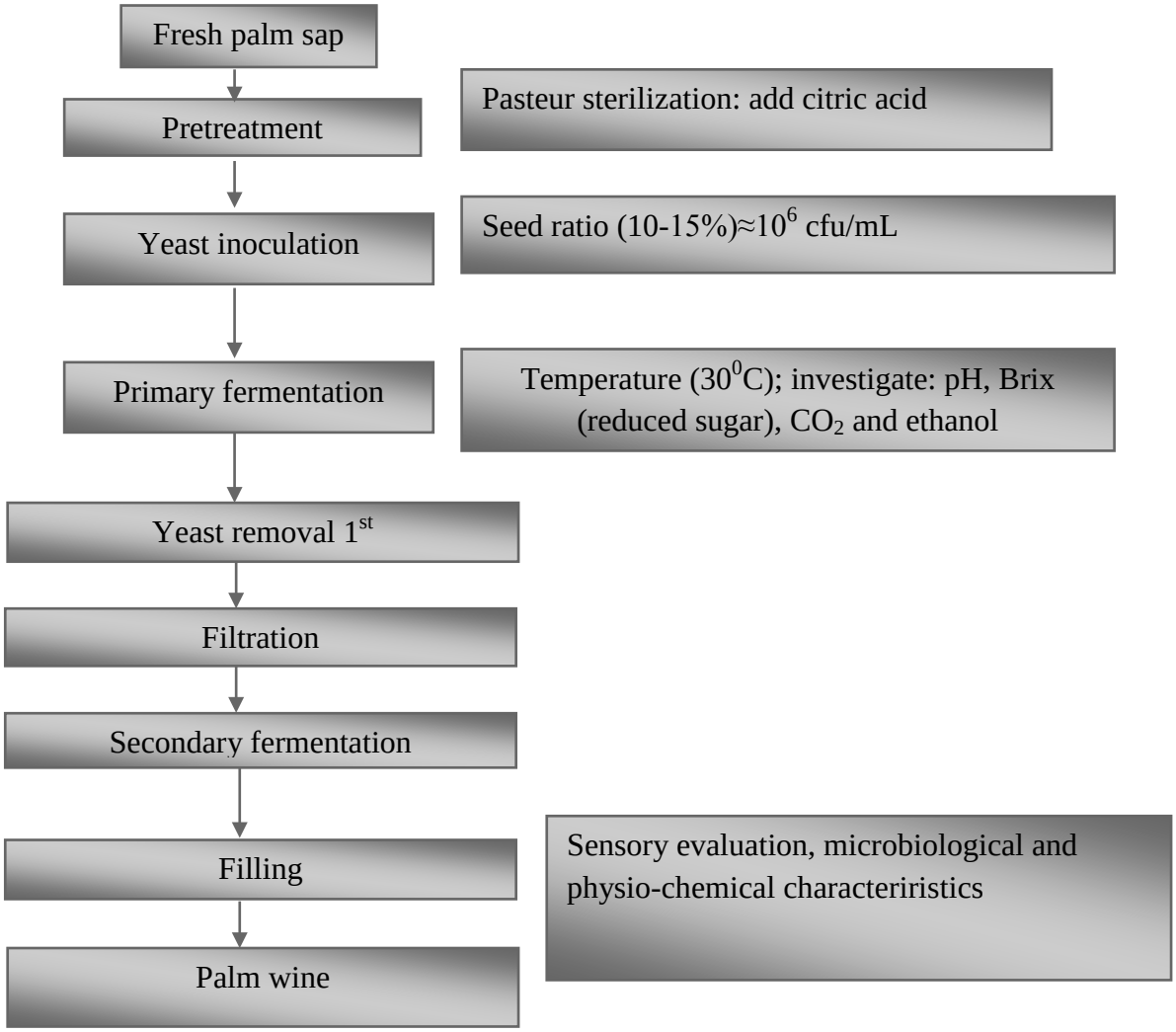

Figure 4. Flow chart of Thot Not palm wine production.

3. RESULTS AND DISCUSSION

3.1 Processing conditions

Filtered palm sap is supplemented siro to get the right Brix, pH adjusted by NaOH and citric acid, and then sterilized by steaming. Yeast ratio (2 – 5 % to fermenting sap) and temperature 25 - 30^{o}C in Einhorn vessel. After 0.5 -1.0 hour, we view CO_2 emission until it gets to 5 mL to stop fermentation. The less time of fermentation, the more power is.

3.1.1 Effect of pH and temperature to fermentation

Table 1. Effect of pH and temperature to fermentation

pH	Time of fermentation to reach 5mL CO_2					
	Yeast strain RD		Yeast strain Rh		Yeast strain C_1	
	T=25°C	T=30°C	T=25°C	T=30°C	T=25°C	T=30°C
3.5	8h20	6h	15h	9h30	15h40	11h10
4.0	8h20	6h	13h30	9h20	15h30	10h20
4.5	8h30	5h30	14h15	10h10	14h	10h10
5.0	9h15	5h30	15h40	8h	14h30	7h45
5.5	9h	5h20	16h	7h30	15h30	7h15
6.0	9h25	6h10	17h	8h45	15h55	9h

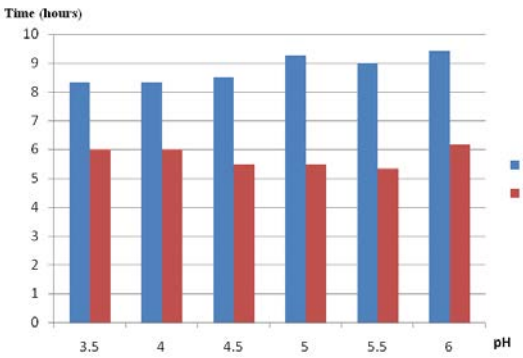

Figure 5. Effect of pH and temperature to fermenting time – yeast strain RD.

At pH = 5.5 and temperature 30^0C, yeast strain RD has the best fermenting power.

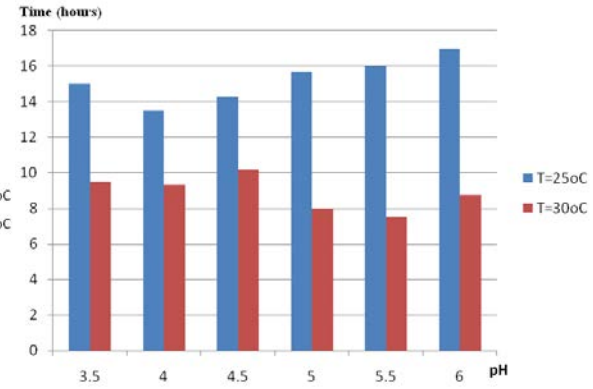

Figure 6. Effect of pH and temperature to fermenting time – yeast strain Rh.

At pH = 5.5 and temperature 30^0C, yeast strain Rh has the best fermenting power.

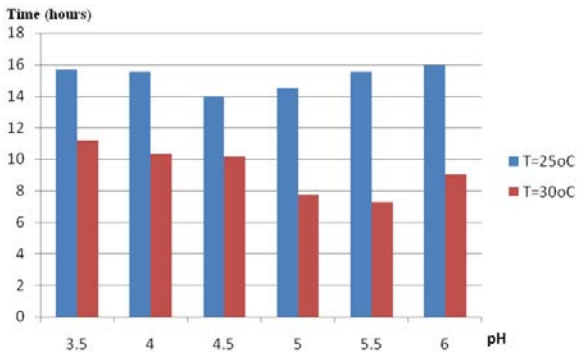

Figure 7. Effect of pH and temperature to fermenting time – yeast strain C_1

At pH = 5.5 and temperature 30^0C, yeast strain C_1 has the best fermenting power.

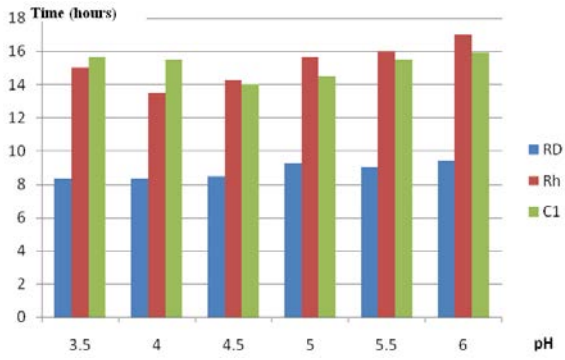

Figure 8. Effect of pH to fermenting time – 3 yeast strains at 25^{0}C.

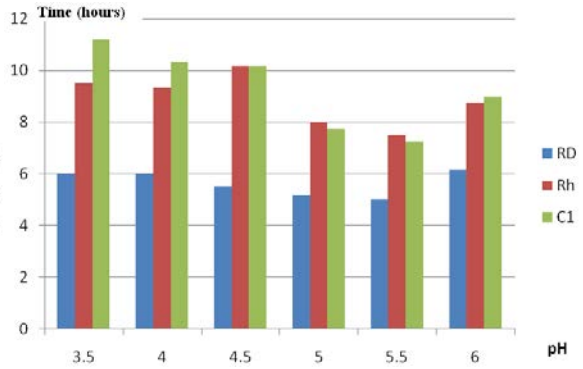

Figure 9. Effect of pH to fermenting time – 3 yeast strains at 30^{0}C.

3.1.2 Effect of dry matter (Brix) and temperature to fermentation

Table 2. Effect of dry matter (Brix) and temperature to fermentation

% Brix	Time of fermentation to reach 5mL CO_2					
	Yeast strain RD		Yeast strain RD		Yeast strain RD	
	T=25^{o}C	T=30^{o}C	T=25^{o}C	T=30^{o}C	T=25^{o}C	T=30^{o}C
18	7h^a	5h10^a	20h^a	11h^a	16h30^a	12h30^a
20	7h30^b	5h20^b	20h50^b	13h15^b	20h10^b	12h15^a
22	7h30^b	5h45^b	23h45^b	14h20^b	22h45^b	10h15^a
24	8h^c	6h10^c	25h^c	29h^c	23h30^c	17h30^b

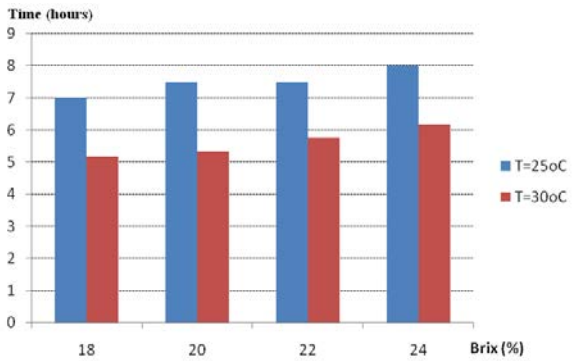

Figure 10. Effect of dry matter (Brix) and temperature to fermentation – yeast strain RD

Yeast strain RD has the powerful fermentation in range 18 – 20% Brix and 30^{0}C.

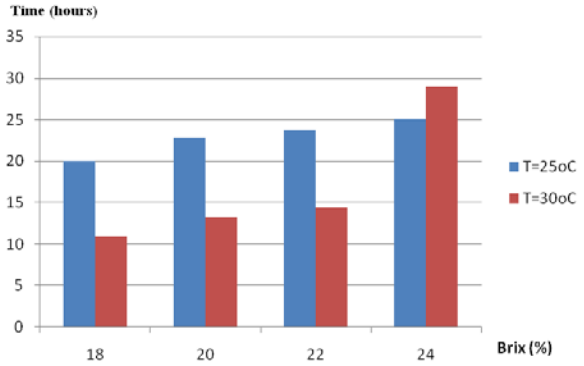

Figure 11. Effect of dry matter (Brix) and temperature to fermentation – yeast strain Rh
Yeast strain Rh has the powerful fermentation in 22% Brix and 30^0C.

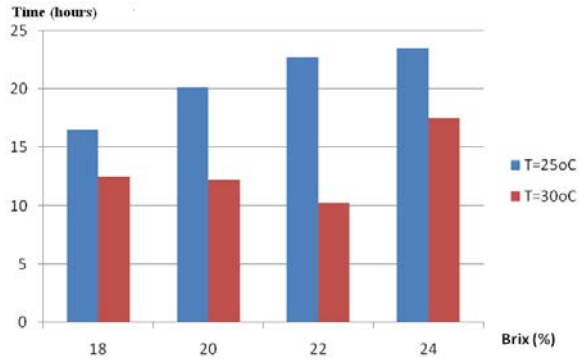

Figure 12. Effect of dry matter (Brix) and temperature to fermentation – yeast strain C_1
Yeast strain C_1 has the powerful fermentation in range 20 – 22% Brix and 30^0C.

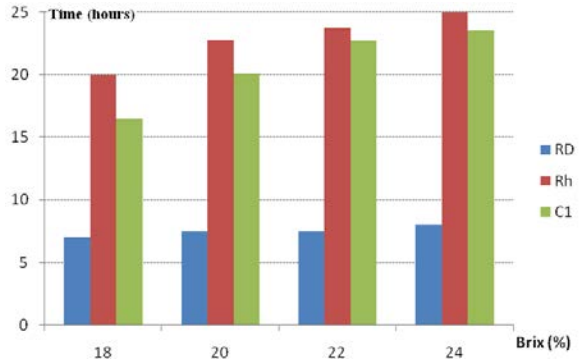

Figure 13. Effect of dry matter (Brix) to fermentation – 3 yeast strains at 25^0C
At 25^0C and 20 -22% Brix, yeast strain RD has the most powerful fermentation.

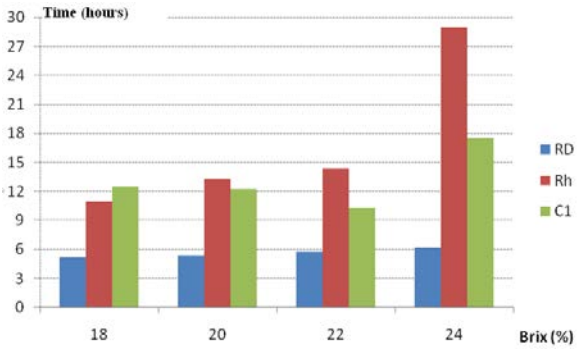

Figure 14. Effect of dry matter (Brix) to fermentation – 3 yeast strains at 30^0C
At 30^0C and 20 -22% Brix, yeast strain RD has the most powerful fermentation.

3.2 Thot Not palm sap fermentation

3.2.1 Add siro to get 22% Brix and adjust pH in range 5.0 ÷ 5.5.

Table 3. Property of Thot Not palm sap after Pasteur sterilization and siro supplementation

Parameter	Result
pH	5.5
% Brix	22
Reduced suagr	12.30g/100mL
Total sugar	22.58g/100mL
TPC	Investiagte at different temperature of Pasteur sterilization

3.2.2 Pasteur sterilization for palm sap

- **TPC microorganism after sterilization**

Table 4. TPC microorganism on PCA medium

Temp. / Time	$70^oC \div 75^oC$	$75^oC \div 80^oC$	$80^oC \div 90^oC$	$90^oC \div 100^oC$
15 minutes	10 CFU/mL	0	X	X
30 minutes	20 CFU/mL	0	X	X
10 minutes	X	X	10 CFU/mL	10 CFU/mL
20 minutes	X	X	0 CFU/mL	X
5 minutes	X	X	X	10 CFU/mL

Table 5. Yeast and mold microorganism on YGC medium

Temp./ Time	70°C ÷ 75°C	75°C ÷ 80°C	80°C ÷ 90°C	90°C ÷ 100°C
15 minutes	10 (CFU/mL)	10 (CFU/mL)	X	**X**
30 minutes	0	0	X	**X**
10 minutes	X	X	20 CFU/mL	**0**
20 minutes	X	X	0	**X**
5 minutes	**X**	**X**	**X**	**10 FU/mL**

At temperature 75 ÷ 80^{0}C, TPC microorganism is acquired; sensory quality has mild flavor and aroma. If increase to 90^{0}C, palm sap will loose mild flavor, become stringent aroma owing to Mallard reaction. So steaming at 75 ÷ 80^{0}C in 15÷ 30 minutes is adequate.

- **Palm sap fermentation**

Inoculate yeast into barley sugar 15% Brix. Incubate 24 ÷ 36 hours. Check numbers of yeast cells by OD measurement based on standard line. Then add 10^6cfu/mL yeast into 500mL pasteurized palm sap.

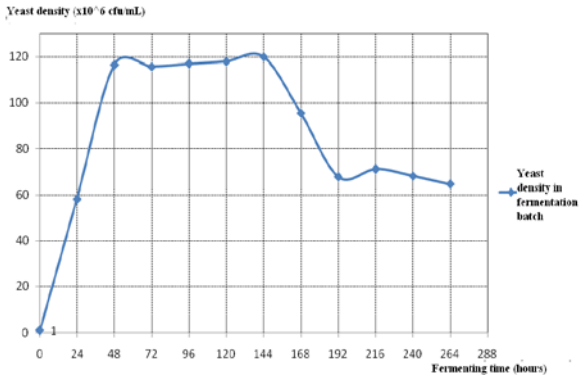

Figure 15. Yeast RD density during fermentation.

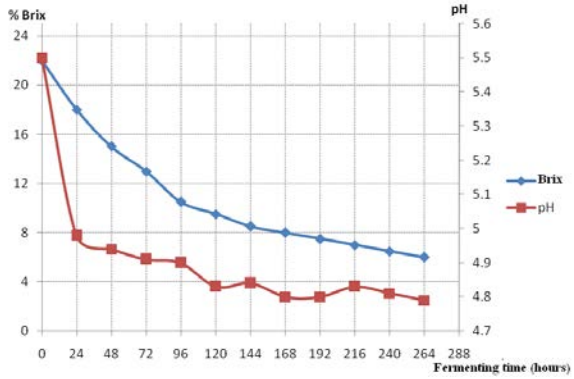

Figure 16. Changes of Brix and pH during fermentation – yeast strain RD.

On experiment with yeast RD, at the end of the primary fermentation final dry matter 6% Brix, pH 4.79, alcohol 12.5% v/v.

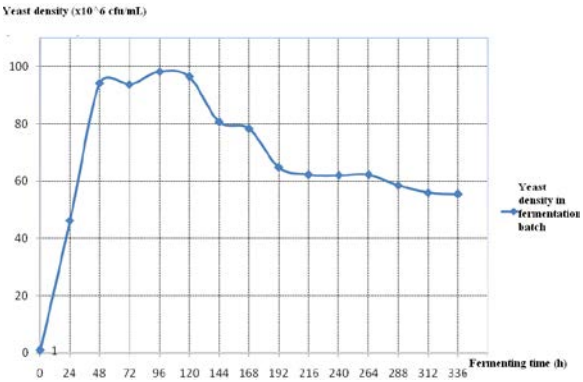

Figure 17. Yeast Rh density during fermentation

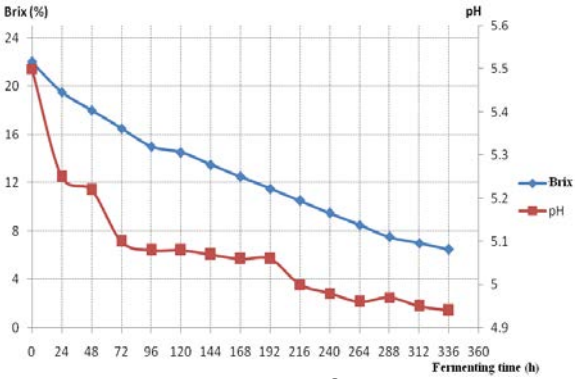

Figure 18. Changes of Brix and pH during fermentation – yeast strain Rh

On experiment with yeast Rh, at the end of the primary fermentation final dry matter 7% Brix, pH 4.94, alcohol 11.5% v/v.

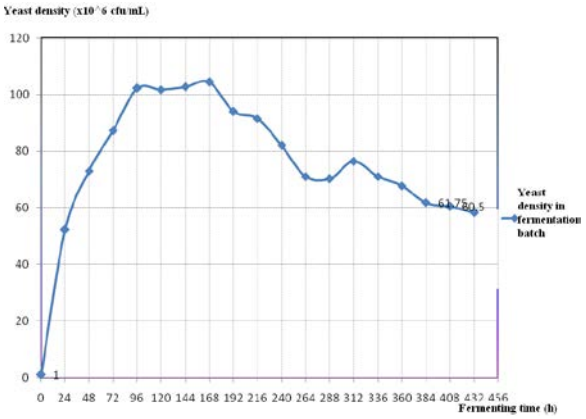

Figure 19. Yeast C_1 density during fermentation.

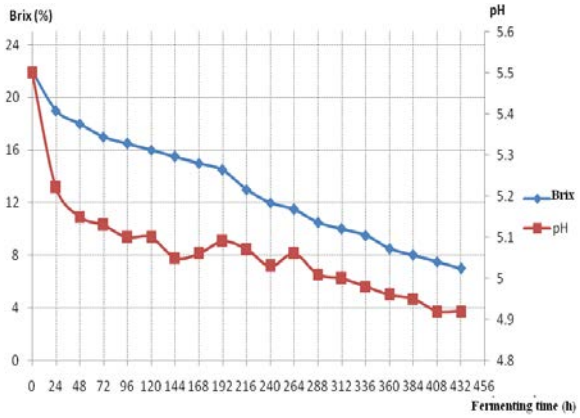

Figure 20. Changes of Brix and pH during fermentation – yeast strain C_1.

On experiment with yeast Rh, at the end of the primary fermentation final dry matter 7% Brix, pH 4.92, alcohol 12.0% v/v.

- **Finished products after fermentation**

Table 6. Palm wine fermentation by different yeast strains

Parameter	RD	Rh	C_1
pH	4.79	4.94	4.92
% Brix	6	6.5	7
Total acidity	0.99g/l	1.34g/l	1.45g/l
Alcohol	12.5 % v/v	11.5 % v/v	12 % v/v
Reduced sugar	0.24g/100mL	0.47g/100mL	1.67g/100mL
Total sugar	0.33g/100mL	0.85g/100mL	2.05g/100mL

Table 7. Reduced sugar before and after fermentation

Parameter	RD	Rh	C_1
Reduced sugar in fresh palm sap	8.5g/100mL	8.5g/100mL	8.5g/100mL
Reduced sugar in palm sap after being adjusted Brix and Pasteured	12.30g/100mL	12.30g/100mL	12.30g/100mL
Reduced sugar in palm sap after fermentation	0.24g/100mL	0.47g/100mL	1.67g/100mL

Table 8. Total sugar before and after fermentation

Parameter	RD	Rh	C_1
Total sugar in fresh palm sap	10.78g/100mL	10.78g/100mL	10.78g/100mL
Total sugar in palm sap after being adjusted Brix and Pasteured	22.58g/100mL	22.58g/100mL	22.58g/100mL
Total sugar in palm sap after fermentation	0.33g/100mL	0.85g/100mL	2.05g/100mL

Figure 21. Thot Not palm wine from 3 yeast strains.

Figure 22. Thot Not palm wine bottle fermented from yeast strain C_1 (stored 3 months).

Figure 23. Thot Not palm wine from yeast strain Rh.

Figure 24. Thot Not palm wine from yeast strain C_1.

Figure 25. Thot Not palm wine from yeast strain RD.

- **Sensory evaluation**

Table 9. Sensory evaluation on three fermented products

Yeast strain	Score		
	RD	Rh	C_1
Taste	2.250	4.000	4.400
Flavor	2.425	4.225	4.225
Color	2.825	3.85	3.925

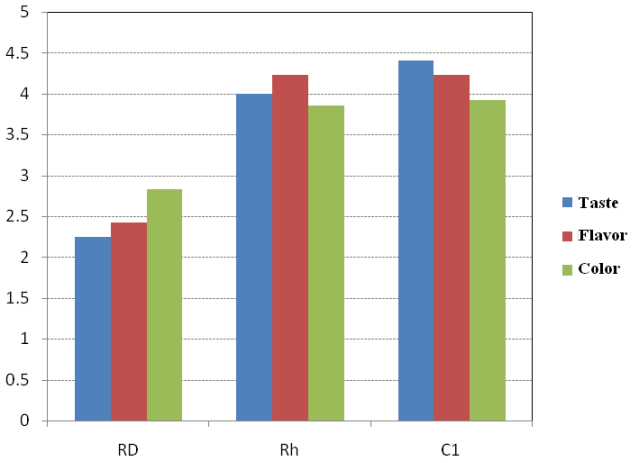

Figure 26. Favorite of different palm wines fermented from three veast strains

On this figure, the palm wines fermented from yeast strain Rh and C_1 are the most favorite because they give good flavor, gentle sweet, mild alcohol, and pleasant taste.

4. CONCLUSION

Palm wine is the fermented sap of certain varieties of palm trees. Palm sap can be fermented (or) processed into an alcoholic beverage it just needs the correct the yeasts, temperature and processing conditions. The drink is common in various parts of Asia and Africa. In Vietnam, palm wine will be a new potential approach to diversify products from palm tree.

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