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Potential of snake fruit (*Salacca zalacca*) cultivars on product quality for fermented vinegar beverages

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Abstract Results showed that using naturally vinegar fermentation methods was not successful in two of the cultivars, Mo and Sumalee. Although Noen Wong did succeed in the naturally fermenting vinegar, the final product had undesirable flavor characteristics. Vinegar fermentation from all three snake fruit cultivars using the yeast, *Saccharomyces cerevisiae* and the *Acetobacter pasteurianus* bacteria, yielded the desired product of vinegar beverage. A higher level of total phenolic content was detected in the vinegars produced from Noen Wong cultivar, while those produced from Mo cultivar exhibited the highest levels of antioxidant activity. Sensory evaluation based on the 9-point hedonic scales and tested with 30 panelists, showed that vinegars produced from Mo and Sumalee cultivars showed the highest overall preference, with an average score of 6.07-6.13, which indicated a medium pleasant level of the vinegar preference. This study concluded that the Mo cultivar is found to be most suitable for making fermented vinegar beverage, however, it is recommended that the color characteristics could be improved.

Keywords: *Salacca zalacca*, Fermented vinegar, Beverage

Introduction

Salacca zalacca, commonly known as Salak or snake fruit, is a genus of 21 species of palms tree belongs to Arecaceae (Rangsiruji *et al*., 2006). It is found throughout the Indo- Malaysian region, i. e. Indonesia, Malaysia, Thailand, Cambodia, South of Myanmar, Vietnam, Philippines and China (Lestari and Ebert, 2002; Supriyadi *et al*., 2002; Wjaya *et al*., 2005; Rangsiruji *et al*., 2006;). It is a fruit with a unique sweet taste, growing and yielding fruit quickly. Flowers gradually emerge throughout the year; thus, fruits can be produced throughout the year. These reasons support snake fruit to become one of the economically important crops of Thailand. Its Eastern region is an important area for snake fruit plantation, particularly in Chanthaburi province. Most yield from Chanthaburi province enters both domestic and export markets, in fresh form.

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However, a wide range of seasonal fruits also grow in Chanthaburi province, which can cause market problems for farmers, through low prices. One option to better make use of this fruit is to produce a good quality competitively processed fruit product for the local market. Presently, processed snake fruit products having been developed and gaining local popularity include: juice, snake fruit in syrup, pickled snake fruit and jam (Choorak, 2024). Unfortunately, development of a fruit vinegar drink has never been attempted.

Fruit vinegar is a liquid product produced from the proper fermentation process of fermented fruit juice. Its popularity has been increased recently, as a healthy drink, rich in bioactive compounds that provide several beneficial properties. Purported weight loss, blood sugar- lowering, and antimicrobial benefits, are reported instances of benefit (Johnston *et al.*, 2013; Saithong and Permpool, 2019). This study has been undertaken to develop snake fruit into a fruit vinegar drink, creating another processed product and adding further channels to value for *Salacca* spp.

There are three main snake fruit cultivars commercially grown in Thailand, namely Noen Wong, Mo and Sumali (Phattharatham, 2011). Fruit shape of Noen Wong is a slender head and tail, with larger fruit and contain much more flesh. The fruit bark is orange-brown color with long thorns. The tree produces less fruit. Raw fruit has an astringent taste but when ripe, the fruit has a sweet and fragrant flavor. Its flesh is firm and the flavor is not strong, when compared to Mo. The fruit shape of Mo is rather long with a pointed beak at the end. Its fruit bark is dark red. When ripe, the taste is sweet and sour, with an intense flavor, the flesh being thick and juicy. The seeds are sifted. The fruit shape of Sumalee is short, the flesh being orange colored and tasting sweet and fragrant. Each fruit contains considerable flesh and small seed pellets. The flesh is firm, sweet and crisp. It produces many fruits continuously throughout the year. Since, there are differences in the flesh amount, production capacity within the local area and the selling price, it necessary to consider selecting the appropriate cultivars for making vinegar drinks. This study was conducted to compare the efficiency of the three snake fruit cultivars on creating the best quality fermented vinegar drink.

Materials and methods

Preparation of feedstock

Three cultivars of *Salacca zalacca* (Gaertn.), Noen Wong, Mo and Sumalee (Figure 1), fruit were collected from snake fruit farmers in Chanthaburi province, in the Eastern part of Thailand. The collected snake fruits were peeled,

cleaned, and de-seeded, with only flesh being taken. The flesh was then cut into small pieces, in preparation for the next fermentation process.

(a) (b) (c)

Figure 1. Appearance of three cultivars snake fruit, (a) Noen Wong, (b) Mo and (c) Sumalee

Fermentation process to get fermented snake fruit vinegar

Naturally vinegar fermentation of snake fruit

Small pieces of each variety were fermented with sugar at a ratio of 1:1 w/w, in a 5-liter capacity clean glass jar, having an airlock fermenting lid. The jars were left in a dry place, away from sunlight, at room temperature. Seven days later, the sugar content in the juice was then adjusted down to 24 ºBrix, by addition of water. During the fermentation process, acid values were monitored every day.

When the acid value reached 4.2, the fermentation was terminated. The fermented vinegar was then filtered, using clean cheesecloth, prior to additional boiling and pasteurization. Further examine for chemical quality was then carried out.

Vinegar fermentation from Snake fruit using fermented vinegar starter culture

One kilogram of small pieces from each variety was ground up, with 3 liters of clean water, using a blender. Then their pomace was strained out by cheesecloth, with only juice being further used. The juice was then heated until boiling. Sugar was then added, gradually and stirred, to incorporate the value of soluble solids. When the soluble solids were at 20 Brix, heating was stopped, leaving the juice to cool. This 3-liter juice was then poured into a 5-liter capacity

clean glass jar, adding the yeast, *Saccharomyces cerevisiae* and *Acetobacter pasteurianus* bacteria for alcohol fermentation, at a ratio of 0.75% (v/v).

Measurement of fermented snake fruit vinegar quality

Chemical properties analysis

Chemical quality characteristics of fermented vinegar, in terms of pH, acetic acid, total soluble solid, total phenolic content, was carried out using methods summarized in Table 1.

Table 1. Analysis methods for chemical properties

Parameter	Analysis method
pH	pH-meter (Oakton, PC2700, Spain)
Acetic acid (%, w/v)	Titration (Department of Medical Sciences, 2016)
Total soluble solid (°Brix)	Hand refractometer (Master, Japan)
Total phenolic content	Folin-Ciocalteu colorimetric method (Dewanto, *et al.,* 2002)
Antioxidant	DPPH, 2,2-diphenyl-1-picrylhydrazyl radical scavenging capacity (Haruenkit *et al.,* 2007)

Sensory evaluation

Quantitative descriptive analysis was evaluated sensory qualitative of the samples, in terms of color, odor, flavor and overall liking. Thirty untrained panel members were selected from local people to participate in the development of sensory profiles for all of the above trials. Ten milliliters of the vinegars produced from each of three snake fruit cultivars were mixed with 10 milliliters of 10 °Brix syrup solution, to make beverage vinegars. A hedonic 9 scale (i.e.,9= like extremely, 5= neither like nor dislike, and 1=dislike extremely) was used to ensure consistency between panelists, across repeated evaluation. Sensory evaluation was performed in a laboratory setting, with clean sensory cabinets containing fresh water; using a complete randomized design with triplicates. Randomized complete block design and statistical package (SPSS) were used to perform the sensory evaluation analysis

Statistical analysis

Chemical data collected from each treatment (variety) was subjected to statistical analysis through a One-way ANOVA analysis. Significant difference among treatments was compared using the average values with Duncan's new multiple range test, at a confidence level of 95%. Randomized complete block design were used to perform the sensory evaluation analysis. All data was analyzed, using SPSS Statistics for Windows.

Results

Efficiency of cultivars on the successful of vinegar fermentation process

The results found that two snake fruit cultivars, Noen Wong and Sumalee were not successful in the procession to naturally vinegar fermentation. There were considerable fungi occurring in the fermented jars, throughout the entire run of more than 3 replicates. Whereas, all three cultivars were successfully produced vinegar fermentation when the process used fermented vinegar starter culture instead.

Chemical properties of fermented vinegar from three cultivars snake fruit

All snake fruit fermented vinegar products from the three cultivars, both naturally vinegar fermentation and using fermented vinegar starter culture as an inoculant, were analyzed for their chemical compositions (Table 2).

It was found that the pH value, total soluble solid and total phenolic content of the fermented vinegar product using natural microorganisms tended to be higher than those using fermented vinegar starter culture, and vice versa with total phenolic content and antioxidant (Table 2). At the same time, no differences were found in acetic acid values.

In the case of using fermented vinegar starter culture in the fermentation process, it was found that there were not significantly different in pH value and percentage of acetic acid between the three snake fruit cultivars. Total soluble solid content in Noen Wong was higher than in Mo and Sumalee. The highest total phenolic content was also found in Noen Wong; with the lowest found in Sumalee. The highest antioxidant activities were found in Mo; with the lowest found in Sumalee.

Sensory evaluation

Panelist sensory scores, in their evaluation for each product, are shown in Table 3; having statistically significant differences ($p \leq 0.05$) in all snake fruit cultivars. The fermented vinegar produced from Sumalee displayed the highest score for all sensory qualitative parameters. Meanwhile, fermented vinegar produced from Mo had scores that were not significant different from Sumalee in all parameters ($p > 0.05$), except for color. The Noen Wong variety had the lowest preference scores in all parameters except for color, which was higher than the Mo ($p \leq 0.05$).

Table 2. Chemical properties of the fermented vinegar, produced from three different cultivars of snake fruit

Chemical properties	Cultivars		
	Noen Wong	Mo	Sumalee
Naturally vinegar fermentation			
pH	2.90 ±0.02	-	-
Acetic acid (%, w/v)	5.07 ±0.03	-	-
Total soluble solid (°Brix)	26.2 ±0.15	-	-
Total phenolic content	12,425.79±1,060.65	-	-
Antioxidant activities	17.96 ±0.38	-	-
Fermentation by fermented vinegar starter culture			
pH	2.69 ± 0.02	2.65 ±0.02	2.63 ±0.04
Acetic acid (%, w/v)	5.11 ±0.02	5.20 ±0.06	5.15 ±0.05
Total soluble solid (°Brix)	7.20 ±0.10[a]	6.90 ±0.05[b]	7.00 ±0.05[b]
Total phenolic content (Micrograms of gallic acid per milliliter of sample)	6,198.12 ± 68.89[a]	5,864. ±186.63[b]	75 5,027.77 ± 39.07[c]
Antioxidant activities (Micrograms of BHT per 1 milliliter of sample)	19.78 ± 0.03[b]	22.14 ± 0.05[a]	17.70 ± 0.04[c]

Note: Mean followed by different letters in the same row differs significantly ($p \leq 0.05$)

Table 3. Sensory score (n = 30) of fermented vinegar produced from different snake fruit cultivars (mean±SD)

Cultivars	Cultivars			
	Color	Odor	Flavor	Overall preference
Noen Wong	5.67±0.48[b]	5.17±0.38[b]	3.93±0.58[b]	4.93±0.52[b]
Mo	5.00±0.37[c]	6.33±0.48[a]	5.73±0.52[a]	6.07±0.58[a]
Sumalee	6.10±0.31[a]	6.33±0.61[a]	5.73±0.52[a]	6.13±0.57[a]

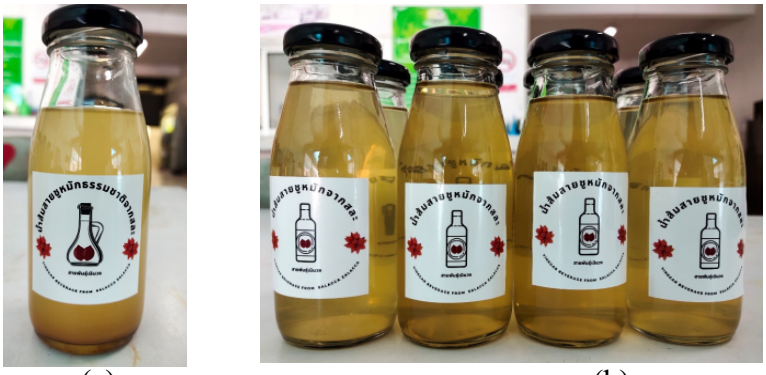
Note: Mean followed by different letters in the same column differs significantly ($p \leq 0.05$)

Discussion

This study noted that snake fruit may not be a suitable as a naturally fermented vinegar beverage. It is known that fungi are the most common pathogenic microbes in post-harvest fruits (Korsten, 2006). Flesh of snake fruit is soft and has a high moisture content (Manurung *et al.*, 2013). This makes it easy for fungi to penetrate into the flesh, whereas the high moisture allows the fungus to grow well in the process of fruit fermentation naturally, without adding microorganisms. The microorganisms that play a role in fermentation are already present in the fruit and the environment in which the fruit is produced. However, natural fermentation makes it difficult to control the fermentation process to be constant.

In this study, only the Noen Wong variety was successful in naturally fermenting vinegar, because it had a thicker and denser texture (Prampramote, 2022), compared to the other two cultivars. However, the final product has a

cloudy, non-clear appearance (Figure 2), consistent with higher total soluble solids (Table 2), when compared to clear products of fermentation, using fermented vinegar starter culture. Snake fruit fermented vinegar by natural microbial was found to be less effective as a fermented vinegar beverage than fermented vinegar beverages created by pure microorganism starter culture, as similarly noted by Deeraksa (2005).



(a) (b)

Figure 2. Final product of fermented vinegar from Noen Wong cultivars; (a) naturally vinegar fermentation, (b) fermentation with fermented vinegar starter culture

When the fermented vinegar starter culture was applied, the cultivars of Noen Wong and Mo were more suitable for healthy fermented vinegar production than Sumalee, as both cultivars have higher total phenolic content and antioxidant activities ($p \leq 0.05$). Further, fermented vinegar beverage products from the Mo had higher sensory scores in terms of odor, flavor and overall preference from 30 panelists ($p>0.05$). The higher levels of consumers' preference of them might be because the taste of the vinegar was sweet, blended with sour and the flavor included some alcohol odor. This study is concluded that the Mo variety is found to be the most suitable cultivar for making fermented vinegar beverage products. However, since it had the lowest color preference score, it should undergo color enhancement before being commercially viable.

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