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Production of Clarified, Concentrated Juice from Mango Variety Kaew

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ABSTRACT. *Enzyme liquefaction of mango puree (variety Kaew) with commercial enzyme preparations, Pectinex Ultra SP-L and cellulase, and production and applicability of concentrated, clarified juice were studied under laboratory and pilot production scale. Enzyme liquefaction with 150 ppm Pectinex Ultra SP-L enzyme preparation and 150 ppm cellulase enzyme at 40°C for 2 h of holding time were the most suitable conditions for enzyme liquefaction of mango puree variety Kaew. Clarified juice separated at 5000 rpm (laboratory scale) from the treated puree with the above conditions was 46.8% (40°C) and 47.6% (45°C). The results were not significantly different at 5% level DNMRT. From the pilot scale processing 40.8% (3rd run) and 37% (4th run) clarified juice with acceptable clarification (21 °Brix) was obtained by centrifugal separation at 8500 rpm. Clarified, single strength juice was concentrated using a falling film vacuum evaporator, and the concentrated juice showed 28 °Brix without a noticeable colour change. Straight-to-drink juice product, mango nectar (14 °Brix, 0.45% acidity) with 20% and 50% clarified single strength and concentrated juice were subjected to sensory evaluation (Hedonic scale). Overall acceptability of nectar with 20% and 50% juice content were scored as 'like slightly' over the control (20% of strained mango puree) which scored as 'neither like nor dislike'. The mean scores for overall acceptability of the products were significantly different over the control at 5% level LSD test. The clarified juice production is a promising technique to utilize the surplus of mango variety Kaew and to prevent the post harvest losses during short production season that falls between March to July in Thailand.*

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INTRODUCTION

Mango (*Mangifera indica* L.), which belongs to the family Anacardiaceae is one of the most important commercial fruit crops in Thailand. There are many varieties of mango that are abundant during the season. The main cultivars, named as Okrong, Red, Nam dok mai, Klangwan, Tongdum and Kaew, are marketed as ripe, mature green and immature green fruits. Kaew is a common mango variety available all over Thailand at a low price during the season.

The total production of 16 kinds of economically important mango fruits was 3,180,225 tons with an average yield of 779.5 tons/ha. Eighty five percent of this was domestically consumed, out of which 50% of the fruits was consumed as fresh, and the rest was used for processing. The post-harvest losses were 14% of the total fruit production (Buangsuwon, 1991).

A wide variety of processed products are derived from mango. These include canned whole or sliced mangoes in syrup, mango slices in brine, mango juice, pulp or nectar, mango jam, mango sauces, chutney and pickles. The demand for mango juice products is increasing due to consumer demand in the local and the international markets.

However, due to seasonality and short duration of availability from March to June, there is a considerable surplus of production over consumer demand during each season. In Asian countries alone, the post-harvest losses of fruits are estimated to be in the range of 10-30%, due to inadequate and inefficient handling, processing, storage, transportation and distribution facilities (Ilangantileke, 1993). Therefore introduction of efficient processing techniques with low production cost which improve the quality of processed products will benefit both the fruit processing industry and the end user. The fruit juice industry using tropical fruits has developed progressively during the past few decades. Enzymes are used widely in the disintegration of fruit pulps and for the clarification of juices and wines. Usage of enzymes for fruit juice clarification was introduced by Kertesz (1930) and Willaman and Kertesz (1931) in the United States, and Mehlitz (1930) in Germany. The enzyme treatment is useful for disintegration of pulp in tropical fruits including banana (Plinik, 1981).

The application of enzymes on pulp for pressing operation has certain advantages, mainly, high juice yield, clarification, retention of cloudiness and improvement of natural colour in the juice (Bielig, 1973).

Therefore, the specific objectives of this study were to investigate the enzyme liquefaction of mango puree (variety Kaew) using commercial enzyme preparations, Pectinex Ultra SP-L and cellulase, the production of clarified, single strength and concentrated mango juice under pilot production scale and the production of straight-to-drink or ready-to-serve mango juice from clarified, concentrated juice.

MATERIALS AND METHODS

Enzyme liquefaction on mango puree

The optimum conditions for the enzyme treatment were investigated. Pectinex Ultra SP-L, at three dosages, namely, 100, 200 and 300 ppm with the control, were tested with mango puree at temperatures of 30°, 35°, 40°, 45° and 50°C. Adjustment of pH in the puree was not a necessity because the pulp pH varied (4.13 - 4.6) within the optimum pH range (3.5 - 4.5) for pectinase activity. The holding time for the experiment was 4 h. The juice yield was determined at 30 min intervals by centrifugation at 5000 rpm for 8 min.

Subsequently, Pectinex Ultra SP-L enzyme dosages of 40, 60, 80, 100, 130, 150 and 200 ppm were selected. The samples for the experiments were prepared from ripe mango after washing, blanching, peeling and blending. The replicated samples were placed in a water bath, and the puree temperature was maintained at 40°C for 2 h. At the end of 2 h holding time, the puree was heated in the same container up to 80°C for enzyme inactivation and allowed to cool before centrifugation.

An experiment was conducted at puree temperatures of 40°C and 45°C, using two enzyme treatments and the control. Each treatment was triplicated. The treatments were 200 ppm of Pectinex Ultra SP-L with 200 ppm of cellulase, 150 ppm of Pectinex Ultra SP-L with 150 ppm of cellulase and the control with no enzymes. Both treated and control samples were tested for percentage juice yield, pH, acidity, alcohol insoluble solid (AIS), and total soluble solids before and after 2 h of holding time. Treated samples were heated up to 80°C and cooled for enzyme inactivation at the end of the holding time.

Pilot scale production of clarified single strength juice

Ripening: Mature green mangoes (365 kg), of variety Kaew were treated with calcium carbide (12 g/4 kg). Texture (Instron testing machine model 1140), pH, acidity, alcohol insoluble solid (AIS), calcium pectate, starch, total soluble solid and total solid of the treated mango were determined on 1st, 3rd, 5th and 7th day during ripening (AOAC, 1984; Ranganna, 1978).

Blanching: Weighed ripe mangoes were washed three times and dipped in water (at room temperature) to remove calcium oxide residues and odour of acetylene gas. Mangoes were selected by removing the rotten, bruised and damaged fruits, after which the peduncle area of the washed mangoes were trimmed. The weight of the mangoes removed was noted. The selected mangoes were blanched in boiling water for three minutes and the water was drained immediately.

Pulp separation: The blanched mangoes were fed into the pulper machine which consisted of two cylindrical sieves (2 mm and 0.5 mm), rotational paddles and brushes. The collected puree from the pulper machine and the waste were weighed separately.

Enzyme inactivation in pulp: In order to inactivate the indigenous enzymes, the puree was heated up to 80°C, allowed to stand for 30-60 sec and cooled immediately.

Enzyme treatment: The enzyme inactivated puree was subjected to enzyme liquefaction with exogenous enzyme preparations, Pectinex Ultra SP-L and cellulase. The required amount of Pectinex Ultra SP-L and cellulase enzyme were weighed, based on the weight of the puree. The suitable conditions, determined by the previous experiments, were provided through out the holding time.

The suitable conditions were 150 ppm of Pectinex Ultra SP-L and 150 ppm of cellulase, 2 h of holding time and 40°C temperature for liquefaction. During the holding time the enzyme treated mango puree was stirred continuously in order to maintain homogeneous conditions in the puree.

At the end of he 2 h holding time, the puree was heated to 80°C and allowed to stand for 30-60 sec for enzyme inactivation, followed by cooling to 30-40°C before centrif igation.

Separation of clarifie l juice by centrifugation

Enzyme lique ied mango puree was centrifuged to separate the juice fraction removing the coarse, fibrous, pulpy portion. A "Westfalia" separator with a de-slugging feature was used for juice separation.

The speed of centrifugation was controlled at 8500 rpm and fixed. Sub samples from the clarified juice, resulting from the 3rd and 4th run were taken for further exper ments.

Concentration of clarified single strength juice

Clarified sin.le strength mango juice at 3rd and 4th run were concentrated using a falling film vacuum evaporator (Alfa-laval, Lund, Sweden) in order to obtain clarified, concentrated mango juice. An adequate quantity of single strength juice was separated and kept for production of straight-to-drink produ:t.

During the ex periment the feed rate was 1 l/50 sec, the pressure was 0.8 kg/cm^2 and the tem perature was 96°C on the heated plate of the separator. The concentrated juice after two passes through the evaporator, was stored in cans under refrigerate condition for further tests and for the production of straight-to-drink produ:t.

Production of straight-to-drink mango juice product (mango nectar)

The clarified, single strength and concentrated juice obtained from 3rd and 4th run centrifugatic n was used for mango nectar preparation in easy open end (Stay On Tab) cylindrical cans (240 ml). The acidity and sugar content of the nectar were 0.45% and 14 °Brix, respectively, while the juice content of the two types of products were 20% and 50%. The control, obtained from manual straining (1.5 - 2 mm sieve size) without enzyme liquefaction and centrifugation for juice separation, possessed the same acidity and Brix with 20% of pulp content.

The sugar solution was prepared by adding the required amount of sugar and citric acid to water. The solution was then boiled followed by filtering through clean filtering cloth. The filtered sugar solution and clarified juice were boiled up to 80-85°C with continuous stirring and filled into sterilized empty cans under hot condition (100°C). The filled cans were passed through the can exhausting chamber followed by the can sealing machine. The sealed cans were finally sterilized at 100°C for 15 min and submerged in a water filled tank for cooling.

Sensory evaluation

The nine-point Hedonic scale was used for preference testing and the subjective evaluation of the products by 12 panelists. The Hedonic scale used by the panelists ranged from 1 to 9 (dislike extremely - 1, dislike very much - 2, dislike moderately - 3, dislike slightly - 4, neither like nor dislike - 5, like slightly - 6, like moderately - 7, like very much - 8, like extremely - 9) for the aroma, flavor, sweetness, acidity, texture, colour and overall acceptability.

RESULTS AND DISCUSSION

Enzyme liquefaction of mango puree

The change in juice yield with holding time at 100 ppm enzyme dosage is shown in Figure 1a. After 1 h of holding time, juice yields of 24.7, 27.8, 44.7, 42.5 and 39.0% were obtained at 30°, 35°, 40°, 45° and 50°C, respectively. Comparatively, yield increment with time at 30° and 35°C were lower than at 40°, 45° and 50°C at the first 2 h of holding time. The maximum yield (52%) was recorded at 40°C with 100 ppm after 2 h holding time. The change in juice yield at 40°C and 45°C followed a similar pattern. At 50°C, juice yield was lower than at 40°C and 45°C. The reason could be the high temperature effect on enzyme that appeared to obstruct the juice separation, trapping the content in puree, thus resulting in less yield. At 30°C and 35°C, increment in juice yield percentage was low due to lower enzyme activity. Therefore it is obvious that 40°C and 45°C puree temperatures were more suitable for enzyme liquefaction than 30°C, 35°C and 50°C.

The relationship between juice yield and holding time at different temperatures, treated with 200 and 300 ppm Pectinex Ultra SP-L enzyme are given in Figure 1b and Figure 1c, respectively. At 300 ppm enzyme dosage,

after 1 h of holding time, juice yields of 40.7, 42.6 and 43.8%, were obtained at puree temperatures of 40°, 45° and 50°C, respectively. The behaviour of yield increment throughout the holding time were similar, and maximum yields of 52, 51.1 and 51.3% at 40°, 45°, and 50°C, respectively, were gained after 2 h of holding time. There was a considerable gap in juice yield between 30-35°C versus 40-50 °C puree temperature. At 30°C and 35°C, juice yield after 1 h were 29.3% and 32 9%. Increase in yield was at a relatively lower rate and reached the maximum after 3 h. The temperature effect on enzyme liquefaction is shown from the above results. Puree temperatures less than 40°C resulted in poor juice yields due to low enzyme activity.

Juice yields of the control samples after 1 h were 0.7, 0.9, 1.3, 1.5 and 1.6% at 30°, 35°, 40°, 45° and 50°C, respectively (Figure 1d). The yield increment of the control was very low, compared with the enzyme treated samples.

A temperature range of 40-45°C, holding time of 2 h, and an enzyme dosage of 100-200 ppm were the most suitable conditions for enzyme liquefaction. The maximum juice yield of 52% has been recorded from the treated puree with 100, 200 and 300 ppm after 2-2.5 h of holding time. Considering the cost of the enzyme, Pectinex Ultra SP-L (100 ml costs 15 US$), the lowest and optimum enzyme dosage was determined.

Considering the juice yields of the Pectinex Ultra SP-L treated puree from 40- 200 ppm, the lowest average of 27.4% was recorded from the treated puree with 40 ppm, while 47.5, 54 and 56% resulted from the treated puree with 130, 150 and 200 ppm, respectively.

The juice yields at 40, 60, 80, 100 and 130 ppm dosages were significantly different at 95% confidence level, DNMRT, and the juice yield values were not significantly different at 150 ppm and 200 ppm enzyme dosages. Pectinex Ultra SP-L 150 ppm dosage and 2 h of holding time at 40°C puree temperature were selected as the most suitable condition for the enzyme liquefaction of mango puree.

The results of the experiment on enzyme liquefaction with Pectinex Ultra SP-L and cellulase prior to pilot scale processing show that the average juice yield of the treated mango puree at 40°C was 46.8% (150 ppm Pectinex Ultra SP-L with 150 ppm cellulase), and 47.5% (200 ppm Pectinex Ultra SP-L with 200 ppm cellulase) while at 45°C, average yield was 47.6% (150 ppm Pectinex Ultra SP-L with 150 ppm cellulase) and 48.7% (200 ppm Pectinex

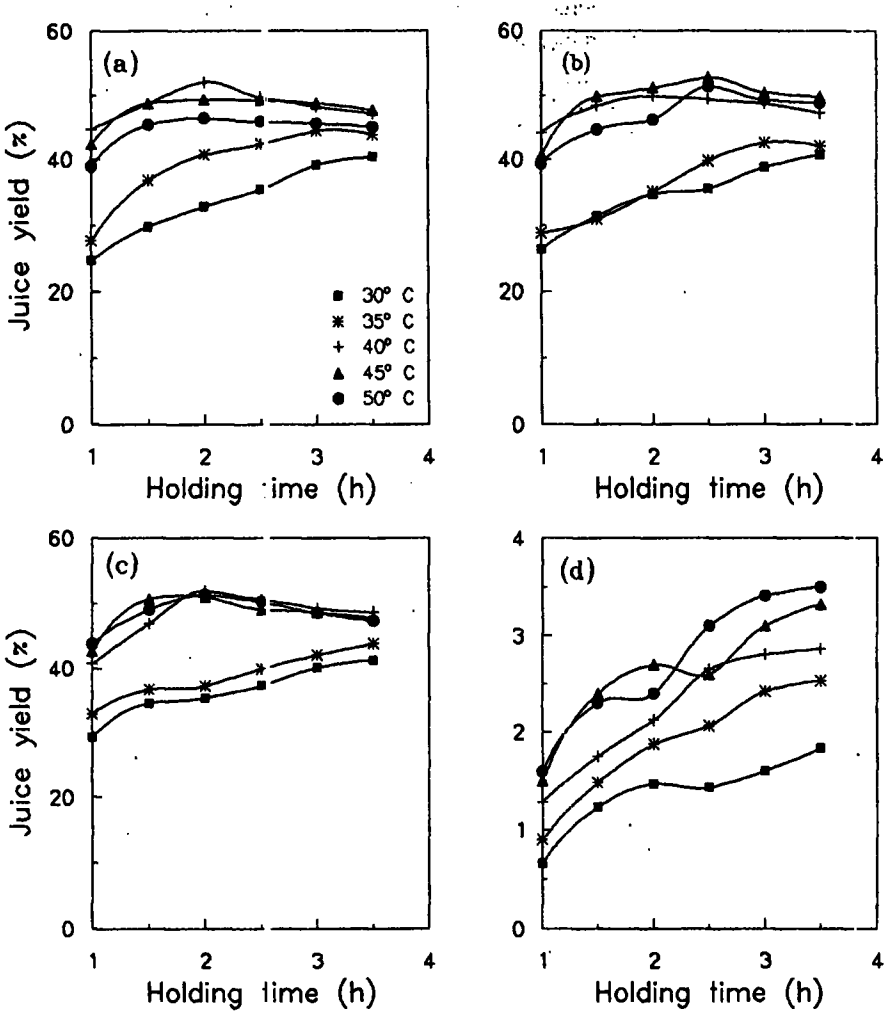

Figure 1. **Relationship between juice yield and holding time. (a) 100 ppm, Pectinex Ultra SP-L; (b) 200 ppm , Pectinex Ultra SP-L; (c) 300 ppm, Pectinex Ultra SP-L; (d) Control.**

Ultra SP-L with 200 ppm cellulase). A measurable amount of juice yield was not obtained from the control.

The juice yield values of the treated puree were not significantly different at 40°C and 45°C (DNMRT, 5% level). Therefore, for the pilot scale production, 150 ppm Pectinex Ultra SP-L with 150 ppm cellulase enzyme dosage was used.

Production of clarified single strength mango juice

Texture of the whole fruit decreased from 37.5 kg/cm^2 to 4.8 kg/cm^2 (87.2% reduction) on the 7th day after calcium carbide treatment (12 g/4 kg). Acidity of the fruit flesh was reduced by 42.9% (Table 1). The reduction of alcohol insoluble solid (AIS) from 10.3% to 0.9%, was due to degradation and hydrolysis of complex carbohydrates in the unripe flesh. On the 7th day, 340 kg of ripe mangoes were taken for processing, and 211.7 kg of puree were obtained (62.3%). The enzyme treated puree was centrifuged after 2 h of holding time at 40°C. The average juice yields were 58.2, 46, 40.8 and 37% from 1st, 2nd, 3rd and 4th run centrifugation and the the pulp removed during the separation were 41.8, 16.3, 5.2 and 3.8% from 1st, 2nd, 3rd, and 4th run, respectively. The removal of coarse portion in the puree was higher in the 1st and 2nd run while at 3rd and 4th run the percent removal was very low. The clarified, single strength juice possessed an acceptable clarification after the 3rd run.

Clarified, concentrated mango juice

The clarified single strength juice obtained after the 3rd and 4th run was concentrated using a falling film vacuum evaporator (Alfa-laval). The temperature of the resulted concentrated juice ranged from 64 -68°C.

Sensory evaluation

The nectar with 20% concentrated juice (3rd run) and reconstituted scored 6.56 (slightly like) for colour while the score for the control was 6.83 (slightly like) which were not significantly different at 5% level LSD test (Table 2). The results proved that the colour of nectar from both single strength

Table 1. Changes in composition during the fruit ripening.

Parameter	Day			
	1	3	5	7
Texture* (kg/cm^2)	37.50	17.16	8.50	4.80
pH*	3.27	3.81	4.22	4.81
Acidity* (%)	1.68	1.36	1.21	0.96
Alcohol insoluble solid* (%)	10.25	2.85	2.70	0.88
Calcium pectate (%)	0.65	0.39	0.20	0.13
Starch (%)	12.04	7.35	3.19	0.96
Total soluble solid* (%)	7.60	10.60	14.20	17.80
Total solid* (%)	17.17	17.00	16.84	16.60

* Average of three replicates.

and concentrated juice was not significantly different and no discoloration of the concentrated juice existed in the products. Colour attribute of the products with 50% juice content, compared with the control were not significantly different at 5% level by the LSD test.

Nectar prepared from the 3rd run clarified, single strength juice (50%) was the best for colour attribute and possessed a score of 7.2 (like moderately). There was no considerable difference in colour of the products from concentrated, single strength and concentrated, reconstituted juice with 20% and 50% juice content.

The flavour attribute of nectar with 20% juice content was rated at 'neither like nor dislike' by the panelists which was not significantly different to that of 50% juice content. There was no significant difference between aroma attribute of both products with 20% and 50% juice content compared

Table 2. Average sensory evaluation scores of the straight-to-drink mango products.

Attribute	3 SS	4 SS	3 CR	4 CR	Control
20% juice content					
Colour	5.83ab	5.26a	6.56bc	5.40a	6.83c
Flavour	5.73a	5.60a	5.93a	5.66a	5.53a
Aroma	6.03a	5.66a	5.76a	5.33a	5.33a
Texture	5.80ab	5.73ab	6.43b	5.46a	5.80ab
Sweetness	6.13a	6.10a	6.20a	5.66a	5.93a
Acidity	5.73a	5.40a	5.60a	5.66a	5.16a
Overall acceptability	6.10ab	5.86ab	6.60b	6.03ab	5.60a
50% juice yield					
Colour	7.20a	6.43a	6.86a	6.93a	6.83a
Flavour	5.70ab	5.90ab	6.03ab	6.46b	5.53a
Aroma	5.66a	6.03a	5.70a	5.83a	5.33a
Texture	6.40a	6.03a	6.33a	6.33a	5.80a
Sweetness	5.93a	6.43a	6.36a	6.60a	5.93a
Acidity	5.63ab	6.00ab	6.03ab	6.16b	5.16a
Overall acceptability	6.20ab	6.30ab	6.40b	6.60b	5.60a

* Means followed by the same letter/s in the same row are not significantly different at 5 % level by LSD test.

3SS - Clarified juice (3rd run centrifuged), single strength
3CR - Concentrated juice (3rd run centrifuged) and reconstituted
4SS - Clarified juice (4th run centrifuged), single strength
4CR - Concentrated juice (4th run, centrifuged) and reconstituted
Control - Mango nectar contains 20% strained mango puree obtained without enzyme addition.

with the control. The mean scores of the products with 50% juice content were not significantly different for the texture attribute. Mango nectar with 20% juice, yielded from the 3rd run single strength, 4th run single strength and 4th run concentrated, reconstituted scored 'neither like nor dislike' for the texture attribute. Although the 3rd run concentrated, reconstituted juice scored 'like slightly', it was not significantly different (P = 0.05) to the control, which scored 'neither like nor dislike'.

The overall acceptability of the nectar produced from clarified juice was more acceptable by the panelists. The reason was good mouth feel and the less viscous nature of the drink. Therefore, the product is good for use as a thirst quencher or a drink. The control scored 'neither like nor dislike'.

The above sensory evaluation results proved that mango nectar with clarified juice is more acceptable than the nectar prepared from the strained puree. In terms of the overall quality, there was no significant difference between the nectar with 20% and 50% juice content, although the colour of the nectar with 20% juice content was slightly lower than that of 50% juice content.

CONCLUSIONS

Enzyme liquefaction with 150 ppm Pectinex Ultra SP-L enzyme preparation and 150 ppm cellulase enzyme at 40°C for 2 h of holding time were the most suitable conditions for making mango puree from the variety Kaew. It was observed that 46.8% of juice yielded by centrifugation of enzyme treated puree at 5000 rpm for 8 minutes (Laboratory scale) and the juice yielded from enzyme treated puree at 40°C and 45°C were not significantly different.

Under the pilot scale processing, a juice yield of 40.8% of clarified, single strength mango juice with an acceptable clarification has been obtained from the treated puree (150 ppm Pectinex Ultra SP-L and 150 ppm cellulase enzyme) after the 3rd run centrifugation at 8500 rpm. Clarified concentrated juice with 28 °Brix was obtained by evaporation in the falling film evaporator after 2 passes. There was no significant colour change between the clarified, single strength juice and the clarified, concentrated juice.

Mango nectar with 20% and 50% juice content (except from the nectar of 4th run single strength juice) scored as 'slightly like' over the control which scored as 'neither like nor dislike' for the overall acceptability by the sensory evaluation (Hedonic scale).

Production of clarified, single strength and concentrated juice is a promising technique in order to absorb the surplus of mango variety Kaew during the production season of March to July.

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