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Effect of mechanisation operations on recovery of frozen breaded Gandul pineapple at different processing stages

(Kesan operasi mekanisasi terhadap pulangan nanas Gandul bersalut reroti pada peringkat pemprosesan yang berlainan)

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Key words: processing, mechanisation, recovery, breaded pineapple

Abstract

Suitable mechanised methods for upscaling the production of frozen breaded pineapple from laboratory scale to commercial scale, in particular the peeling and coring operations, as well as the battering and breading operations were evaluated. The effect of these mechanised methods on the recovery of the product as well as the need to modify the formula were studied. This is with the view of recommending semi-mechanised and fully mechanised operations for upscaling the production of breaded pineapple to commercial scale. Water blanching and steam blanching methods were also evaluated to see the recovery of the product.

Mechanisation of the processing stages of (a) deskinning and removal of eyes (b) trimming of core and (c) battering and breading could be accomplished for the processing of frozen breaded pineapple. The mechanised operation of deskinning, and removal of eyes and core was 45 times faster than the manual operation of deskinning and removal of eyes. Mechanised battering and breading was 2.55 times faster than the manual operation. However, the mechanised operations resulted in significantly different (p <0.05) percentage recovery of wedges from fresh fruit, percentage recovery of coated fruit from syruped wedges as well as percentage pick-up of coating from the manual method. Also, modifications had to be done to the batter mixture formulation by diluting the batter.

Introduction

Frozen coated pineapple is a new product, developed with the aim of diversifying the use of fruits in processed products. It was also intended to provide more variety of fruit products to consumers of all age groups, especially as fruits and vegetables are able to provide many essential vitamins and minerals and are rich in fibre (Tee and Khatijah 2001).

The product was successfully developed and can be coated with commercial breadcrumbs, oatbran, wheatgerm or unprocessed wheatbran. Laboratory trials have established the processing parameters as well as the physico-chemical, nutritional and organoleptic properties of coated Gandul pineapple developed with different coatings (Hasimah et al. 2002). In order to transfer the technology to entrepreneurs, studies need

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to be conducted to upscale the production and mechanise the processing steps where possible.

The objective of this study was to evaluate suitable mechanised methods for upscaling the production of breaded pineapple from bench scale, in particular the peeling and coring operations, as well as the battering and breading operations and to study the effect of these mechanised methods on the need to modify the formula as well as the recovery of the product. This is with the view of recommending semi-mechanised and fully mechanised operations for upscaling the production of breaded pineapple to commercial scale.

Technical specifications provided by machine suppliers are only an indication of performance of machines and would not be able to give accurate data on new products, which the supplier is unfamiliar with. Problems encountered with the processing step upon mechanisation, which need to be addressed by modifying the formulation and steps of the process, would only be known by evaluating the performance of a machine for a new product.

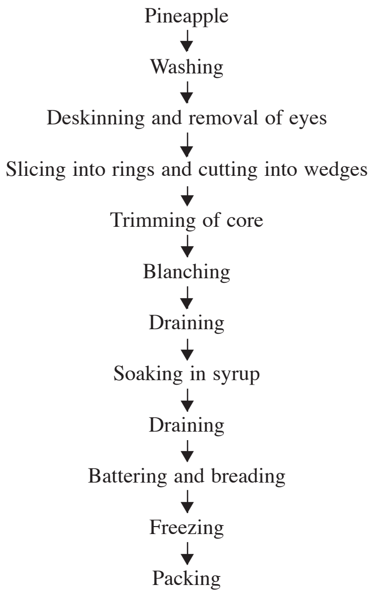

Figure 1. Process flow for manual processing of frozen breaded pineapple

Materials and methods

The method of processing frozen breaded pineapple was established in earlier studies as shown in *Figure 1*. Gandul pineapple fruits of maturity index 1 were obtained from a farm in Pontian, Johor. Fruits of 1.60 ± 0.17 kg were selected. Other ingredients were bought from local suppliers.

Fruit processing method

In the manual production of frozen breaded pineapple, the skin and eyes of the fruits were removed manually by cutting with a knife longitudinally along the vertical axis of the fruit stem. The fruits were then cut into rings of approximately 1 cm thick along the fruit length. The rings were further cut into 4–5 wedges of approximately 10 g each with the core slightly trimmed. The wedges were arranged in a single layer on the second tier of a steamer pot which had a base container containing boiling water. The water was kept boiling by means of a gas cooker. The wedges were blanched for 2 min in the steamer pot, followed by soaking in 30 °Brix syrup overnight. After draining excess syrup, the wedges were placed in batches into a container containing batter made with a mixture of flour and water (1:1.15), drained in a colander basket and coated with commercial breadcrumbs by hand. The products were then arranged onto stainless steel trays and blast frozen to –18 °C after which they were packed in high density polyethylene bags and sealed.

Three steps of the manual method for processing frozen breaded pineapple were studied to compare manual methods against mechanised operations. The three steps were (a) deskinning and removal of eyes (b) trimming of core and (c) battering and breading. The blanching step was evaluated by comparing steam blanching against water blanching.

The deskinning, removal of eyes and trimming of core steps were accomplished by using a pineapple peeling and coring machine manufactured by Teck Meng Engineering, Johor available at MARDI Johor Bahru research station. The knives were adjusted to cut 1.5 cm diameter of the fruit core and retain 11.7 cm width of the cut fruit. The fruits were then manually cut into rings of approximately 1 cm thick along the length of the fruit and further cut into wedges. This was carried out in two trials using 55 fruits per trial.

Two blanching methods were tested i.e. steam blanching and water blanching. Steam blanching required 2 min while water blanching required 1 min 20 s for equivalent treatment, as established in earlier preliminary studies. Steam blanching was carried out using two types of cookers (i) steamer pot as described in the earlier section and (ii) steam retort, where a single layer of the pineapple wedges was put onto a stainless steel mesh tray and then loaded into the steam retort at atmospheric pressure. Water blanching was carried out by filling a stainless steel wire basket with the pineapple wedges and lowering the basket into a stainless steel steam jacketed kettle filled with boiling water (ratio of 1: 6 of fruit:water) which was kept boiling. This was carried out in three trials for each blanching method.

Battering and breading was carried out by a Koppens Alfa Laval PR200 battering and breading machine adjusted to feed 2.1 kg pineapple pieces per minute. The machine was operated with the blower on. Product entered the machine on a conveyor passing through a shallow bath of batter and batter was also applied from above. This was carried out in two trials.

Recovery of the product at each stage of the operation was recorded. Recovery percentage was calculated as:
[(Weight of product at the end of the particular operation)/(Weight of fresh fruit or weight of wedges at the start of the operation)] x 100.

The percentage pick-up of coating material was calculated for the battering and breading step using the formula as described by Johnson and Hutchison (1983):
[(Weight of coated product – weight of uncoated product)/Weight of coated product] x 100.

Modifications needed for each mechanisation step to work were also recorded. Viscosity of the batter mixture was determined with a Brookfield DVII Viscometer, Model RV with spindle number 1 at 25 °C.

Data for the manual operations were obtained from six separate trials. Data was evaluated using the SAS (Statistical Analysis System) program release 8.01 (SAS Inst. 2000). The values obtained were tested using the t-test.

Results and discussion

Deskinning, removal of eyes and trimming of core

Recovery of pineapple wedges from fresh fruit was significantly different (p <0.05) when the deskinning, removal of eyes and trimming of core were mechanised as compared to the manual operation. Mechanising the operation resulted in a lower recovery of 23% as compared to 40.4% *(Table 1)*. The diameter of the deskinned fruit was 11.7 ± 0.2 cm.

Even though Gandul variety is recommended for processing as reported by Abd. Shukor et al. (1998) due to its fairly uniform circumference over the whole fruit length as compared to other varieties such as Sarawak and Moris, recovery of wedges equivalent to manual operations was not possible as the coring and cutting knives need to be adjusted to a fixed cutting diameter to ensure all fruits are cut. Fruits being natural products still vary in size to a certain extent even though selection of fruits was done based on weight.

The physical characteristics of fresh Gandul pineapple are as follows: length 17.44 ± 0.86 cm, width 12.54 ± 0.63 cm, circumference 40.54 ± 1.27 cm and weight

Table 1. Percentage recovery of product at different stages of processing during manual and mechanised operations of frozen breaded pineapple processing

Processing stage	Manual operation	Mechanised operation
Deskinning, removal of eyes and core		
% recovery of wedges from fresh fruit	40.4 ± 1.17a	23.0 ± 2.83b
Battering and breading		
% recovery of coated fruit from syruped wedges	119.0 ± 0.33a	157.5 ± 12.35b
% pick-up of coating	16.0 ± 0.23a	39.1 ± 1.05b
Frozen product recovery from fresh fruit (%)	38.02 ± 2.14a	28.1 ± 3.96a

Means in the same row followed by the same letter are not significantly different (p <0.05)

Table 2. Time taken, number of workers needed for operation and rate of work using the same amount of material

	Time taken	No. of workers	Rate of work
Semi-mechanised operation			
Mechanised deskinning, removal of eyes and core*	3 min	1	18.3 fruits/min/worker
Manual cutting into rings and wedge shape*	34 min	4	0.4 fruit/min/worker
Mechanised battering and breading**	20 min	4	0.196 kg/min/worker
Manual operation			
Deskinning and removal of eyes*	34 min	4	0.4 fruit/min/worker
Cutting into rings, wedge shape and removal of core*	45 min	4	0.3 fruit/min/worker
Battering and breading**	51 min	4	0.077 kg/min/worker

*For 55 fruits
**For 15.7 kg syruped wedges

1.60 ± 0.17 kg, based on 25 fruits (Hasimah et al. 2002). The recovery obtained after deskinning, removal of eyes and trimming of core of Gandul at 23% is comparable to 18–20% recovery of pineapple parts which can be processed for canned pineapple (Muhammad and Ab. Aziz n.d. [1974]).

Despite the lower recovery of cut wedges by using the peeling and coring machine, the time taken to process was much faster than manual operations. The machine could cut approximately 18.3 fruits/min using only one worker. This was a saving in labour and time as the manual deskinning and removal of eyes operation would need an additional three workers and an additional 31 min to do the same operation which took only 3 min by using machine *(Table 2)*. This means that the mechanised operation of deskinning, and removal of eyes and core was 45 times faster than the manual operation of deskinning and removal of eyes.

Under large scale operations, the by-product of the deskinning and trimming step can be further utilised to produce juice. The excess flesh which are attached to the skin can be scraped, comminuted, pressed and peeled for juice extraction. This would be viable under large scale operations to maximise recovery of product and profit from the raw materials. Peelers which can peel, core and scrape flesh from pineapple skin are commercially available (Anon. 2002). For high speed operations, the Ginaca machine was reported to be able to deskin and core 100 fruits per minute (Lienhard 1997).

Labour intensive operations need workers, which are quite expensive in Malaysia as compared to Indonesia. In order to produce products on a commercial basis on a large scale, mechanisation needs to be incorporated into some of the processing steps such as the deskinning and coring as well as the battering and breading operations. The economies of scale need to be there in order to justify the investment in the machine.

Careful choice of equipment can have a lasting effect on the profitability of a business because equipment always affects costs, volume and revenue (Dakanay 1985). Thus, the production capacity of the factory needs to be looked at when recommending mechanisation for processing stages. Small or cottage industries are still able to produce products viably using manual methods due to lower overheads and specific market needs. Itao (1985) reported that process industries with large labour content in value added production are suitable for small firms.

Blanching

Recovery of blanched pineapple wedges using a steam retort was significantly different ($p < 0.05$) to using water blanching by boiling in a jacketed kettle *(Table 3)*. Lower recovery was obtained for water blanching (82.9%) even though time of blanching was slightly shorter. This is probably due to soluble solids of the pineapple wedges leaching out and insoluble solids dropping off from the pineapple wedges into the vigorously boiling water in the water blanching method. Both methods can be used for blanching pineapple wedges. Steam and water blanching are methods employed in blanching of fruits and vegetables as pretreatments before processing (Nickerson and Ronsivalli 1980).

Table 3. Recovery of blanched pineapple wedges from unblanched wedges using different blanching methods

Steam blanching in steamer pot	Steam blanching in steam retort	Water blanching in jacketed kettle
87.8 ± 3.48ab	90.0 ± 0a	82.9 ± 2.24b

Means in the same row followed by the same letter are not significantly different (p <0.05)

Blanching is carried out to inactivate enzymes in the fruit, which would react with other food components resulting in changes to colour and taste of the product upon storage. Steam blanching in a steamer pot gave recovery that was not significantly different (p <0.05) from steam blanching in steam retort and water blanching in jacketed kettle. Thus, this method of blanching would be suitable for a small company to produce the product as lower investment would be needed. Other heating media such as hot air and microwave can also be used for blanching (Lund 1975).

The final choice of method would depend on the capacity of the factory and the investment that the entrepreneur has in mind. Smaller companies can opt for batch type systems using steam blanching in a steamer pot or water blanching in jacketed kettle, whereas larger companies can opt for steam blanching using a conveyor tunnel system.

Battering and breading

The percentage recovery of coated pineapple from syruped wedges using the battering and breading machine (157.5%) was significantly higher (p <0.05) than that using the manual method (119.0%) *(Table 1)*. This was because the machine had to be operated such that the products passed twice under the battering and breading section of the machine for an even and full coating of the breadcrumb. A single pass under the battering and breading section resulted in a bald appearance to the product. This was due to modifications that had to be made to the batter mixture for the mechanised operation. The optimal batter mixture of flour:water (1:1.15) with a viscosity of 8.18×10^3 cp (1 rpm) in manual trials was too thick for the pump to circulate batter in the machine. The optimal formulation in manual trials had to be diluted to enable the pump to deliver the mixture in the machine. Thus the batter mixture for the machine had a flour:water ratio of 1:1.94 with a viscosity of 142 cp (50 rpm) for these trials (minimum water).

The significant difference in pick-up of the batter and breadcrumb was shown by the percentage pick-up of coating material, whereby the mechanised method picked up 39.1% of the breadcrumb as compared to 16.0% for the manual method. This would mean additional cost to the production of the product as more breadcrumb would need to be used. Suderman (1993) and Kirn (1996) reported that batter viscosity influences the quantity and quality of pick-up and the final coating texture, where thicker batter results in higher pick-up.

The time taken for battering and breading was 20 min in the mechanised operation while in the manual operation the time taken was 50 min using the same number of workers *(Table 2)*. The mechanised operation at 0.196 kg/min/worker was 2.55 times faster than the manual operation at 0.077 kg/min/worker. Mechanisation thus results in time savings in addition to consistent quality and high production capacities.

In order to achieve the same pick-up as the manual method, more trials would have to be conducted to dilute the batter further as well as to operate the battering and breading machine such that only a single pass is used with the diluted batter. However adhesion of breadcrumb to the fruit would need to be considered when diluting the batter and incorporation of other ingredients such as starches may be necessary (Kimber and Holding 1987). A single pass would also reduce the machine operation time.

Frozen product recovery from fresh fruit

In terms of frozen product recovery from fresh fruit, there was no significant difference ($p < 0.05$) between the manual and the mechanised operation *(Table 1)*. The lower recovery during deskinning, and removal of eyes and core was offset by the higher pick-up of coating material during the battering and breading step in the mechanised operation.

Conclusion

Mechanisation of the processing stages of (a) deskinning and removal of eyes (b) trimming of core and (c) battering and breading could be accomplished for the processing of frozen breaded pineapple. The mechanised operation of deskinning, and removal of eyes and core was 45 times faster than the manual operation of deskinning and removal of eyes. Mechanised battering and breading was 2.55 times faster than the manual operation.

However, the mechanisation operations resulted in significantly different ($p < 0.05$) percentage recovery of wedges from fresh fruit, percentage recovery of coated fruit from syruped wedges as well as percentage pick-up of coating from the manual method. Also, modifications had to be done to the batter mixture formulation by diluting the batter to a flour:water ratio of 1:1.94 in the battering and breading step to enable the processing step to be mechanised by using a battering and breading machine.

In terms of raw materials, more fruit and breadcrumb would be needed in the mechanised operation to produce the same amount of product as in the manual operation. In terms of labour and time, there would be less number of people and less time needed for the mechanised operations.

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Abstrak
Kaedah mekanisasi bagi peningkatan skala pengeluaran nanas bersalut reroti dari peringkat makmal ke peringkat komersial yang melibatkan operasi pengupasan dan pembuangan empulur serta operasi pembateran dan penyalutan telah dikaji. Tujuannya adalah untuk mengetahui kesan mekanisasi terhadap pulangan produk dan keperluan untuk mengubahsuai formulasi supaya pengeluaran nanas bersalut secara mekanisasi (separa/sepenuhnya) dapat dijalankan. Kaedah celur dan kukus juga telah dikaji untuk melihat kesan terhadap pulangan.

Mekanisasi dapat dijalankan untuk proses (a) pengupasan dan pembuangan mata (b) pembuangan empulur dan (c) pembateran dan penyalutan. Operasi mekanisasi pengupasan, serta pembuangan mata dan empulur 45 kali lebih cepat daripada operasi manual pengupasan dan pembuangan mata. Mekanisasi pembateran dan penyalutan pula 2.55 kali lebih cepat daripada operasi manual. Walau bagaimanapun, operasi mekanisasi telah menyebabkan peratus pulangan kepingan nanas daripada buah segar, peratus pulangan buah bersalut daripada kepingan nanas bersirap serta peratus 'pick-up' bahan salut berbeza ketara ($p < 0.05$) daripada kaedah manual. Selain itu, pengubahsuaian juga perlu dibuat kepada formulasi adunan bater dengan mencairkannya.

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