UNIVERSITI PUTRA MALAYSIA

OPTIMISATION OF ENZYME AIDED PEELING OF MUSK LIME (*CITRUS MITIS* B.) AND DEVELOPMENT OF ITS CANDIED PEEL

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FSMB 2003 30

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

October 2003

To my beloved families and friends.....

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

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Chairman : Associate Professor Azizah Osman, Ph.D.

Faculty : Food Science and Biotechnology

Studies on the optimisation of enzyme peeling of citrus fruits were carried out on musk lime *(Citrus mitis* B.*)*. The time taken to peel musk lime by enzyme (Peelzym II) was minimised with increasing enzyme concentration and application of vacuum pressure. The optimum enzyme concentration and optimum vacuum pressure for peeling musk lime peel was 1.0% (v/w) and 700 mm Hg, respectively. The effect of vacuum pressure in physico-chemical changes of peeled fruits of musk lime *(Citrus mitis* B.*)* during enzymatic peeling was studied. The pH, total soluble solids, citric acid, ascorbic acid, moisture, total pectin, tannin and sugar contents in the puree of peeled musk lime were not significantly affected by the vacuum pressure, except, total pectin content and 'b' value of puree colour at very high vacuum pressure (700 mm Hg). The naringin content has also been analysed in the puree, seeds and peel (discarded) of peeled musk lime. The

lime. The naringin content in the puree and seeds of peeled musk lime were not significantly affected by the vacuum pressure, however, naringin content in the peel was significantly affected at very high vacuum pressure. The development of candied musk lime peel was carried out using Response Surface Methodology (RSM) and ECHIP® software. In this study, the RSM method was found to be effective in making a new product when the developed product (candied musk lime peel) had matched the sensory profile of a target product (commercial candied peel). This method was then confirmed by a verification process between the experimental value from the developed product (candied musk lime peel) with the target value obtained from the overlapping contour maps of ingredients in the making of optimum candied musk lime peel. Results from sensory evaluation also showed that most of the panelists liked the taste of the product compared to other sensory attributes tested. In comparison, the developed candied musk lime peel has a similar profile in terms of appearance, odour and taste of sourness and bitterness to that of commercial candied peel. Therefore, the candied musk lime peel developed in this study has the potential to be commercialised.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

PENGOPTIMUMAN PROSES PENGUPASAN BUAH LIMAU KASTURI (*CITRUS MITIS* B.) TERBANTU ENZIM DAN PENGEMBANGAN HALWA DARI KULITNYA

Oleh

HAZNIZA DATO' HJ. ADNAN

Oktober 2003

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Kajian ke atas pengoptimuman proses pengupasan buah sitrus terbantu enzim telah dijalankan ke atas buah limau kasturi (*Citrus mitis* B.). Masa yang diambil untuk buah limau kasturi dikupas oleh enzim (Peelzym II) telah diminimakan dengan meningkatkan kepekatan enzim dan tekanan vakum yang digunakan. Kepekatan optimum enzim dan tekanan optimum vakum untuk pengupasan buah limau kasturi ialah 1.0% (isipadu/berat) dan 700 mm Hg, masing-masing. Kesan tekanan vakum dalam perubahan fisiko-kimia buah limau kasturi (*Citrus mitis* B.) yang telah dikupas semasa pengupasan terbantu enzim telah dikaji. Nilai pH, jumlah pepejal larut, kandungan asid sitrik, asid askorbik, kelembapan, jumlah kandungan pektin, tanin dan gula di dalam puri limau kasturi yang telah dikupas adalah tidak signifikan terhadap kesan tekanan vakum, kecuali, jumlah kandungan pektin dan nilai 'b' bagi warna puri pada kesan tekanan vakum yang tinggi (700 mm Hg). Kandungan naringin juga telah dianalisa di dalam kecuali, jumlah kandungan pektin dan nilai 'b' bagi warna puri pada kesan tekanan vakum yang tinggi (700 mm Hg). Kandungan naringin juga telah dianalisa di dalam puri, biji dan kulit (hampas) limau kasturi yang telah dikupas. Kandungan naringin di dalam puri dan biji bagi limau kasturi yang telah dikupas adalah tidak signifikan terhadap kesan tekanan vakum, tetapi, kandungan naringin di dalam kulit adalah signifikan pada kesan tekanan vakum yang tinggi. Pengembangan hasil bagi halwa kulit limau kasturi telah dijalankan dengan menggunakan kaedah 'Response Surface Methodology' dan software ECHIP®. Di dalam kajian ini, kaedah RSM didapati sangat berkesan dalam menghasilkan produk baru apabila produk yang dihasilkan (halwa kulit limau kasturi) sepadan dengan profil ujirasa produk sasaran (halwa kulit limau komersial). Kaedah ini kemudiannya telah diperakui melalui proses pengesahan diantara nilai ujikaji yang didapati daripada produk yang dihasilkan (halwa kulit limau kasturi) dengan nilai sasaran yang diperolehi daripada penindihan peta kontur ramuan-ramuan di dalam penghasilan halwa kulit limau kasturi yang optimum. Keputusan ujirasa juga menunjukkan kebanyakan panelis menyukai rasa produk berbanding lain-lain ciri ujirasa yang diuji. Secara bandingan, halwa kulit limau kasturi yang dihasilkan mempunyai persamaan profil dari segi rupabentuk, bau dan rasa dengan halwa kulit limau komersil. Maka, halwa kulit limau kasturi yang telah dihasilkan di dalam kajian ini didapati berpotensi untuk di komersilkan.

ACKNOWLEDGEMENTS

Alhamdulillah, first of all I would like to express my utmost thanks and gratitude to the Almighty Allah, the Sustainer, the Most Gracious and Most Merciful, without whose will no one can achieve anything, and my salawat and salam to His righteous messenger, prophet Muhammad S.A.W.

I would like to take this opportunity to express my appreciation and gratitude to the chairman of my Supervisory Committee, Assoc. Prof. Dr. Azizah Osman for her invaluable suggestion, guidance, discussion and patience throughout the project. I am also grateful to the other member of my supervisory committee, Prof. Dr. Hasanah Mohd. Ghazali and Assoc. Prof. Dr. Russly Abdul Rahman for their constructive comments towards the project and preparation of this thesis. My sincere gratitude is also extended to the financial support provided by the IRPA fund for this research, which was awarded to Assoc. Prof. Dr. Azizah Osman. I am also indebted to all the staffs of the Department of Food Science, Biotechnology and Food Technology for their generous cooperation. Acknowledgements are also due to all my labmates, friends and also laboratory assistants who had given me the moral encouragement and support to complete my graduate study.

Finally, I also wish to express my deepest, appreciation to my beloved husband and daughters, my parents and my parent in-laws, who have given me encouragement and morally support in anyway during the many years of my seemingly never ending pursue for knowledge.

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CHAPTER 1

INTRODUCTION

Citrus which originated from Southeast Asia, is one of the most important fruit crops in Asia (Ko, 1996). However, yields per unit area in Asia are low compared to most Western countries. Citrus has been chosen as one of the 16 fruit types for commercial production under the Malaysian National Agricultural Policy (Ko, 1996). Presently, there are about 1600 species of citrus in the world amongst which only a few of the better-known species are widely cultivated in Malaysia. The main citrus cultivated are oranges, pomelos and limes (Faridah and Azizah, 1982). In Malaysia, domestic production area of citrus fruit varies considerably between each fruit type. Lime is the second most important citrus after pomelo, followed by sweet orange and mandarin (limau langkat).

To date, reports on the quality of commercial musk lime juice are not available. This may be due to the once less popular status of commercially musk lime juice compared to orange juice. At present, there are many problems confronting the production of musk lime juice. In the industry, juice extraction using screw press is considerably impractical for the extraction of musk lime juice (Swisher and Swisher, 1977). In the process, the whole fruit is crushed (by pressure) in a screw press, then pass through a centrifugal machine to separate the juice from the mixture of peel and pulp (Kale and Adsule, 1995). This excessive extraction pressure could split the seeds and break the peel, which generally contain the bitter principle (naringin) and could also release excessive peel oil into the juice (Jainudin and Mazuin, 1988). Hence, the existence of this bitter taste in the juice is the result of the processing technique. The pronounced bitter taste was relatively less preferable to most of the consumers. The physiological limitation of musk lime fruit such as its small size and very thin peel compared to other citrus fruits, makes the mechanical juice extraction unsuitable for the extraction of musk lime juice. An understanding of these problems is, therefore, of the utmost importance in the promotion of the industrial value of the musk lime juice.

Conventional methods for fruit peeling such as hand peeling, mechanical, chemical, acid, heat and flame usually produce 30-40% of edible waste (Baker and Grohmann, 1995). This waste, containing live cells, are sensitive to the environment and continue to change after processing due to chances of contamination with microorganisms (Setty et al., 1993). However, this wastage can be reduced by recycling (enzyme solution) processes if a proper processing technique is carried out. Therefore, in order to reduce the undesirable effects and the peeling losses due to the conventional peeling methods, enzymatic peeling was developed.

Enzymatic peeling has been defined as the application of exogenous enzymes specifically to alter the characteristics of intact tissues (McArdle and Culver, 1994). In the enzymatic peeling process, enzyme is made to infuse into intact plant tissues such as flavedo and albedo and effectively alter the functional properties of these tissues such as softening the fruit peel and making it feasible to remove (Bruemmer, 1981). The first macerating enzymes were tried on fruit mashes in the 60s mainly on blackcurrant due to the difficulties in extracting its juice (Janser, 1997). Today the maceration of fruit with enzyme preparations is widespread and the advantages have been demonstrated for several fruits, conditions and extraction systems (Janser, 1997). The application of this technology was first developed for the production of fresh peeled fruit, fruit salads and segments. In 1981 a USDA patent was granted for the so-called vacuum infusion process with enzymes. Since then, a lot of development has been done (Janser, 1996).

In enzyme peeling process, a dilute solution of enzyme will be infused into intact citrus fruit tissues where the enzyme will penetrate between the citrus fruit segments loosening adhesion of the capillary membrane and allow the fruits peel to be easily removed (Janser, 1996). The enzymatic technology results in segments with improved freshness, better texture and appearance compared to traditional segments, which are peeled using a caustic soda process (Janser, 1997). Enzyme peeling of citrus benefits the processors by yielding 100% of the edible portion of fruit as salable product compared to the conventional peeling methods (Baker and Grohmann, 1995).

There are many methods that have been reported on ways to infuse enzyme into the fruit. One of the methods is the vacuum infusion where fruits are subjected to vacuum for a fixed time in an enzyme preparation for the infusion of the solution into the albedo layer and incubated in the enzyme preparation after breaking the vacuum until easy removal of the peel was obtained (Soffer and Mannheim, 1994). The advantages of fruit peeling by vacuum-oriented enzyme infusion are obvious. The quality of the obtained peeled fruit was better such as it had a more attractive appearance such as clean flesh, without white adhering albedo and more intensive colour and taste (Janser, 1996). This process also effectively alters the functional properties of the tissues such as softening the fruit peel, firming the fruit flesh and enhancement of desired flavours (Elliott and Julia, 1993).

Fruit processing industries usually have to cope with 40-60% of the incoming harvested fruit exiting the juicers as waste (Baker and Grohmann, 1995). In the enzymatic peeling process, the loosened peel is considered as a waste. In attempting to produce by-products from the waste, the loosened peel has a high potential as a starting material for a development of value-added products. The loosen peel can be converted into more useful by-products through various processing technologies. The loosen peel can be candied, brined or pickled. The other citrus by-products that can be produced are bioflavonoids, flavourings and a gelling agent (Jainuddin and Mazuin, 1988).

Enzyme application for peeling fruits is new in Malaysia. Enzymatic peeling was introduced in Malaysia in late 1990's due to processing and market demand on local citrus juice and minimally processed citrus fruits. Since then, many research have been conducted to solve the processing problems, thus fulfill the market demand (Liu et al., 1999; Aziz et al., 1999).

Therefore, the objectives of this study were:

1. To determine the optimum conditions of enzymatic peeling of musk limes.
2. To determine the physico-chemical characteristics of enzymatic peeled musk limes.
3. To develop candied musk lime peel.

CHAPTER 2

LITERATURE REVIEW

Citrus Fruit

Citrus fruits are classified under the family Rutaceae and genus *citrus*, but botanically they are classified as berries. They are superior fruits with all of their tissues derived from the ovary, in contrast to apples in which some of the tissues are derived from the enlargement of the calyx and receptacle (Albrigo and Carter, 1977). The citrus fruit consists of an outer peel which serves largely as a cover to the inner portion. The outer portion of the peel is called the flavedo and the inner white spongy layer of parenchymatous cells is called the albedo. The flavedo contains numerous oil vesicles and chromatophores. The thickness of the albedo varies from species to species. The thickness of the albedo for the musk lime and mandarin orange is relatively thin measuring about 1.5 to 2.0 mm, while in the mexican lime is 2.5 to 3.5 mm (Jainudin and Mazuin, 1988). The edible portion of the fruit, the pulp is found in segments situated below the albedo layer. The structure (cross section) of citrus fruit is shown as in Figure 1.