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The study of microwave heating time on chemical and microbiological properties and sensory evaluation in sweet fermented glutinous rice (Khao-Mark)

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Abstract: This research aims to study about the effect of microwave heating time on chemical and microbiological properties and sensory evaluation of sweet fermented glutinous rice (Khao-Mark) during storage times (8 days). The results revealed that all heating times did not affect to chemical properties and sensory evaluation (P>0.05) but TPC at 49 and 56 sec heating times decreased much more than others. During storage time, moisture, acid and alcohol contents of non microwave heating treatments were significantly increased 8.91, 29.16 and 19.14%, respectively whereas sucrose contents and pH values of those treatments were decreased 55.18 and 8.53%, respectively. Moisture, acid and alcohol contents of microwave heating treatments at 56 sec were increased 3.74, 10.89 and 12.5% while sucrose content and pH were decreased 46.63 and 2.84%, respectively. However, the chemical properties of 28 – 56 sec of the microwave heating treatments from day 6 were changed lower than others. The heating time for 49 and 56 sec showed significant reduction for TPC compared with others during storage. In conclusion, the appropriate microwave heating time for Khao-Mark was 21 sec due to no significant difference of the chemical properties when compared with the treatments of 35 - 56 sec (P>0.05).

Keywords: microwave, heating time, chemical property, microbiological property, sensory evaluation, Khao-Mark

Introduction

Khao Mark, sweet fermented glutinous rice, is a kind of food brewed with cooked glutinous rice and Look-pang containing mold and yeast inocculum in rice flour mixed with herbs (Ministry of Industry, 2003). This fermented product has various characters such as lump of cooked glutinous rice, soft texture, pale white color, succulent grain, sweet taste and a little alcohol flavor. (Wongpiyachon, 1995). Most of the time, Khao Mark is well known for a sweet dessert of Thailand which is produced in family or/ and community level. Therefore, the production is not considerable in quality control of the product such as sanitation and Good Manufactory Practices (GMPs) which caused the contamination of various microorganisms. Khao Mark, without thermal method treatment, can not be stored for many days because of off-flavor in the product such as too much of alcohol and acid contents after storage for many days which affected to the acceptance of consumer. Consequently, this research focused on a preservative method for control the microorganisms and chemical property changes during storage. The microwave heating is one of the interesting preservative methods for food products in which this radiation is safe and can be transferred into food composition rapidly. Use of some synthetic antimicrobial agents, in other method, may cause to form carcinogens and/or mutagens in human body (Sabater et al., 1999).

Heat treatment by microwave is interesting, due to its radiation affects to microorganism viability even only short time use. Microwave heating is based on the transformation of alternating electromagnetic field energy into thermal energy by affecting the polar molecules of a material (Mullin,1995). Its radiation interacts with water in food products and generates heat. Production of heat occurs primarily when ions accelerate and collide or dipoles rotate and line up in the rapidly alternating electric field (Cunningham, 1978). Microwave energy has been used to pasteurize or sterilize food at lower temperatures and shorter times than necessary with conventional heating. The mechanism for the lethal effects of microwave radiation on microorganisms is not fully understood. Many studies have shown that heat generated by microwaves in food systems exerts most of the killing effective (Dreyfuss and Chipley,

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1980). Previously, microwave treatment for food products on microorganisms destruction has been much reported such as Cunningham (1978), Dreyfuss and Chipley (1980) and Khalil and Villota (1985, 1989). Microwave heating is suitable for many kinds of food products, however, the study on the quality of sweet fermented glutinous rice such as the chemical properties, microorganism and sensory evaluation have never been done. Therefore, the objectives of this research were to study the effect of microwave heating time on chemical and microbiological properties and sensory evaluation of sweet fermented glutinous rice (Khao-Mark) during storage times (8 days).

Material and Methods

Khao-Mak preparation

Glutinous rice was soaked with water for 3 h, and then steamed for 2 h. The sample was cool down, and washed with water. The cooked rice was mixed with Look-pang (0.2% w/w of sample) and fermented in plastic bag at cool temperature (25OC) for 2-3 days. The final product was heated by microwave oven (Amana, model Radarange AMC5143AAW, Newton, IA) for 0, 7, 14, 21, 28, 35, 42, 49 and 56 s (1100 Watts, 2450 MHz, high power). The treated samples were stored at 10OC for 8 days and analysed the chemical and microbiological properties and sensory evaluation in every 2 days.

Analysis of moisture, acid, alcohol and sucrose contents and pH values

Moisture contents and the titratable acidity (TA) were determined by the method of AOAC (1990) and expressed as % of lactic acid based on dry weight. Alcohol contents were measured by using Ebulliometer (Model EB-2359, DUSADIN). Non-reducing sugar (sucrose) contents were determined by following AOAC (1990) procedure. The pH values were measured by using a pH meter (Thermo Orion model 420, USA). Aliquots of 10 g of minced sample were dispersed in 90 ml of distilled deionized water with a tissue grinder. The measurement was carried on triplicate (Zhang et al., 2007).

Microbiological analysis

Sample for microbiological analysis was prepared by homogenized 25 g with 225 ml sterile peptone water. The 10-fold serial dilution with pour plate technique was used for total plate counts (TPC) (AOAC, 1995).

Sensory evaluation

The samples of each treatment were prepared for panel evaluation. The panelists (n=25) were untrained. For each evaluation, all samples were coded with random numbers and liking evaluation for color, appearance, firmness, odor, taste and overall acceptance on a 9-point hedonic scale (9=like extremely; 5=neither like nor dislike; 1=dislike extremely). Another evaluation of overall acceptance was monitored which scored not less than 5.00 were assumed to be acceptable.

Statistical analysis

All the experiments were repeated three times. Statistical analysis performed by using analysis of variance (ANOVA) was done to determine the significance of the main effects in SPSS 14.0 for Windows (SPSS, Chicago, III., USA) software package. Significant differences ($P<0.05$) between means were identified using Duncan's new multiple's range test procedures.

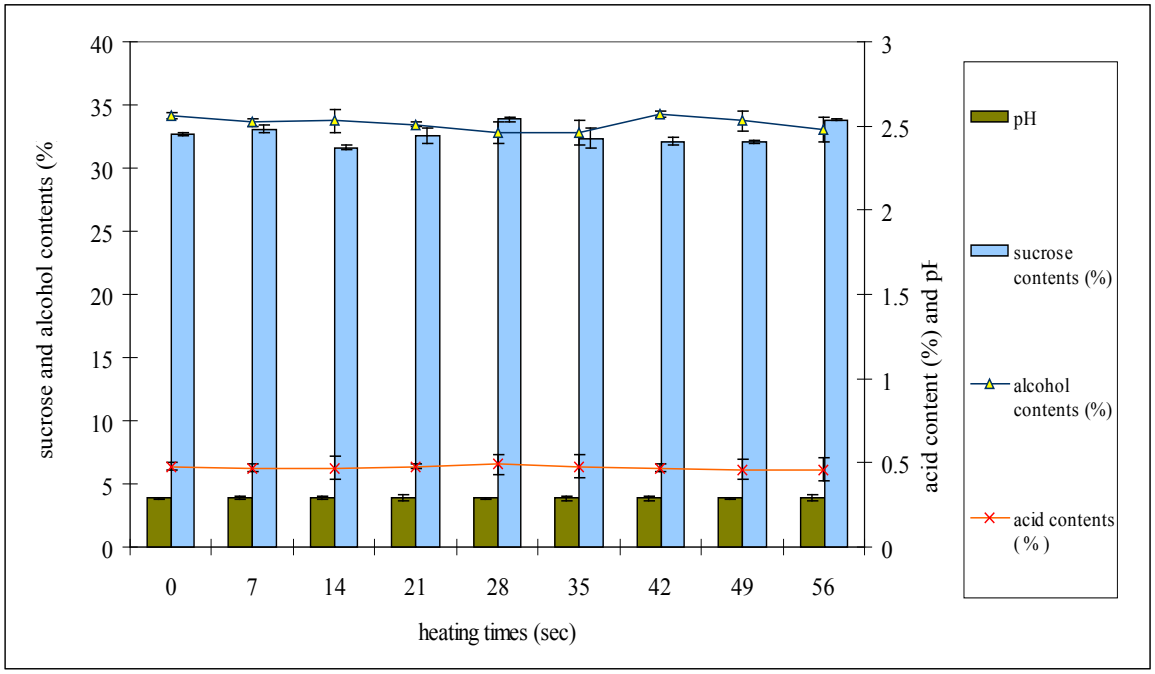
Results and Discussions

Chemical properties

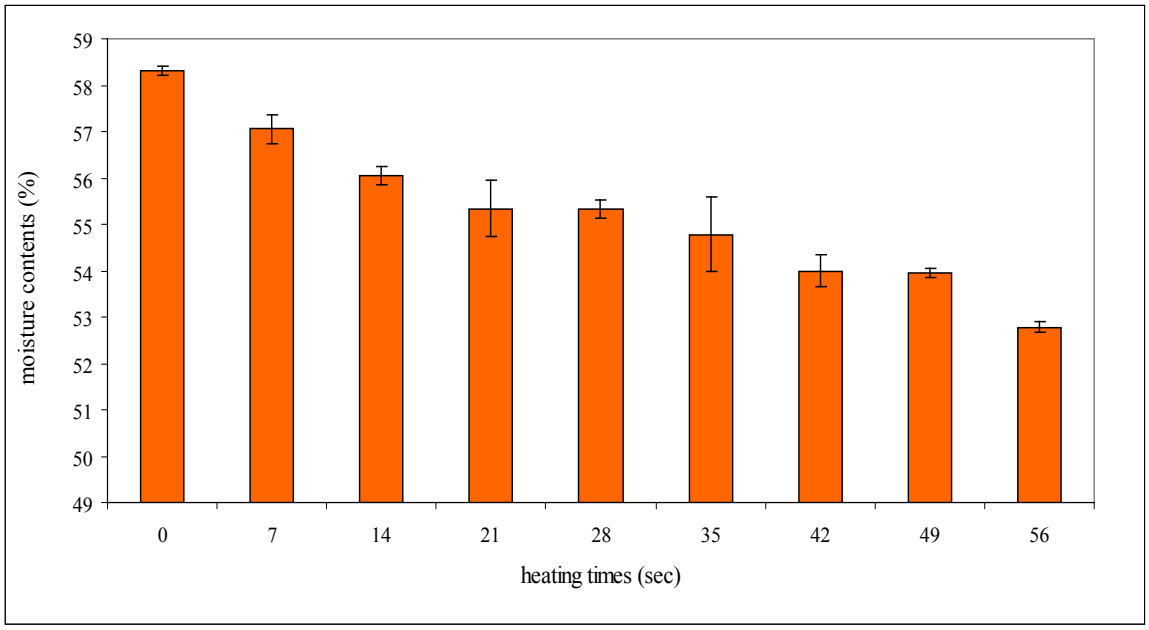
Figure 1 showed the chemical properties data. The pH values, sucrose, alcohol and acid contents during period of heating times (0–56 sec) were not significantly different ($P>0.05$). Microwave drying at the short heating times do not affect the loss of water-soluble components (Maskan, 2000). Kadlec et al. (2001) studied on the effect of microwave heating on the changes of soluble carbohydrates during germination of pea seeds (*Pisum sativum*). The results showed that soluble carbohydrate was not significantly decreased. In addition, considerable increase of antioxidant such as total phenolic and flavonoids contents in mash apple through microwave heating caused from the evaporated water from sample which concentrated the inner substances (Gerard and Roberts, 2004).

However, the longer heating times by microwave caused the decrease of moisture contents (Figure 1b). The sample of 56 sec treatment showed the lowest moisture contents (52.78%). It is because of the moisture in food matrix vaporize out and absorb microwave energy directly and internally and convert to heat. In microwave heating, heat is generated throughout the material and leading to faster heating rates where heat is usually transferred from the surface to the interior (Gowen et al., 2006). Hence, microwave heating is caused by water vapor pressure differences between interior and surface regions, which provide a driving force for moisture transfer (Vadivambal and Jayas, 2007).

Total plate counts (TPC)



a



b

Figure 1. Chemical properties of Khao-Mark from microwave heating (0 – 56 sec): pH values, sucrose, alcohol and acid contents (a); moisture contents (b)

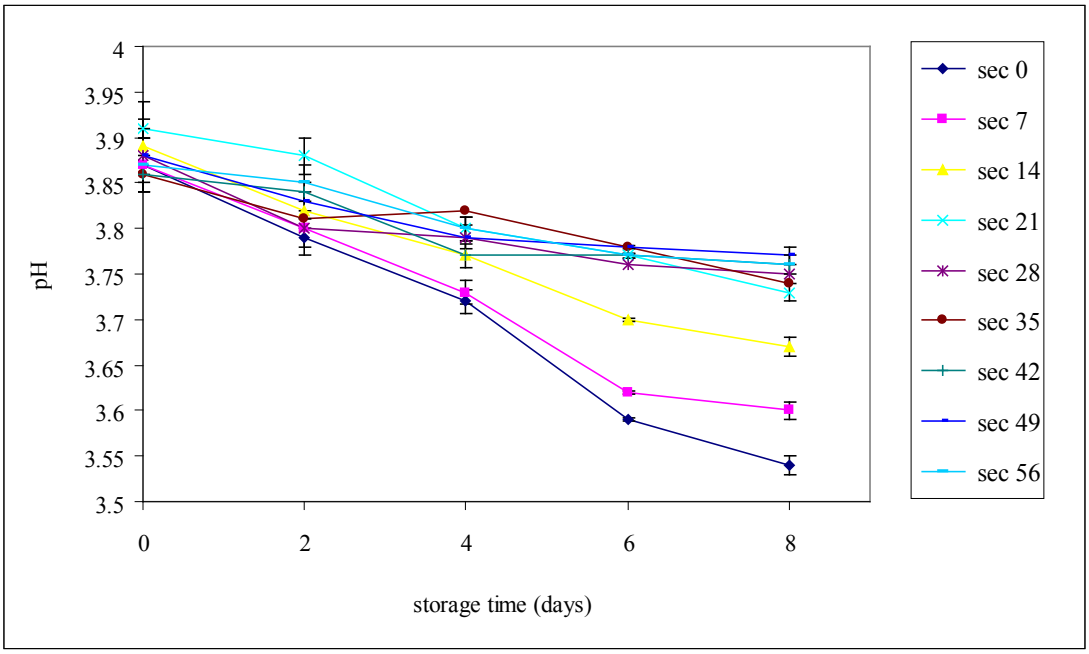
Table 1. Total plate counts (log CFU/g) of Khao-Mark from microwave heating (0–56 sec)

Heating times (sec)	0	7	14	21	28	35	42	49	56
log cfu/g [a]	7.724 ± 0.01[a]	7.724 ± 0.11[a]	7.431 ± 0.19[a]	7.176 ± 0.11[a]	7.361 ± 0.31[a]	7.279 ± 0.31[a]	7.556 ± 0.14[a]	6.612 ± 0.03[b]	6.492 ± 0.13[b]

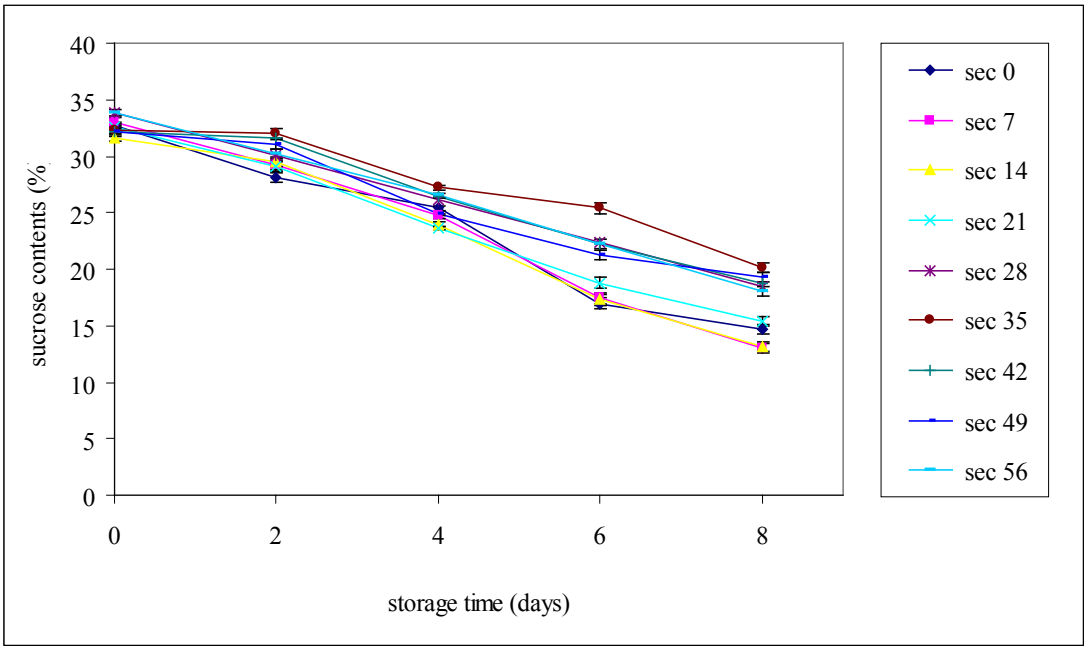
Table 2. Linking score of Khao-Mark from microwave heating (0–56 sec)

Heating time (Sec)	Appearance [a]	Odor	Taste	Texture	Overall
0	6.06 ± 0.72[a]	6.26 ± 0.5[a]	6.60 ± 0.51[a]	6.20± 0.46[a]	6.60 ± 0.42[a]
7	6.00± 0.72[a]	6.26± 0.5[a]	6.26± 0.51[a]	6.20± 0.46[a]	6.46± 0.42[a]
14	6.46± 0.72[a]	6.13± 0.5[a]	6.53± 0.51[a]	6.40± 0.46[a]	6.60± 0.42[a]
21	6.46± 0.72[a]	6.33± 0.5[a]	6.33± 0.51[a]	6.20± 0.46[a]	6.33± 0.42[a]
28	6.40± 0.72[a]	5.93± 0.5[a]	6.33± 0.51[a]	6.13± 0.46[a]	6.33± 0.42[a]
35	6.26± 0.72[a]	6.06± 0.5[a]	6.46± 0.51[a]	6.26± 0.46[a]	6.46± 0.42[a]
42	6.26± 0.72[a]	6.00± 0.5[a]	6.20± 0.51[a]	6.26± 0.46[a]	6.40± 0.42[a]
49	6.26± 0.72[a]	6.20± 0.5[a]	6.40± 0.51[a]	6.60± 0.46[a]	6.46± 0.42[a]
56	6.26± 0.72[a]	6.33± 0.5[a]	6.26± 0.51[a]	6.60± 0.46[a]	6.73± 0.42[a]

[a]Means followed by the same letters are not significantly different (P>0.05)

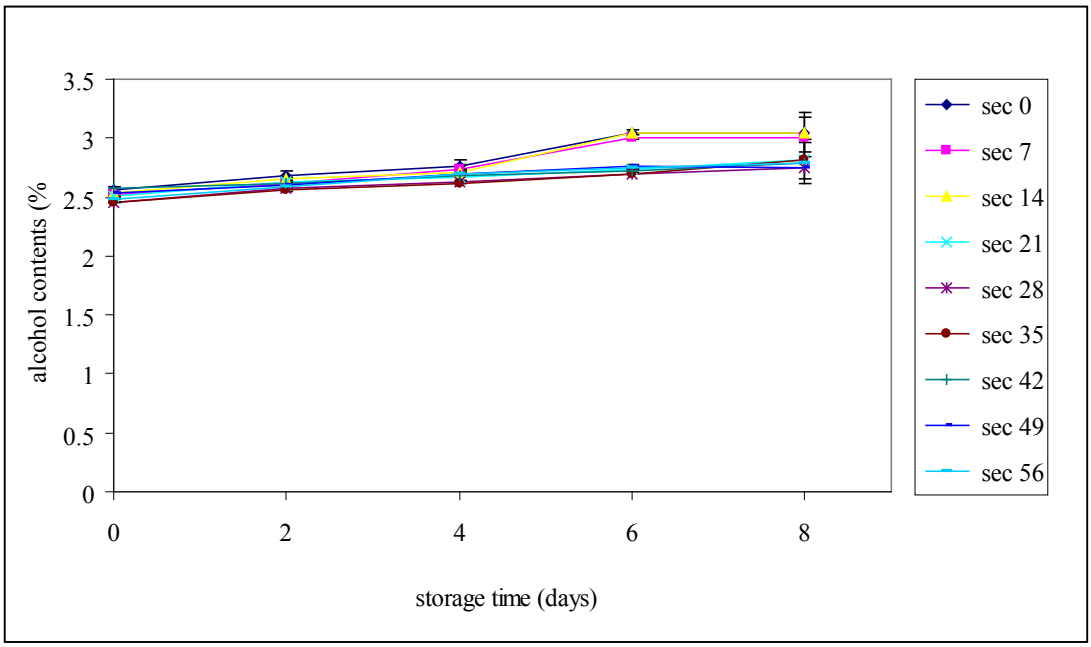


a

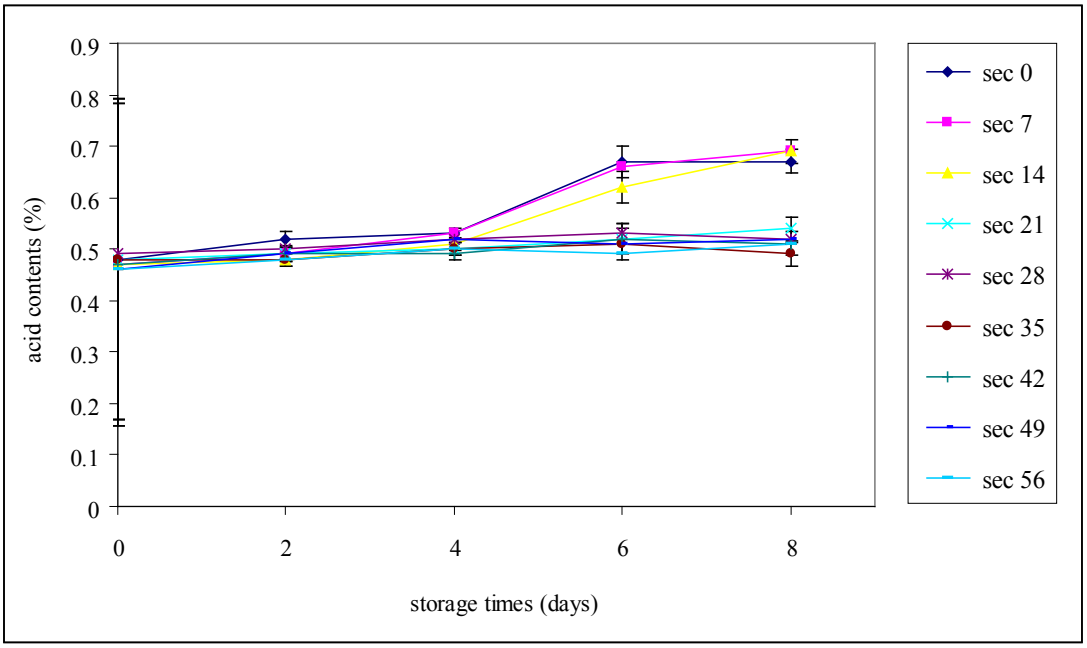


b

Figure 2. Changes of Chemical properties in Khao-Mark from microwave heating (0-56 sec) for 8 days : pH values and sucrose (a) and (b)

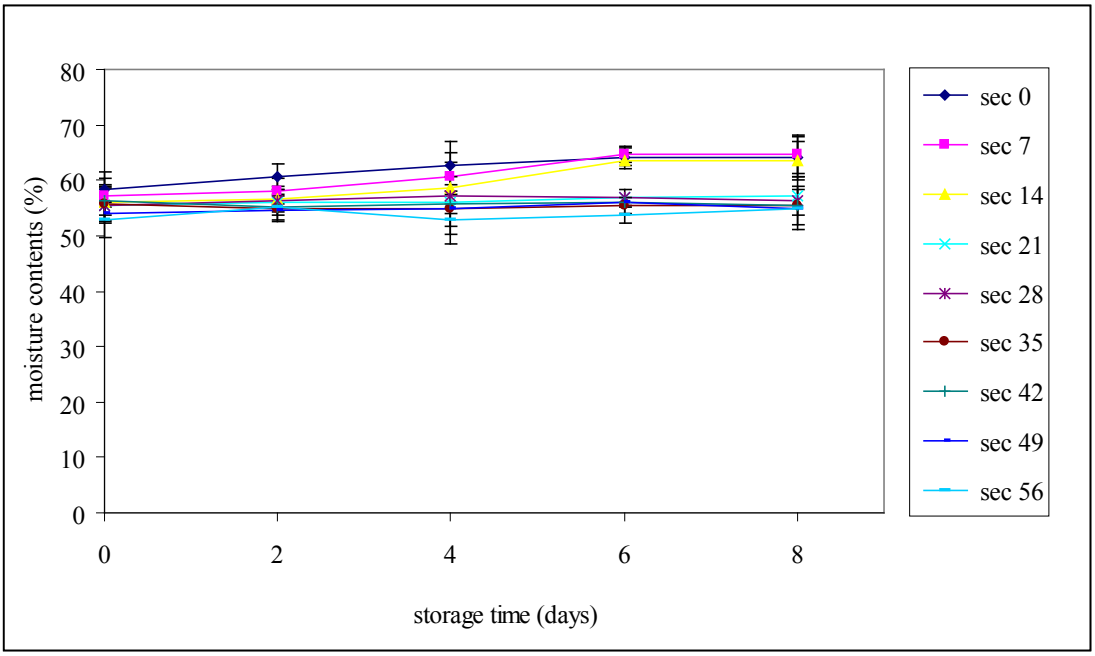


c



d

Figure 2. Changes of Chemical properties in Khao-Mark from microwave heating (0-56 sec) for 8 days : alcohol and acid (c) and (d)



e

Figure 2. Changes of Chemical properties in Khao-Mark from microwave heating (0-56 sec) for 8 days : moisture contents (e)

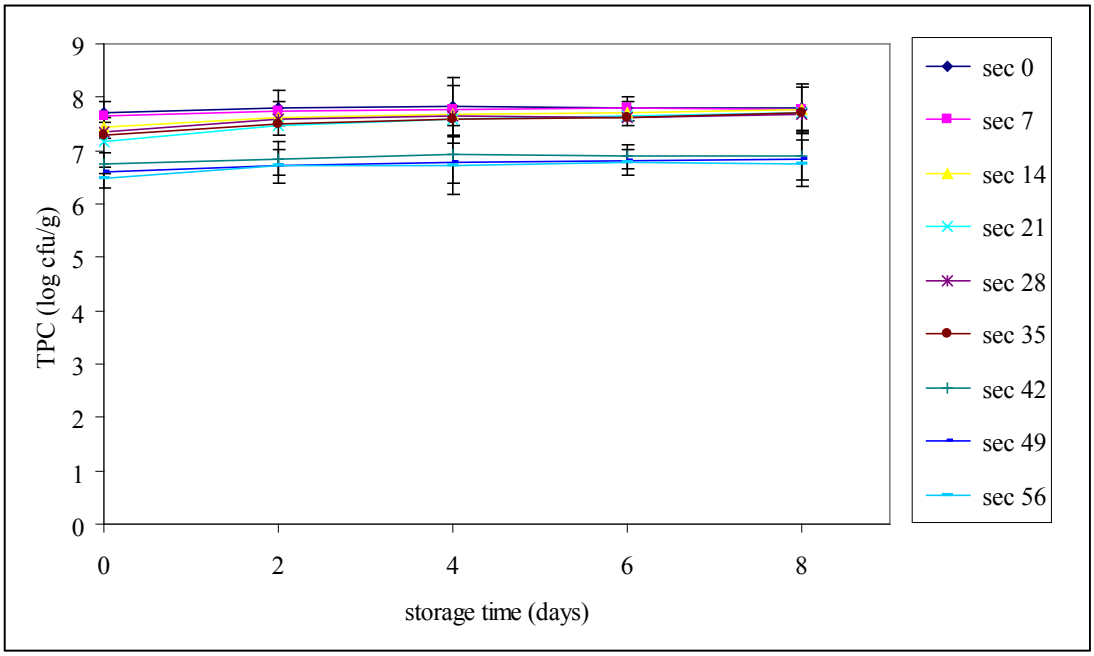


Figure 3. Changes of total plate counts in Khao-Mark from microwave heating treatment (0-56 sec) for 8 days

The TPC data showed in Table 1. The heating times from 0 – 42 sec did not affect to the number (P>0.05) until the second of 49 and 56 sec that showed significantly decrease (P<0.05). It can be observed that, the shorter heating time is not enough to destroy the cell of microorganisms that agreed with Gedikli et al. (2008) who studied the different irradiation times of microwave heating versus temperature in solution containing bacteria cell. Irradiation time for more than 45 sec was equated with 60°C temperature that related to pasteurize temperature (60°C for 30 sec) (Staff of teachers, 2003). Moreover, irradiation of microwave plays the role of cell wall structure destruction of microorganisms and then nucleic acid and protein from the cell are leakage (Dung et al., 2 007).

Sensory evaluation

Sensory attributes scores (appearance, odor, taste, texture and overall attribute) of microwave heating and non-microwave heating (0 sec) treatments were not significantly different (P>0.05) (Table 2). It shows that exposed to the irradiation, however, caused rapidly evaporated moisture from sample interior but maintain chemical components within the samples. Furthermore, the microwave heating at the short times in this trial may significantly contribute to protect the lost of product qualities such as aroma, improving better rehydration, considerable savings in energy and much shorter drying times (Maskan, 2001). Moreover, the report of Warchalewski et al. (1998) revealed that wheat grain were heated by a microwave oven for a long exposure time (180 sec), all sensory attributes was not significantly different. Lin et al. (1998) studied the sensory properties of vacuum-microwave-dried carrot slices and received satisfactory ratings for texture, odour and overall acceptability. Fathima et al. (2001) studied the effect of microwave heating on the shelf life and sensory attributes (appearance, color, odour and overall quality) of coriander (*Coriander sativum*), mint (*Mentha spicata*), fenugreek (*Trigonella foenum-graceum*), amaranth (*Amaranthus* sp.) and shepu (*Peucedanum graveolens*). Amaranth had similar scores for fresh and dried ones; however, there was significant decrease for the sensory attributes of other greens. They concluded that microwave drying was highly suitable for amaranth, moderately suitable for shepu and fenugreek and less suitable for coriander and mint. Microwave heating, in addition, is shown that its irradiation had effectively dried the samples, even though sensory scores of the dried samples are not significantly different.

Changes of chemical properties during storage times

The pH values, acid, alcohol and sucrose contents of all treatments were not significantly different (P>0.05) for early 4 days period (Figure 2). After day 4, acid and alcohol contents of 0-14 sec treatments were increased significantly while sucrose contents and pH values of these treatments were decreased significantly. The changes of chemical properties of non microwave heating treatments were the highest during storage. It revealed that moisture, acid and alcohol contents of non microwave heating treatments were significantly increased 8.91, 29.16 and 19.14%, respectively whereas sucrose contents and pH values of those treatments were decreased 55.18 and 8.53%, respectively. Moisture, acid and alcohol contents of microwave heating treatments at 56 sec were increased 3.74, 10.89 and 12.5% while sucrose content and pH were decreased 46.63 and 2.84%, respectively. The treatments of 0-14 sec showed lower sucrose contents when compared with other treatments (Figure 2b) due to short time of irradiation that were not enough for inhibit the live cell microorganisms which could utilize sucrose for growth that could be seen from the log numbers of TPC in Fig. 3 and produced high contents of alcohol. Pakdeesupaphon (1980) found that yeasts produced alpha amylase and glucoamylase for starch hydrolysis and sugar fermentation to obtain alcohol flavor and ester, while acid contents might possibility be lactic acid, which are produced by lactic acid bacteria (LAB).

The moisture contents of all treatments were not significantly different throughout early 4 days. After day 4, moisture contents of 0-14 sec treatments were slightly increased and stable from day 6–8. The reason is some kinds of microorganisms are still alive. They can hydrolyze starch by using alpha amylase and glucoamylase to provide more softness texture and to obtain succulent within samples (Pakdeesupaphon, 1980). For other reasons, syneresis which derives from retrogradation or setback phenomenon indicates that starch is heated until gelatinization and be converted from swollen starch granule to finally eruptible granule. Fragment of amylose molecule is rearranged by hydrogen bond among molecule to obtain three dimension network structures. This gel structure will protect the return of water into the structure of starch again so the exterior water is around gel starch structure (Smith, 1979).

Changes of TPC during storage times

Total plate counts of all samples were slightly increased during storage times (Figure 3). The numbers of 49 and 56 sec treatments were lower

than other samples. The results showed that the combination of the microwave heating for a proper long time and the storage at low temperature (10°C) might inhibit the growth of microorganisms. This low temperature (10°C) was suboptimum for growth of Amylomyces rouxii, Sacchromycopsis fibuligera and Hansenula anomala (Pakdeesupaphon, 1980). Similar to Yeo et al. (1990) who studied the effect of microwave heating on survivor of Staphylococcus aureus in a model system, the heating for 110 sec could inhibit microbial growth throughout storage times.

Conclusions

The usage of microwave for longer time (49–56 sec) affected on the inhibition of some microorganisms for Khao-Mark production during storage. Nevertheless, the time from 21 sec could control the changes of chemical properties. Therefore, the appropriate time for Khao-Mark production was 21 sec for saving energy and cost production.

References

AOAC International. 1990. Official Methods of Analysis of the AOAC International, (16th ed). Association of Official Analytical Chemists. USA: Arlington, VA.

Cunningham, F.E. 1978. The effect of brief microwave treatment on number of bacteria in fresh chicken patties. International Journal of Poultry Science 3 (3): 157-162.

Dreyfuss, M.S. and Chipley, J.R. 1980. Comparison of effects of sublethal microwave radiation and conventional heating on the metabolic activity of *Staphylococcus aureus*. Applied and Environmental Microbiology 39: 13-16.

Dunga, N.T.P., Romboutsb, F.M. and Nout, M.J.R. 2007. Characteristics of some traditional Vietnamese starch-based rice wine fermentation starters (men). Lebensmittel-Wissenschaft und Technologie 40: 130-135.

Fathima, A., Begum, K. and Rajalaksmi, D. 2001. Microwave drying of selected greens and their sensory characteristics. Plant Foods for Human Nutrition 56(4): 303-311.

Gowen, A., Abu-Ghannam, N., Frias, J. and Oliveira, J. 2006. Optimization of dehydration and rehydration properties of cooked chickpeas (*Cicer arietinum* L.) undergoing microwave-hot air combination drying. Trends in Food Science and Technology 17(4): 177-183.

Khalil, H. and Villota, R. 1985. Acomparative study on the thermal inactivation of *Bacillus stearothermophilus* spores in microwave and conventional heating. Proc. Fourth. Intern. Congr. Eng. Food. Esses, England: Applied Science Publishers.

Khalil, H. and Villota, R. 1989. The effect of microwave sublethal heating on the ribonucleic acids of *Staphylococcus aureus*. Journal of Food Protection 52(8): 544-548.

Lim, G. 1991. Indigenous fermented foods in South East Asia. ASEAN Food Journal 6: 83–101.

Lin, T. M., Durance, T. D. and Scaman, C. H. 1998. Characterization of vacuum microwave, air and freeze dried carrot slices. Food Research International 31(2): 111-117.

Maskan, M. 2000. Microwave/air and microwave finish drying of banana. Journal of Food Engineering 44(2): 71-78.

Maskan, M. 2001. Drying, shrinkage and rehydration characteristics of kiwi fruits during hot air and microwave drying. Journal of Food Engineering 48(2): 177-182.

Ministry of Industry. 2003. Community product standard of sweet fermented glutinous rice. Document of CPS at 162/2003. Agro product standard office, Bangkok.

Mullin, J. 1995. Microwave processing. In: New Methods of Food Preservation (Gould, G. W., ed), pp 112–134. Blackie Academic and Professional, Bishopbriggs, Glasgow

Pakdeesupaphon, S. 1980. Production of Khao-Mak by using pure culture. Master's thesis. Kasetsart University, Bangkok, Thailand.

Sabater-Vilar, M., Roel, F. M. and Fink-Gremmels, J. 1999. Mutagenicity of Commercial fermentation products and the role of citrinin contamination. Mutation Research 444: 7-16.

Sinthavalai, S. 1982. Food theory of volume 2 : Preservative principle and quality control for food. Department of Product Development, Faculty of Agro-industry, Kasetsart University, Bangkok, Thailand.

Smith, R.J. 1979. Food Carbohydrate. The AVI Publishing Co., Westort, Connecticut. 416 p.

Staff of teachers. 2003. Food Science and Technology, (4th ed). Thailand: Kasetsart University Press.

Vadivambal, R. and Jayas, D.S. 2007. Changes in quality of microwave-treated agricultural products – a review. Biosystem Engineering, 98, 1-16.

Velu, V., Nagender, A., Prabhakara Rao, P.G. and Rao, D.G. 2006. Dry milling characteristics of microwave dried maize grains. Journal of Food Engineering 74(1): 30-36.

Warchalewski, J. R., Gralik, J., Wojtasiak, R. Z., Zabielski, J. and Kusnnierz, R. 1998. The evaluation of wheat grain odour and colour after gamma and microwave irradiation. Electronic Journal of Polish Agricultural Universities 1(1): 1-11.

Walde, S.G., Balaswamy, K., Velu, V. and Rao, D.G. (2002). Microwave drying and grinding characteristics of Wheat (Triticum aestivum). Journal of Food Engineering 55(3): 271-276.

Wongpiyachon, S. 1995. Utilization of rice for wine and whisky. Master's thesis. Kasetsart University, Bangkok, Thaiand.

Yeo, C.B.A., Watson, I.A., Stewart-Tull, D. and Koh, V. 1999. Heat transfer analysis of Staphylococcus aureus on stainless steel with microwave radiation. Journal of Applied Microbiology 87:396-401.

Zhang, X., Kong, B. and Xiong, Y.L. 2007. Production of cured meat color in nitrite-free Harbin red sausage by Lactobacillus fermentum fermentation. Meat Science 77: 593-598.