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Packaging and shelf-life studies of coconut biscuits

(Kajian pembungkusan dan penyimpanan biskut kelapa)

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Key words: coconut biscuits, packaging, storage, shelf-life

Abstrak

Biskut kelapa dibungkus secara berasingan dan di dalam bungkusan 10 keping untuk keluarga. Beg yang berukuran 9 cm x 9 cm diperbuat daripada plastik jenis OPP/Q5/VMCP, OPP/PE dan PP (setebal 0.04 mm) digunakan untuk bungkusan berasingan sementara 'gusseted bags' daripada OPP/CPP digunakan untuk bungkusan keluarga. Bahan pembungkus ini dibandingkan dengan beg plastik jenis PP yang setebal 0.07 mm (pak pengusaha). Plastik lapisan kertas/PE/Al/PE digunakan sebagai kawalan untuk bungkusan berasingan. Semua bungkusan dipateri dengan haba kecuali beg PP 0.07 mm yang bahagian hujungnya dilipat beberapa kali dan dikokotkan. Tempoh simpan ditentukan dengan cara penilaian deria dan dikira dengan menggunakan formula. Perubahan mutu semasa penyimpanan diawasi dengan mengukur pertukaran lembapan dan ketengikan (sebagai nilai peroksid dan peratus asid lemak bebas). Keputusan menunjukkan bahawa pembungkus jenis PP 0.04 mm dan OPP/PE hanya sesuai digunakan bagi penyimpanan selama 60 hari pada suhu 25 ± 3 °C dan kelembapan bandingan 60–80% sementara OPP/Q5/VMCP memberi tempoh simpan selama 115 hari. Bungkusan untuk keluarga dengan menggunakan OPP/CPP memberi tempoh simpan yang melebihi 145 hari berbanding dengan 126 hari bagi PP 0.07 mm.

Abstract

Coconut biscuits were packed both as single pieces and as 10-piece family packs. Pouches of 9 cm x 9 cm made from OPP/Q5/VMCP, OPP/PE and PP (0.04 mm thickness) were used for the single packs while gusseted bags made from OPP/CPP were used for the family packs. These were compared with PP pouches of 0.07 mm thickness (producer's pack). Paper/PE/Al/PE in unit package form was used as a control. All packs were heat-sealed except the PP 0.07 mm pouches. The ends were folded several times and stapled. Shelf-life was determined both organoleptically and estimated by calculation. The changes in quality during storage were monitored by measuring changes in moisture content and rancidity (as measured by peroxide value and free fatty acids). The results indicated that PP 0.04 mm and OPP/PE were only suitable up to 60 days of storage at 25 ± 3 °C and 60–80% relative humidity while OPP/Q5/VMCP gave a storage life of about 115 days. The family packs of OPP/CPP gave a storage life of more than 145 days compared with 126 days for PP 0.07 mm.

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Introduction

The coconut biscuit, locally known as 'biskut kelapa', is a popular snack in Malaysia. A chemical analysis of the fresh product from a local supplier shows that it contains about 2% moisture, 10% protein, 14% fat, 30% total sugar (as invert sugars), 35% starch and 2% fibre. Its eating quality appeals to all age groups. Given proper packaging and attractive presentation, this product has good potential for the local as well as export markets.

Basically, the biscuit is made from grated coconut (40–50%), wheat flour, sugar, salt and some water as the binding agent. The mixture is moulded into circular discs of 6.5 cm diameter and 1–1.15 cm thickness. It is then baked in the oven until brown, crispy and crunchy. Smaller sizes are also available. Some producers substitute the flour with ground bread crumbs and margerine or egg is used as the binding agent. Sometimes, ground maize is also incorporated in its formulation.

The product is usually marketed either as a family pack of 10 pieces or sold loosely as single pieces. The packaging materials commonly used for family packs are polypropylene (PP)and polyethylene (PE) films of varying thickness, or polyvinyl chloride (PVC) moulded trays with sealed plastic overwraps. The packs are sealed either by heat or flame, or closed by folding back the open ends several times and securing it with staples. The loose pieces are normally packed in glass or PVC bottles with screw caps, each containing 20–30 pieces.

The common problems associated with this product during marketing are the loss of crispiness, rancidity, breakage, 'dusting' and poor presentation. The objectives of this study are to determine the shelf-life of the product using the common packaging system practised by the processors and to investigate the use of other packaging materials and forms.

Materials and methods

Freshly baked products were obtained from a local supplier in Batu Pahat, Johor. Packaging was done at the factory using packaging materials and package forms as indicated in *Table 1*.

For the unit pack, a single piece of coconut biscuit weighing 25 g was placed in a 9 cm x 9 cm pouch and for the family pack, 10 pieces weighing 250 g were packed in a 17.5 cm x 15 cm gusseted bag. All the packs were heat-sealed except the producer's family pack, the open end of which was folded several times and secured with staples.

Two methods were used to determine the shelf-life of the product. In the first method, the product was evaluated organoleptically at periodic intervals. A 9-point hedonic rating scale was used by a panel of 20 people to indicate their preferences for criteria such as texture, taste and overall acceptability. A score of 9 indicated 'like extremely' and a score of 1 'dislike extremely' while a score of 5 meant 'neither like nor dislike'. On the other hand, the panelists indicated either 'Yes' or 'No' for the presence of rancidity in the product. The percentage of panelists indicating positively for the presence of rancidity was plotted against storage time *(Figure 1* and *Figure 2)*. Changes in these attributes were followed chemically in terms of moisture content for texture and peroxide value (A.O.C.S. 1964) and free fatty acids (as lauric acid) for rancidity (Cock and Rede 1966). The storage study was carried out for 6 months under laboratory conditions [approximately 25 ± 3 °C and 60-80% relative humidities (r.h.)].

The second method involved calculating the shelf-life of the product based on its sorption isotherm. A known weight of the product was placed in weighing bottles which were exposed to different saturated salt solutions of known r.h. ranging from 8% to 85% at room temperature (25 ± 3 °C) (Labuza 1984). The samples were weighed at regular intervals until equilibrium was

Table 1. Properties of packaging materials and packaging forms

Packaging material	Abbreviation	Combined thickness (µ)	Oxygen transmission rate (cc/m^2)*	Water vapour permeability rate (g/m^2)**	Package form
Oriented polypropylene/Q5/vapour metallised cast polypropylene (Totai Co. Ltd., Japan)	OPP/Q5/VMCP	55	3	1.0	Unit pack
Oriented polypropylene pack laminated with polyethylene	OPP/PE	55	1 000	5.9	Unit pack
Polypropylene	PP 0.04 mm	40	3 000	7.0	Unit pack
Paper/polyethylene/aluminium/polyethylene	Paper/PE/Al/PE	45/15/40/30 (g/m^2)	0	Theoretically 0 (control)	Family pack
Polypropylene (producer's pack)	PP 0.07 mm	70	1 000	4.0	Family pack
Oriented polypropylene/cast polypropylene	OPP/CPP	60	760	5.0	Family pack

Note: The unit for combined thickness of paper/PE/Al/PE is expressed in g/m^2 according to the specifications given by the supplier.
*For 24 h at 20 °C, 100% r.h.
**For 24 h at 40 °C, 90% r.h.

reached. The moisture contents of the product (on wet basis) at different r.h. were then determined and changes in the physical nature of the product were observed. The equilibrium moisture contents were plotted against equilibrium r.h. to obtain the sorption isotherm *(Figure 3)*. From this curve, the maximum allowable moisture content, initial equilibrium r.h. and maximum allowable r.h. were obtained. According to Heiss (1970), the shelf-life of a product could be calculated if the amount of moisture permeating the package under normal conditions, as well as the filling weight and humidity gradient from the exterior to the interior of the package are known. Using such information, Hanousek and Hassan (1970) developed a simplified empirical formula to calculate the shelf-life as shown below.

$$t = \frac{3.83 \times 10^4 (M_a - M_i) W}{p \times A (Q_2 - Q_1)} \log \frac{(90 - Q_1)}{(90 - Q_2)}$$

where t = shelf-life of the packed product (days),
p = permeability of the packaging material to water vapour at 38 °C, 90% r.h. (g/m^2, 24 h),
M_i = initial moisture content of product (%),
M_a = maximum allowable moisture content of product (%),
W = weight of product inside the package (g),
A = effective surface area of the package (cm^2),
Q_1 = equilibrium r.h. for initial moisture content of product (%),
Q_2 = equilibrium r.h. for maximum allowable moisture content of product (%).

This formula was used to estimate the shelf-life of coconut biscuits in this study.

Results and discussion

Organoleptic acceptance

Products packed in paper/PE/Al/PE which had the lowest water vapour and oxygen transmission rate *(Table 1)* showed good organoleptic qualities throughout the storage study. On the other hand, a general deteriorating trend in texture and taste was observed for products in OPP/PE and PP 0.04 mm (unit pack, *Figure 1*) and PP 0.07 mm (family pack, *Figure 2*). The loss in textural and organoleptic qualities was due

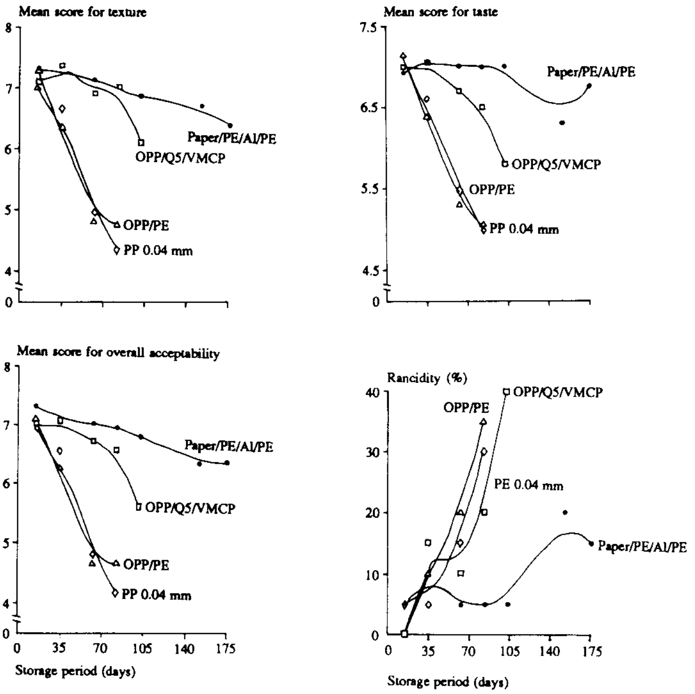

Figure 1. Effects of storage time on the acceptability of coconut biscuit in unit pack

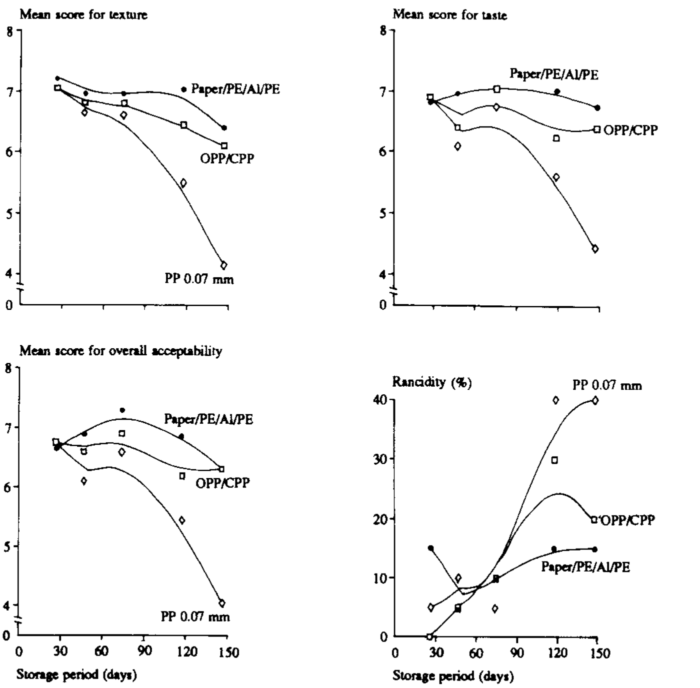

Figure 2. Effects of storage time on the acceptability of coconut biscuits in family pack

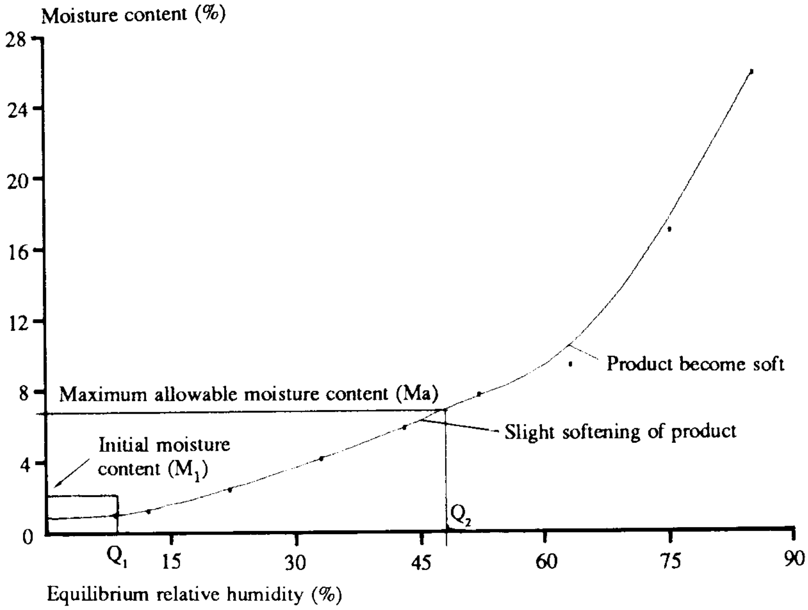

Figure 3. Sorption isotherm of coconut biscuit at 25 ± 3 °C

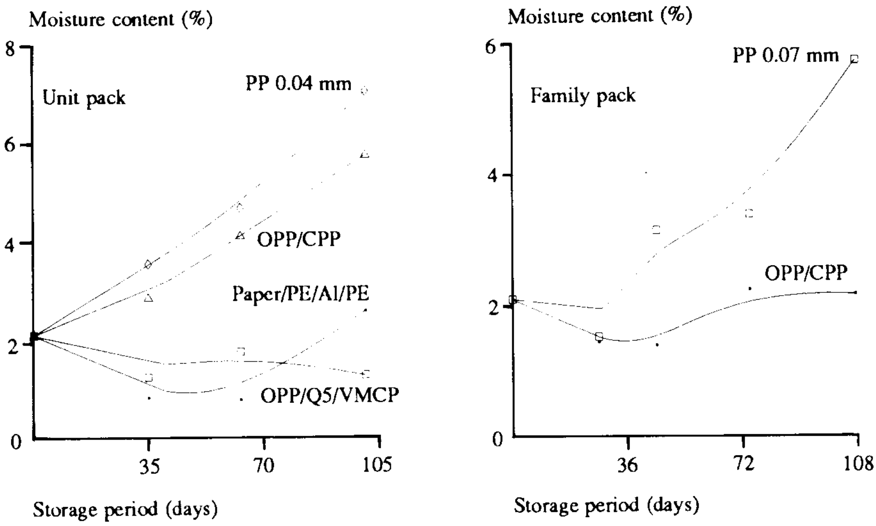

Figure 4. Changes in moisture content during storage

to an increase in moisture content and rancidity as shown in *Figure 4* and *Figure 5*.

The freshly baked coconut biscuits had low moisture content and high fat and sugar contents. Coconut oil has a high proportion of short- and medium-chain fatty acids which are more susceptible to breakdown. As such, the problem of moisture ingress, leading to physical, chemical and thus organoleptic deterioration is expected in the case of unsuitable packaging materials. The deterioration in organoleptic qualities is mainly due to softening of the product and

Table 2. Observed and calculated shelf-life of coconut biscuits

Packaging material	Shelf-life (days)	
	Observed	Calculated
Unit pack		
Paper/PE/Al/PE (control)	>180	α
OPP/Q5/VMCP	115	239
OPP/PE	64	40
PP 0.04 mm	60	34
Family pack		
OPP/CPP	>145	147
PP 0.07 mm	126	184

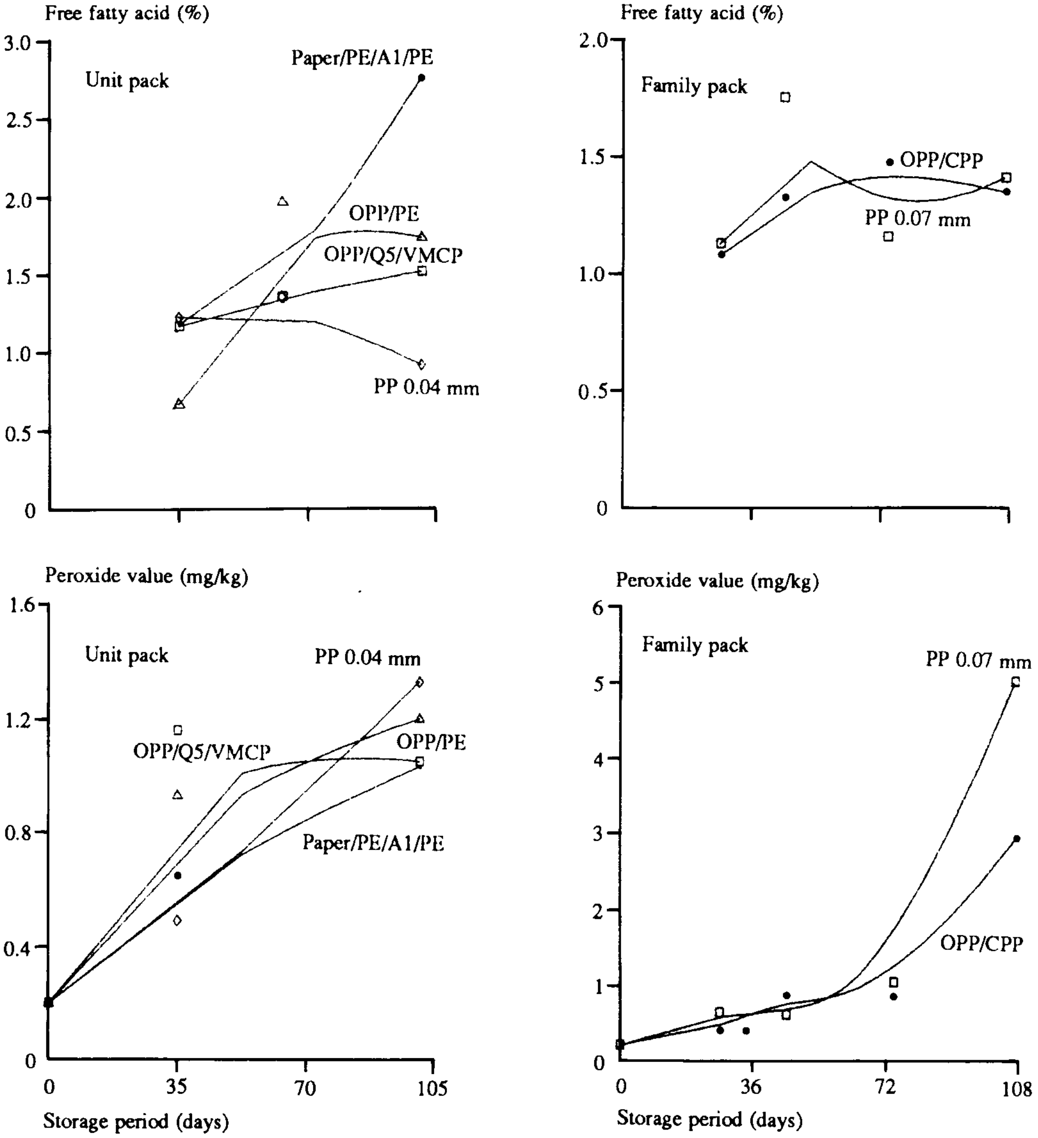

Figure 5. Changes in free-fatty acids and peroxide values during storage

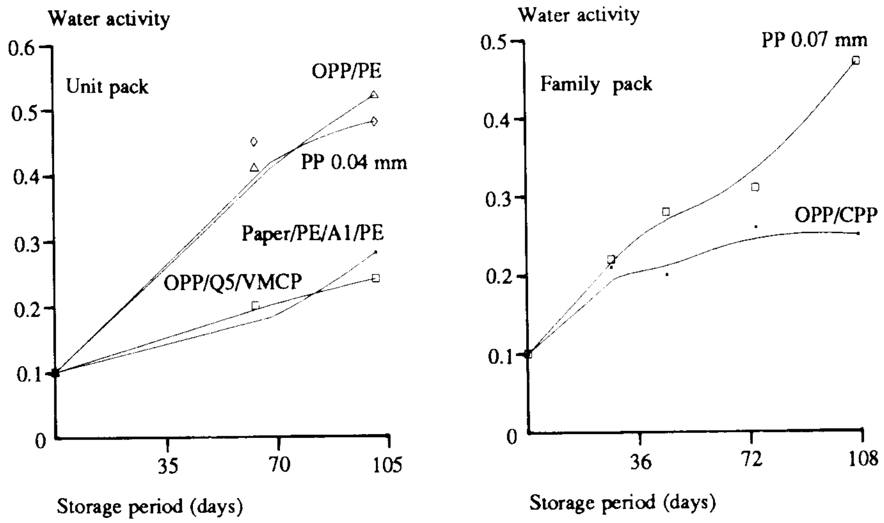

Figure 6. Changes in water activity during storage

the development of rancidity.

Some changes in moisture content and water activity (A_w) of samples were observed during storage (*Figure 4* and *Figure 6*). Among the unit packs, the increase in moisture was the highest for PP 0.04 mm followed by OPP/PE, OPP/Q5/VMCP and paper/PE/Al/PE. In the case of family packs, the gain in moisture was higher in PP 0.07 mm than in OPP/CPP. Similar patterns were also observed for both unit and bulk packs where changes in A_w were concerned.

Shelf-life

Taking a mean score of five as the lowest limit of overall organoleptic acceptability, the observed shelf-life of the product in the various packaging materials is compared with that of the calculated shelf-life (*Table 2*).

The calculation method is a rapid way of estimating the shelf-life of a product whose moisture sorption properties are known in situations where elaborate storage studies cannot be carried out. This method considers only the physical deterioration of the product as a result of moisture uptake and not the changes in organoleptic properties. As such, the derived shelf-life values are just estimates which will enable the producer to select a suitable packaging material.

In this study, the sorption isotherm and the storage trials were carried out under laboratory conditions (approximately 25 ± 3 °C and 60–80% r.h.) while the water vapour permeability rates of the various packaging materials for the calculation of shelf-life were obtained at 38 °C and 90% r.h. Theoretically, had the temperature and r.h. of the storage study been in unison with those at which water vapour permeability rates were derived, the observed shelf-life values could have been lower or vice-versa. This is because the permeability of a plastic film generally increases with temperature (Hennessy et al. 1967). According to Labuza (1984), the moisture sorption isotherm is also dependant on temperature. Hence if a product in a sealed package is stored at a higher temperature for long periods, the A_w will increase even if the moisture content within remains unchanged. With such an increase in temperature and the subsequent A_w, any other reactions that can lead to quality loss will also be accelerated.

Besides the shelf-life of the packaged products being influenced by the nature of the products, atmospheric conditions during storage, and overall resistance of the package to the passage of moisture, atmospheric gases and odours, it is also affected by the size of the package in relation to its cubic capacity (Paine 1969). All factors being constant, the ratio of weight to effective surface area, as derived from the formula, is higher for family packs indicating that they have a higher shelf-life. This is also substantiated by the observed shelf-life values *(Table 2)*.

The family packs had an observed shelf-life of >145 days for OPP/CPP and 126 days for PP 0.07 mm (producer's pack). Even though the producer's bulk package could give a shelf-life of 4 months, the use of staples is not encouraged as it poses potential safety hazards.

If heat-sealed, both PP 0.07 mm and OPP/CPP could be used for family packs up to 4–5 months. However, OPP/CPP would be a better choice as it provides better printing effects and presents less problems during sealing. A secondary pack is not required for this form of packing as the product is quite firm within the packet. The market is quite limited for family packs and once the package is opened, the remaining pieces will require another container for storage until further consumption.

For unit packaging, either OPP/PE or PP of 0.04 mm thickness (heat-sealed) could be used. However, OPP/PE has the advantage of providing better printing effects and thus enhances consumer attraction over PP. In terms of sealing, PP tends to melt easily if the temperature is not carefully monitored, thus giving poor seals which, in turn, will affect the keeping quality of the product. For export purposes where longer shelf-life is required, paper/PE/Al/PE and OPP/Q5/VMCP could be used. These are opaque and more expensive, but have good barrier properties and also better consumer appeal. A secondary package such as a box is required for the unit packs to facilitate display while providing some rigidity to prevent breakage. The quantity per box will depend on the targeted market. This form of packaging is better as any unconsumed biscuits can still be protected against deterioration after the box is opened. It is more hygienic, presentable and could be used for distribution to a wider market such as school canteens, coffee shops, bread vendors and retail sundry shops.

Conclusion

The experiment shows that both PP 0.04 mm and OPP/PE are suitable packaging materials for unit packaging if a shelf-life of less than 2 months is required. For family packs, OPP/CPP provides a shelf-life of >145 days compared with 126 days for the producer's packaging material, PP 0.07 mm, with staple-sealing. The loss of quality during storage of coconut biscuits can be attributed to softening of texture due to uptake of moisture and to development of rancidity.

References

A.O.C.S. (1964). *Official and tentative method of the American Oil Chemical Society* 2nd ed. Vol. 1, p. 8–53. Chicago: A.O.C.S.

Cock, L. V. and Rede, G. V. (1966). *Lab. Handbook for oil and fat analyst* London: Academic Press, Inc.

Hanousek, J. and Hassan, M. H. (1970). Protective packaging of biscuits in Malaysia, Mimeograph Report No. 29, Food Tech. Res. and Dev. Centre, Ministry of Agric. Malaysia

Heiss, R. (1970). Influence of packaging on the shelf life of foodstuffs. In *Principles of food packaging* Munich: FAO of the United Nations

Hennessy, B. J., Meed, J. A. and Stenning, T. C. (1967). *The permeability of plastic films* London: The Elastic Institute

Labuza, T. P. (1984). Moisture sorption. In *Practical aspects of isotherm measurement and use* St. Paul, Minnesota: Am. Ass. of Cereal Chem.

Paine, F. A. (1969). *Fundamentals of packaging*. London, Glasgow: Blackie and Son Ltd.

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