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Packaging and shelf life of high fibre high protein coconut-oat snack

(Pembungkusan dan penyimpanan snek kelapa-oat berserat dan berprotein tinggi)

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Key words: coconut-oat snack, packaging, storage, shelf life

Abstrak

Snek kelapa-oat yang baru diproses dibungkus di dalam dua jenis bungkusan iaitu OPP/PP (dengan ketebalan 20 µ:40 µ) dan OPP/Al/PP (dengan ketebalan 20 µ:7 µ:50 µ). Bungkusan tersebut tidak dicetak dan telah dibentuk menjadi beg berukuran 12.5 cm x 11.5 cm. Setiap bungkusan diisi dengan empat keping snek dengan anggaran berat 40 g dan dipateri dengan haba. Hasilan disimpan pada suhu 28 ± 5 °C dengan kelembapan bandingan 70–80%. Tempoh simpan dan perubahan mutu semasa penyimpanan ditentukan dengan menggunakan kaedah penilaian deria, analisis kimia, ujian mikrobiologi dan penyerapan isoterma. Bahan pembungkus jenis OPP/Al/PP sesuai digunakan bagi penyimpanan snek kelapa-oat selama 6 bulan berbanding dengan OPP/PP yang hanya bertahan selama kurang daripada 4 bulan.

Abstract

Freshly processed coconut-oat snack was packed in two types of packaging material. The unprinted pouches of 12.5 cm x 11.5 cm were made of OPP/PP with thickness of 20 µ:40 µ and OPP/Al/PP with thickness of 20 µ:7 µ:50 µ . Each pouch was filled with four pieces of snack of approximately 40 g of total weight and was heat-sealed. Samples were stored at 28 ± 5 °C with relative humidity of 70–80%. Shelf life studies and quality changes during storage were determined by using organoleptic, chemical analysis, microbiological tests and sorption isotherm methods. The OPP/Al/PP was suitable to be used for storage of coconut-oat snack for 6 months compared to OPP/PP, which could only keep the product for less than 4 months.

Introduction

Snack food includes a very wide range of products. Since the end of World War II, snack food has become a very important part of the daily diet in most of the developed countries. However, because of its high salt and fat contents, it has battled the junk food image for a long time (Wang 1997). In recent years, consumers are placing more and more emphasis on healthier lifestyle and eating habits. As a result, they are demanding more nutritious and healthier snacks (Anon. 1997).

Coconut-oat snack contains 20.5% total dietary fibre and 13.3% protein (Hasimah 2001). It is a “high fibre” and “high protein”

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product based on the definition of Codex Alimentarius draft table of conditions for nutrient contents, whereby the minimum content of total dietary fibre and protein are 6% and 10% respectively for solids (Codex Alimentarius Commission 2001). According to Anderson et al. (1990), high fibre, high carbohydrate diets, including foods with a low glycemic index, have been associated with the prevention and treatment of diseases such as coronary heart disease and diabetes. Nevertheless, the level of oat bran in commercial baked products is usually low, possibly because bran adversely affects product texture compared to original formulations (Hudson et al. 1992).

The traditional materials that have been used for biscuit packaging are the regenerated cellulose film (RCF) coated with either low density polyethylene (LDPE) or poly vinyl chloride/ poly vinylidene chloride (PVC/PVdC) copolymer, and often with a layer of glassine in direct contact with the product if it contains fat. However, in recent years, this combination of materials has been replaced to a large extent by oriented polypropylene (OPP), either as a plain or pearlized OPP film, coextruded OPP film or acrylic-coated on both sides. Plain OPP film is economical but generally requires a heat seal coating on the sealing side to improve sealability (Gordon 1993).

The common problems associated with snacks during storage are rancidity, loss of crispiness, colour and also breakage. The oil in the desiccated coconut and shortening which is used as ingredient in the snack can cause rancid taste when the product is not properly packed or not using the suitable packaging materials. The presence of light and oxygen around the product will also accelerate the rancidity process (Heiss 1970).

The role of packaging is to maintain the quality or state of the food not only at the beginning of the shelf life but also to extend the product shelf life. Deterioration of product texture is usually caused by water vapour passing through the packaging materials into the product and also due to pinholes and imperfect seals. This problem can be reduced by the use of good and suitable packaging materials, which have low permeability to water vapour and oxygen as both these factors, are responsible for texture deterioration. Therefore, the objectives of this study were to determine suitable packaging material for the high fibre high protein coconut-oat snack, and the product shelf life, and to study the physical, chemical and microbiological changes during storage. From this study, suitable packaging material for this product and also products of similar type could be recommended.

Materials and methods

Preparation of product

High fibre high protein coconut-oat snack was produced at the Bakery Processing Unit of MARDI. The product was made from desiccated coconut, oat fibre, oat bran, flour, shortening, sugar, salt (commercially available) and water as the binding agent. The dough (720 g) was spread onto an ungreased tray of 67 cm x 25 cm x 1 cm and cut into pieces of 8.3 cm x 4.2 cm. It was baked in a preheated rotary oven at 110 °C for 55 min, after which the product was removed from the oven and allowed to cool. Upon cooling, the product was then removed from the trays and packed in pouches of 12.5 cm x 11.5 cm.

Packaging and storage

The packaging material was prepared at the Packaging Laboratory of MARDI. Samples were packed in unprinted pouches of 12.5 cm x 11.5 cm made from oriented polypropylene/aluminium/polypropylene (OPP/Al/PP) of 20 µ:7 µ:50 µ thickness and oriented polypropylene/polypropylene (OPP/PP) of 20 µ:40 µ thickness. Four pieces of sample of approximately 40 g of total weight were put into each bag and were heat-sealed. The samples were kept at ambient temperature (approximately 28 °C; 70–80% RH). Samples were taken at monthly intervals for chemical, microbiological and sensory evaluation. Properties of the packaging materials used in this study are indicated in *Table 1*.

Organoleptic evaluation

Organoleptic evaluation of coconut-oat snack was carried out by using a 7-point hedonic rating scale where 25 panellists were asked to evaluate the colour, taste, odour, texture and overall acceptability of the product. A score of 7 indicated "like very much," a score of 1 indicated "dislike very much" while a score of 4 meant "neither like nor dislike". Panellists were also asked to indicate if they could detect rancidity in the product during each organoleptic evaluation.

Chemical analyses

Free fatty acid (FFA) of the stored sample was determined according to the method of Pearson (1976) while peroxide value (PV) of sample was determined according to AOCS (1975). Moisture content was analysed throughout the storage period according to the method of Pearson (1976). Analyses were done in duplicates.

Sorption isotherm

Sorption isotherm was analysed according to the method of Labuza (1984). A 10-g sample of the product was placed in weighing bottles, which were exposed to different saturated salt solutions of known relative humidity ranging from 11–93% at room temperature (28 ± 5 °C). The samples were weighed at regular intervals until equilibrium was reached. The moisture contents of the product (on wet basis) at different relative humidity were determined in duplicate and the physical changes of the product observed. Sorption isotherm curve was obtained by plotting equilibrium moisture content of the product at different relative humidity against the corresponding equilibrium relative humidity. From this curve, the initial equilibrium relative humidity and critical equilibrium relative humidity were obtained.

Water vapour permeability rate

Water vapour permeability rate of OPP/PP was measured by using TNO/PIRA direct reading Water Vapour Transmission Rate meter (PIRA/United Kingdom TNO/PIRA – 220V 50Hz 1 phase AC) according to the manufacturer's instructions. The unit of water vapour permeability rate was directly read in gramme per metre square for 24 hours at 38 °C and relative humidity of 90%.

Microbiological analysis

A 10-g sample of coconut-oat snack from each type of packaging material was homogenized with 90 mL Ringers (Ozoid, England) solution using a Seward Stomacher

Table 1. Properties of packaging materials

Packaging material	Abbreviation	Thickness (μ)	Oxygen transmission rate* (cc/m^2)	Water vapour permeability rate* (g/m^2)
Oriented Polypropylene/ Polypropylene	OPP/PP	20:40	760[a]	5.0
Oriented Polypropylene/ Aluminum/ Polypropylene	OPP/Al/PP	20:7:50	0[b]	Theoretically 0[b]

*For 24 h at 30 °C, 65% RH
Source: [a]Kanaemichi (1990)
[b]Wiley (1986)

Lab Blender (Model 400) for 1 min. The suspension was held for 30 min to allow the larger particles to settle. Appropriate serial dilutions were made and 1 mL of appropriate decimal dilutions was poured on plate using total plate agar (Ozoid, England) and potato dextrose agar (Ozoid, England) to determine total viable count, yeast and mould count respectively. Microbial colony was counted after 48 hours of incubation at 37 °C for TPCA and 3 days at 25 °C for PDA. Standard microbiological procedures were used for the detection of *Coliform, Staphylococcus aureus* and *Salmonella* sp. only in the fresh samples to determine the initial quality of the snacks (ICMSF 1978). Water activity was determined at 30 °C with a Novasina AG/Switzerland Water Activity Measuring System model Aw-Centre/Aw-Box Cat. No. 0253-201.

Statistical analysis

For data analyses, the SAS programme was used (SAS Institute 1985). The values obtained were subjected to analysis of variance (ANOVA) and tested using the Duncan Multiple Range Test for different packaging materials and storage periods (Gomez and Gomez 1984).

Results and discussion

Organoleptic evaluation

Organoleptic quality was determined based on colour, odour, texture, taste and overall acceptability. There were no significant differences ($p > 0.05$) in colour and odour of coconut-oat snack packed in different packaging materials during storage *(Figures 1a–1b)*. On the other hand, there were significant differences ($p < 0.05$) between different packaging materials for texture, taste and overall acceptability of coconut-oat snacks during storage *(Figures 1c–1e)*.

A general deteriorating trend in texture and taste were observed for product packed in OPP/PP upon storage. The loss in texture and organoleptic qualities were due to an increase in moisture content and rancidity as supported by results of moisture content and peroxide value (*Figures 2* and *3* respectively). Panellists started to detect rancidity in OPP/PP sample after 4 months of storage. Termination of the product shelf life studies was due to the result of organoleptic evaluation. The OPP/PP of 20 μ:40 μ thickness could give a shelf life of less than 4 months compared with OPP/Al/PP (20 μ:7 μ:50 μ) which could give a shelf life for 6 months.

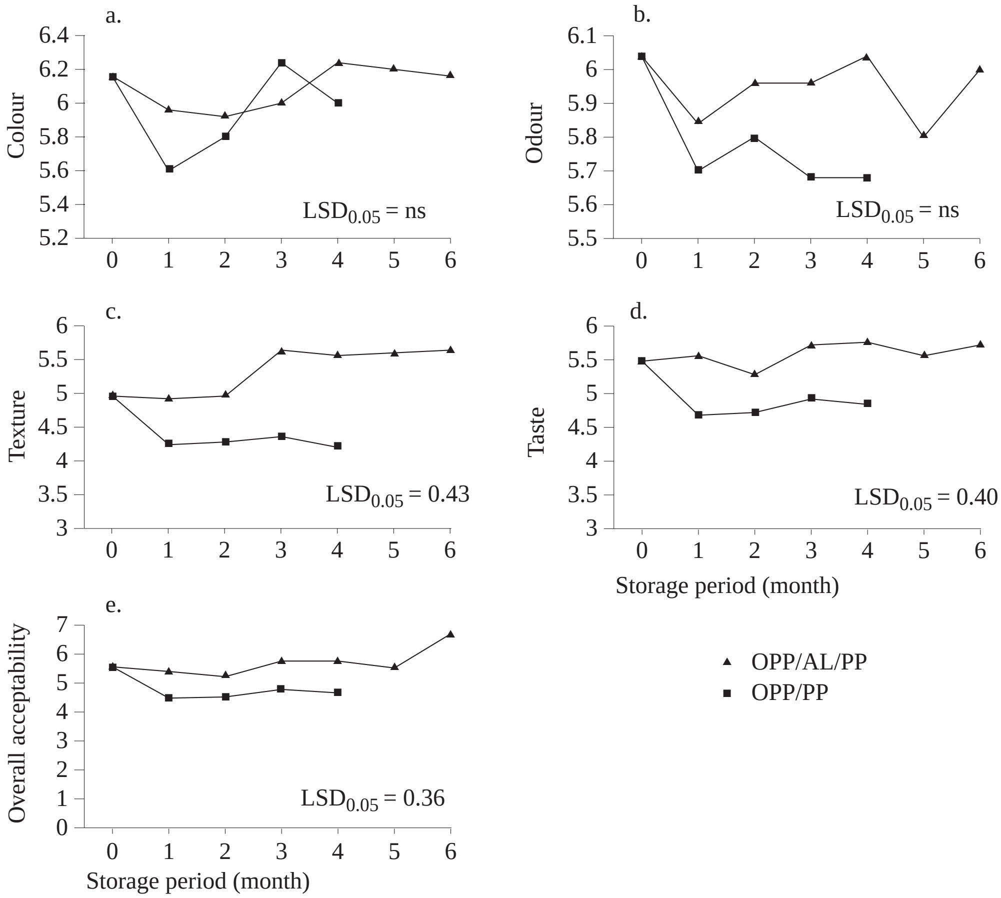
Products packed in OPP/Al/PP showed higher scores for odour, texture, taste and overall acceptability throughout the storage period. This is because the OPP/Al/PP had zero rate of water vapour permeability and oxygen transmission (theoretically). This would prevent the product from absorbing water vapour and oxygen and consequently becoming moist, less crispy and rancid. This is the main factor to consider to maintain the quality of product.

Free fatty acid and peroxide value

The FFA value in coconut-oat snack using different packaging materials showed significant difference ($p < 0.05$) after 3 months of storage *(Figure 4)*. At the early stages of storage, the FFA value of the sample was 0.35% and this subsequently increased to 0.52% for OPP/PP and 0.41% for OPP/Al/PP after 6 months of storage.

Besides that, PV was also analysed to assess the rancidity of the stored products. There were significant differences ($p < 0.05$) of PV in the samples packed using different packaging materials only after 3 months of storage *(Figure 3)*. The PV in the coconut-oat snack was not detectable earlier than that. However, both samples packed in different packaging materials had PV below 5 mEq/kg throughout the storage period. Egan et al. (1981) reported that fresh oil usually has PV well below 10 mEq/kg. According to Augustine and Chong (1986), a PV greater than 10 mEq/kg indicates that the fat has undergone a substantial degree of oxidation.

However, panellists only detected rancidity of the sample packed in OPP/PP



Figures 1(a)–1(e). Effects of different packaging materials on colour, odour, texture, taste and overall acceptability of coconut-oat snack during storage at 28 ± 5 °C

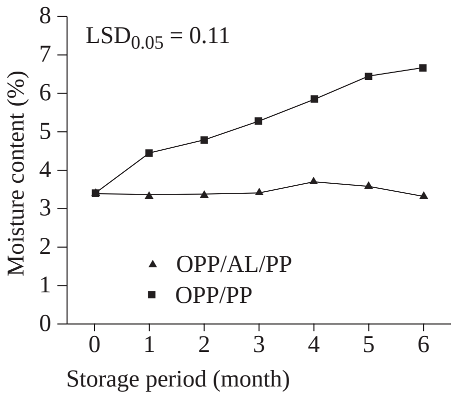


Figure 2. Effect of different packaging materials on moisture content of coconut-oat snack during storage at 28 ± 5 °C

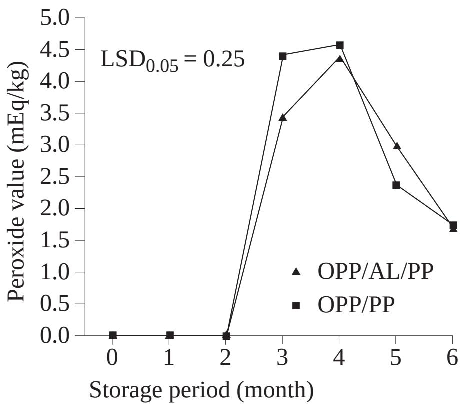


Figure 3. Effect of different packaging materials on peroxide value of coconut-oat snack during storage at 28 ± 5 °C

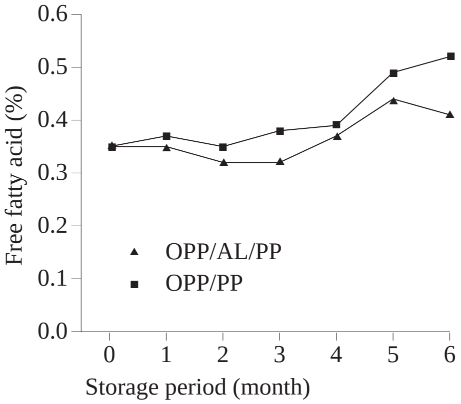


Figure 4. Effect of different packaging materials on free fatty acid value of coconut-oat snack during storage at 28 ± 5 °C

during organoleptic evaluation after 4 months of storage whereby the PV was 4.39 mEq/kg. This result was contrary to that reported by Egan et al. (1981) and Augustine and Chong (1986). This could be due to the type of fat used and also the system studied here was fat in combination with other ingredients in a processed product, as opposed to fat or oil by itself.

The result also indicated that PV decreased after 4 months of storage *(Figure 3)*. This is because lipid oxidation is unstable with increasing moisture content (Katherine and Theodore 1992). The increment of FFA and PV throughout 6 months of storage was due to fat containing ingredients used in the snack. The fat content in the freshly baked coconut-oat snack was 23.2% (Hasimah 2001). Desiccated coconut used in the snack contains coconut oil and this has a high proportion of short and medium-chain fatty acids. These fatty acids are susceptible to breakdown and contribute to lipid oxidation and also the development of rancid flavours during storage (Smith et al. 1986). The oxidation rate increases considerably when a product stored at ambient temperature at a certain oxygen concentration is exposed to light. To reduce this problem, the use of packages that are highly impermeable to oxygen and lightproof is required (Heiss 1970).

OPP/Al/PP has a layer of aluminium in the material. According to Wiley (1986), theoretically, laminated aluminium with appropriate film has zero oxygen transmission rate. Thus, OPP/Al/PP has blocked allow any gas to be penetrated into the packaged product. Nevertheless, the results showed that FFA and PV increased during storage period. This was probably due to the internal oxygen content in the package, which could not be totally removed unless it was vacuum packed.

Sorption isotherm

The relation between the moisture content of coconut-oat snack and the relative humidity at which it is in equilibrium at the temperature obtained is called the sorption isotherm for water vapour. Coconut-oat snack is sensitive to water vapour. The initial moisture content for coconut-oat snack was 3.51% and water activity was 0.28 *(Figure 5)*. At this point, the water molecules are quite tightly bound in a monomolecular layer and will not be able to migrate within the food matrix or to transport water-soluble food ingredients. The critical moisture content of snack was 5.86% with 47.5% of equilibrium relative humidity (which means $a_w = 0.47$). At this critical point, coconut-oat snack loses in crispiness because of monomolecular adsorption of water, whereby additional layers of water molecules are formed, which are less tightly bound and able to migrate to some extent. This water fraction is ready for solution and transport of food components (Eichner 1986). Therefore, at level 5.86% of moisture content, the crispiness of coconut-oat snack was lost.

Moisture content

The percentage of moisture content in coconut-oat snack using different packaging materials showed significant difference ($p < 0.05$) during storage period *(Figure 2)*. The moisture content of sample packed in

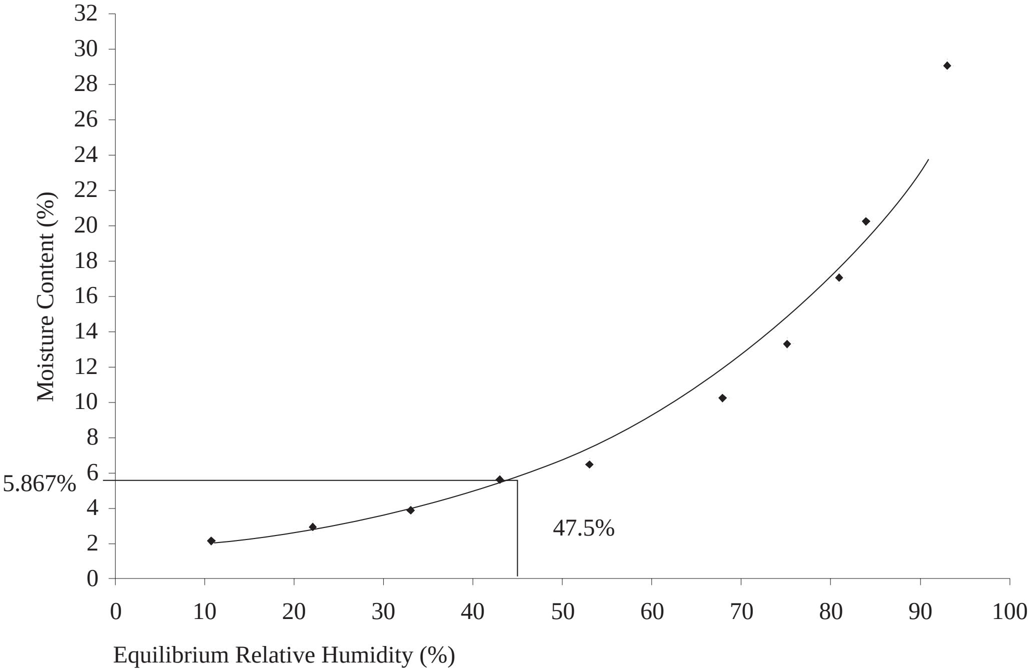


Figure 5. Sorption isotherm of coconut-oat snack during storage at 28 ± 5 °C

OPP/PP stored at 28 ± 5 °C increased throughout the storage period from an initial of 3.5% to 5.3% at 3 months of storage and up to 6.7% after 6 months of storage *(Figure 2)*. The trend was similarly reported by Mohd. Ariff et al. (1991) on "tebaloi", which is a snack made with sago starch and coconut packed with OPP/PP and OPP/PE/Al/PE, during storage at 25 °C.

The loss in crispiness of the sample packed in OPP/PP was detected by organoleptic evaluation panellists after 4 months of storage, whereby moisture content was 5.9%, i.e. the critical moisture content *(Figure 5)*. Products packed in OPP/Al/PP showed lower increases of less than 1%. The moisture content after 6 months of storage was 3.3% for OPP/Al/PP. This is because the water vapour that was absorbed into the samples was most likely only from the headspace of the package, since no permeation from outside of the package was possible.

The difference in moisture content of the samples in the two types of packaging was due to the difference in water vapour permeability rate of the packaging material used. Difference in the water vapour permeability rate of each packaging material will cause different moisture uptake in the product (Gordon 1993). The rate of water vapour permeability of OPP/PP was 5.0 g/m^2 for 24 hours while for OPP/Al/PP was 0 g/m^2. The laminated aluminium with appropriate film had zero water vapour permeability *(Table 1)*.

Microbial count

The growth of microorganisms in the coconut-oat snack was not much affected by the use of different packaging materials. The initial load of microorganisms was considered very low. The total plate count (TPC) was consistently at $<3.0 \times 10^2$ colony forming units per gramme of sample (cfu/g) during 6 months of storage for both packaging materials used. Similar trend was obtained for yeast and mould count during the storage period, which was consistently at <1 x 10 (cfu/g) of sample. This suggests that the packaging can adequately protect and maintain the product from contamination.

According to Gordon (1993), extensive studies on a variety of plastic films and metal foils have shown that microorganisms (including moulds, yeasts and bacteria) cannot penetrate these materials in the absence of pinholes.

Besides that, the water activity of all the packed samples was below 0.6, which indicated that coconut-oat snack was stable against microbial attack during the storage period studied (Labuza 1980). The minimum value of water activity for most of bacteria growth was 0.9 and 0.8 for yeast and mould (Frazier and Westhoff 1978). The *Coliform, Staphylococcus aureus* and *Salmonella* sp. were analysed only for fresh sample in order to determine the initial quality of the product. The result showed that the bacterial growth for these three parameters were undetected. This was probably because the cooking process (110 °C at 55 min) was adequate to kill most of the microorganisms.

Conclusion

The deterioration in quality of coconut-oat snack during storage condition of 28 ± 5 °C and 70–80% relative humidity was mainly due to loss in crispiness and the development of rancidity. This study showed that OPP/Al/PP of 20 µ:7 µ:50 µ thickness was a suitable packaging material for coconut-oat snack stored at 28 ± 5 °C up to 6 months of storage. However, OPP/PP of 20 µ:40 µ thickness provided a shelf life of less than 4 months.

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