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MOISTURE ADSORPTION THROUGH PACKAGING MATERIALS USED FOR DESICCATED COCONUTS

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Abstract: In Sri Lanka, desiccated coconuts are dried to a moisture content below 3 percent and packed in 50 kg quantities in bags made of 85 μ thick low density polyethylene forming the inner lining of a 5 tier paper bag. These bags are exposed to varying relative humidities for several months during storage and transport permitting adsorption of moisture by desiccated coconuts. Fine grade desiccated coconuts (10 g) were sealed in 10 cm x 5 cm bags made of packaging materials low density polyethylene (85 μ), double layer low density polyethylene (60 μ), high density polyethylene (40 μ), polypropylene (50 μ), adhesive laminated aluminium foil (10 μ) on low density polyethylene (75 μ) and triple laminated foil made of polyester (12 μ)/aluminium foil (10 μ)/polyethylene (60 μ). The bags were stored at relative humidities of 33%, 70%, 80%, 100% and that of the atmosphere. The gain in weight by the bags was estimated at 5 day intervals for 90 days. At 33% RH a drop in weight of the bags was observed. An increase in weight was observed at all other relative humidities. Of the materials tested the laminated materials showed better resistance to moisture movement across them. The double laminated material was the best. The desiccated coconuts stored in the laminated materials did not gain moisture to reach the critical level of 3.5% at relative humidities below 80% and at RH of the atmosphere. Even at 100% RH the desiccated coconuts stored in laminated materials reached the critical moisture level only after 83 days as against 6 days observed for other materials. It is recommended that desiccated coconuts be packed in double laminated aluminium/polythene materials.

1. Introduction

The shredded dried coconut kernel is used in the preparation of confectionaries in many Western countries. The coconut kernel is preserved for this purpose by drying it to a moisture level below 3 percent. The product is called desiccated coconut. In Sri Lanka, desiccated coconuts are packed into 50 kg bags for export. The bags are made of an inner low density polyethylene (LDPE) lining of 85 μ thickness and an outer 5 tier paper bag. The LDPE is heat sealed at the two ends to prevent adsorption of moisture. However, the packaging material, LDPE and the craft paper are not completely impermeable to moisture.

These bags are exposed to varying relative humidities for durations upto six months in storage and transport permitting movement of moisture across the packaging materials and adsorption or desorption by the desiccated coconuts. Moisture levels as low as 4–7 percent have been observed to support mold growth¹ and cause off odours due to growth of xerophilic fungi in desiccated coconuts.²

In this study six types of packaging materials used for the storage of desiccated coconuts were compared at different relative humidities with respect to their moisture adsorption/desorption patterns.

2. Materials and Methods

2.1 Packaging materials

The following packaging materials were tested :

- Double layer low density polyethylene (60 μ)
- High density polyethylene (40 μ)
- Low density polyethylene (85 μ)
- Adhesive laminated aluminium foil (10 μ) on low density polyethylene (40 μ)
- Polypropylene (50 μ)
- Triple laminated foil made of polyester (12 μ), aluminium foil (9 μ) and polyethylene (60 μ)

2.2 Estimation of moisture

Desiccated coconut (5 g) was dried at 102°C for 2 hours for the estimation of moisture.³

2.3 Moisture adsorption

Desiccated coconut (10 g) containing 2.7% moisture were sealed in bags (10 cm x 5 cm) of the above packaging materials. They were exposed to different relative humidities at 25°C in desiccators equilibrated with the following saturated solutions for 2 weeks prior to introduction of the bags :

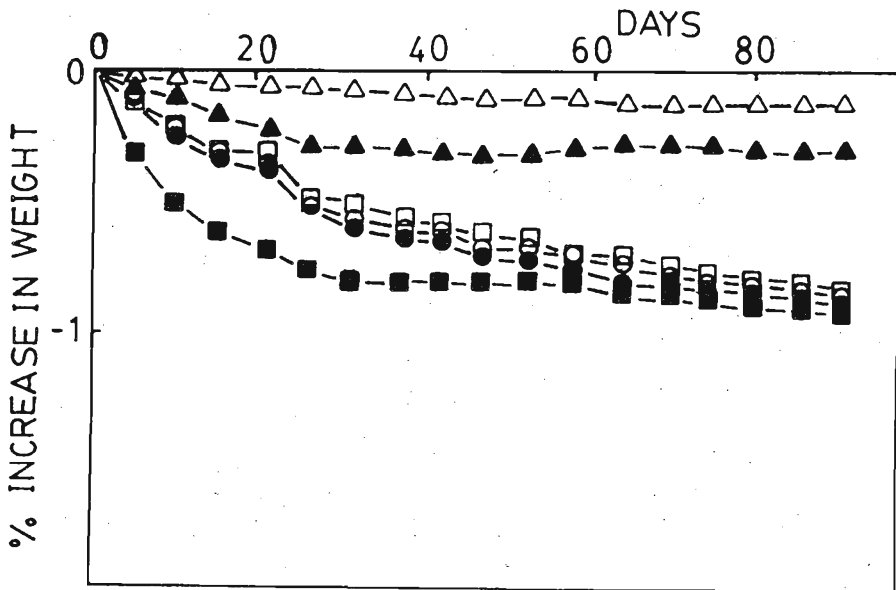
- 33% – magnesium chloride
- 70% – sodium chloride
- 80% – potassium chloride
- 100% – distilled water
- Atmospheric – open desiccator with no solution (varied between 72% to 83%).

The packed samples were weighed at 5 day intervals. They were observed for visible growth of molds. The moisture content of the desiccated coconuts was determined after termination of the experiment on the 90th day. All experiments were done in duplicate.

3. Results and Discussion

3.1 Moisture adsorption pattern

The percentage increase in weight of desiccated coconuts (DC) due to adsorption of moisture at relative humidities (RH) of 33%, 70% and atmospheric are presented in Figures 1 - 3.



Legends for figures

Figure 1. — Moisture adsorption by desiccated coconuts at 25°C and 33% RH when stored in high density polyethylene (■) polypropylene (□) low density polyethylene (●) double layer low density polyethylene (○) double laminated aluminium/polyethylene (▲) and triple laminated polyester/aluminium/polyethylene (△)

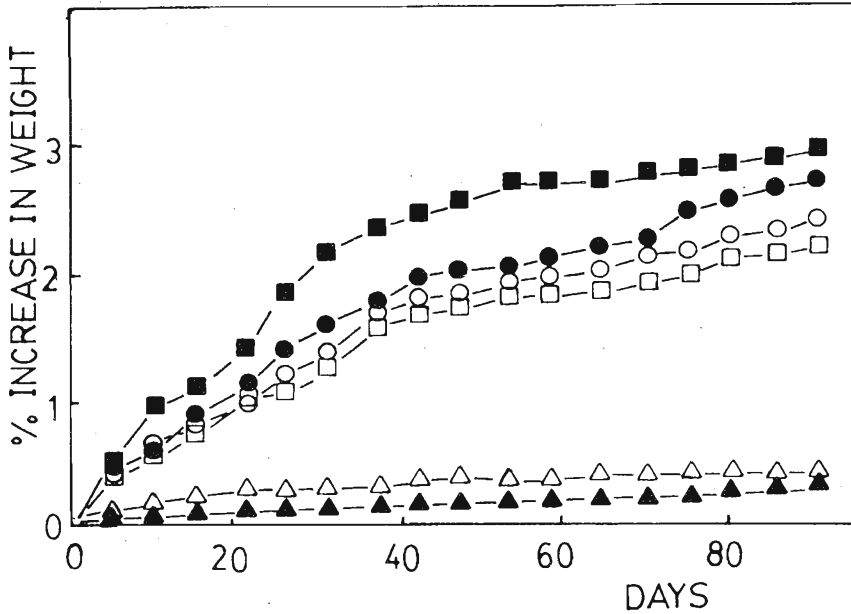


Figure 2. — Moisture adsorption by desiccated coconuts at 25°C and 70% RH when stored in high density polyethylene (■) polypropylene (□) low density polyethylene (●) double layer low density polyethylene (○) double laminated aluminium/polyethylene (▲) and triple laminated polyester/aluminium/polyethylene (△)

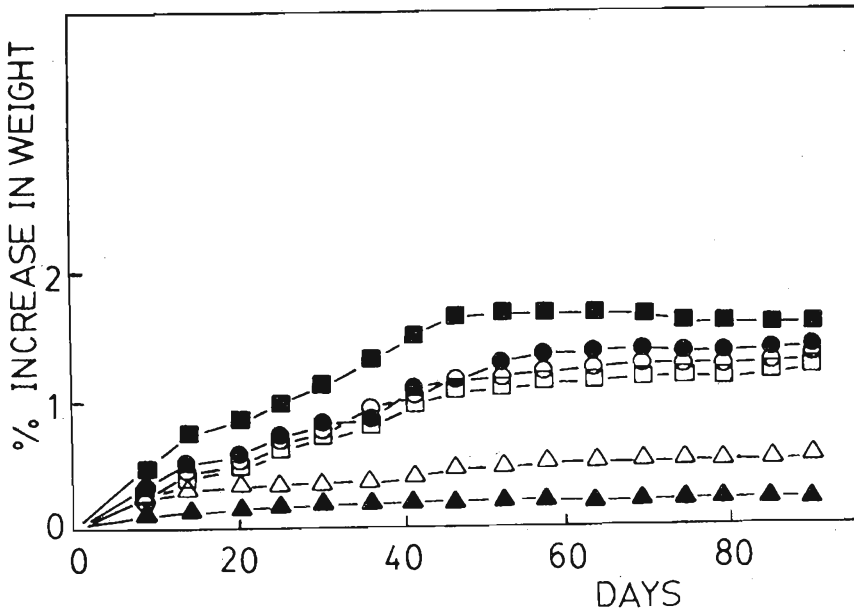


Figure 3. — Moisture adsorption by desiccated coconuts at 25°C and atmospheric relative humidity when stored in high density polyethylene (■) polypropylene (□) low density polyethylene (●) double layer low density polyethylene (○) double laminated aluminium/polyethylene (▲) and triple laminated polyester/aluminium/polyethylene (△)

At 80% and 100% RH moisture adsorption were higher than at 70%. At 33% RH loss of moisture was observed. At atmospheric RH the moisture in the DC appeared to equilibrate with that of the atmosphere in about 2 months in the six packaging materials tested.

Of the packaging materials tested the double laminated and triple laminated materials permitted minimum moisture movement across them at all relative humidities. The double laminated material appeared to be a better moisture barrier than the triple laminated material.

3.2 Final moisture percentage

The final moisture percentages observed in DC after 90 days of storage are presented in Table 1. At 33% RH the double and triple laminated materials showed resistance to moisture loss and the original moisture content of 2.7% in DC was more or less retained, whereas other materials permitted loss of moisture. At higher relative humidities the adsorption of moisture was observed with materials other than the double and triple laminates. The increase in order of permeability to moisture shown by the packaging materials at atmospheric RH is as follows :

1. Double laminated aluminium/polyethylene
2. Triple laminated polyester/aluminium/polyethylene
3. Polypropylene
4. Double layer low density polyethylene
5. Low density polyethylene
6. High density polyethylene

The same pattern with occasional differences were observed at other relative humidities.

3.3 Critical moisture level

In the Industry in Sri Lanka, 3.5% of moisture in desiccated coconuts is accepted as the critical level. The duration to reach the critical moisture level with the six packaging materials at different relative humidities are presented in Table 2. At 33% RH this situation did not arise as there was no adsorption of moisture by DC. With double and triple laminated materials the adsorption of moisture by DC to reach critical moisture level was observed only at 100% RH. This, too, was after 12 weeks of storage. Here the double laminated material appeared to be slightly better than the triple laminated material. The packaging material used today in the industry, low density polyethylene permitted adsorption of moisture beyond critical level within 30 days. This indicates the possibility of DC adsorbing sufficient moisture to permit the mold spoilage during storage at atmospheric RH.

Table 1. The final moisture percentage observed in desiccated coconuts after exposure to different relative humidities (R.H.) in different packaging materials at 25°C for 90 days

Packaging material	Moisture % after 90 days at R.H. of				
	33%	70%	80%	100%	Atmospheric
Double layer low density polyethylene	1.9	5.2	6.2	9.2	4.1
High density polyethylene	1.8	6.2	9.5	13.8	4.4
Low density polyethylene	1.8	5.4	6.2	10.6	4.3
Double laminated aluminium/polyethylene	2.5	3.1	3.1	3.7	3.1
Polypropylene	1.9	4.8	6.1	11.2	4.0
Triple laminated polyester/aluminium/polyethylene	2.6	3.3	3.5	3.8	3.4

Table 2 The duration in days to reach the critical moisture level of 3.5% when desiccated coconut containing 2.7% moisture was stored in different packaging materials at different relative humidities (R.H.) and 25°C

Packaging material	Number of days to react 3.5% moisture at R.H. of				
	33%	70%	80%	100%	Atmospheric
Double layer low density polyethylene	—	14	12	2	33
High density polyethylene	—	8	6	4	15
Low density polyethylene	—	13	11	2	30
Double laminated aluminium/polyethylene	—	—	—	87	—
Polypropylene	—	15	13	6	35
Triple laminated polyester/aluminium/polyethylene	—	—	—	83	—

— 3.5% was not reached

The atmospheric RH observed during the experiment varied between 72% to 83%. In contrast to this, the moisture adsorption by DC under atmospheric RH corresponded to RH of 54% to 74% when calculated on the basis of other RH conditions used in the experiment. This difference is perhaps, due to the variations in RH with time allowing both gain and loss of moisture through the packaging materials and also may be associated with movement of air in the open desiccator which prevented a continuous fixed RH around the packed DC bags at atmospheric RH in contrast to fixed RH in closed desiccators.

3.4 Growth of molds

Molds were visible to the naked eye in the packed desiccated coconut as the moisture concentration passed 6 percent level irrespective of the packaging materials and the relative humidity of storage.

4. Conclusion

The packaging material used today for DC, low density polyethylene appeared to permit the adsorption of moisture allowing DC to reach the critical moisture level of 3.5% in about a month. The double laminated aluminium/polyethylene was the best among the materials tested. The attention of the desiccated coconut industry is drawn to this.

Acknowledgements

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