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THREE DIFFERENT TYPES OF PLASTIC PACKAGING MATERIALS: THEIR EFFECTS ON MOULD INFECTION AND AFLATOXIN CONTAMINATION IN PEANUTS

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ABSTRACT

The effect of three types of plastic packaging materials used to pack peanut kernels under normal and low oxygen concentrations on storage mould infection and aflatoxin B_1 contamination during storage was investigated together with moisture contents and the percentage of damaged kernels of peanuts. Peanut kernels of local variety with initial moisture content of 7% were stored in three types of plastic packaging materials under normal oxygen concentration (O_2 concentration before storage was about 21%) and low oxygen concentration (O_2 concentration before storage was about 10%). Samples of peanuts were collected before storage, and subsequently after one, two, three, four and five months of storage. The composition of the three types of plastic packaging materials were OPP30/PE15/LLDPE80, NY15/PE15/LLDPE80, and NY15/PE15/LLDPE70. Their codes were OPP, NY80 and NY70, respectively. The results showed that the moisture contents fluctuated during storage, but they were considered safe for storage (6.5 – 6.9%). The percentage of damaged kernels increased during storage. Total mould population of peanuts packed in the three types of packaging materials (OPP, NY80, and NY70) either under normal (6.7×10^3, 6.7×10^3, and 9.8×10^3 cfu/g, respectively) or low oxygen concentration (3.3×10^3, 4.2×10^3, and 2.2×10^3 cfu/g, respectively) were not significantly different. After four months of storage, total mould population in peanuts packed either under normal or low oxygen concentration increased. Nevertheless, total mould population in peanuts packed under normal oxygen concentration (7.7×10^3 cfu/g) was higher and significantly different from those packed under low oxygen concentration (3.2×10^3 cfu/g). *Aspergillus flavus* population in peanuts packed in the three types of packaging materials either under normal or low oxygen concentration fluctuated during storage. Aflatoxin B_1 content in peanuts packed under normal oxygen concentration (32.06 ppb) was higher and significantly different from those packed under low oxygen concentration (31.14 ppb). During storage (0, 1, 2, 3, 4 and 5 months of storage) aflatoxin B_1 contents in peanuts packed in OPP (18.6, 23.6, 29.0, 32.0, 35.7, and 43.3 ppb, respectively) was lower than those packed either in NY80 (18.8, 25.4, 33.7, 34.1, 40.2, and 42.3 ppb, respectively) or NY70 (19.8, 25.0, 32.2, 32.6, 40.5, and 42.3 ppb, respectively). Infact, the content in OPP after 5 month of storage was higher than that in NY80 or NY70, but based on statistical analyses, they were not significantly different. During storage aflatoxin B_1 contents increased. As total mould population of peanuts packed in the three types of packaging materials were not significantly different, while aflatoxin B_1 content of peanuts packed in OPP was the lowest, consequently OPP is recommended to be used as packaging material to store peanut kernels under low oxygen concentration.

Key words: plastic-packaging materials, *Aspergillus flavus*, aflatoxin, peanuts.

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INTRODUCTION

Peanuts are next to maize and soybean as the important secondary crop in Indonesia. Since Indonesia has a humid tropical climate, peanuts can easily be infected by moulds (including *A. flavus*) during the drying phase in the fields, or under poor storage conditions. According to Sauer (1992) mould infection can cause a decrease in physical quality of grains (kernels) and nutritional content, rancidity, discoloration, and production of mycotoxin, among other aflatoxin. Aflatoxin has been recognized as human and domestic animals carcinogen, and is produced following the infection of peanuts by certain strains of *A. flavus*.

In 2003 Codex Alimentarus Commission has determined the maximum level of total aflatoxin content in peanuts intended for further processing at 15 ppb. Dharmaputra *et al.* (2005a) reported that aflatoxin B_1 contents have been recorded from peanuts collected from farmer's fields, collectors and retailers in the Wonogiri regency and the city of Surakarta (Central Java) during the wet and dry seasons in 2003. The results showed that the highest aflatoxin B_1 contents were found in raw peanut kernels collected from retailers in traditional markets, with the range of < 3.6 – 1859.3 and < 3.6 – 1804.6 ppb during the wet and dry seasons, respectively. The percentage of raw kernel samples contaminated with aflatoxin B_1 (exceeding 15 ppb) collected during the wet and dry seasons was 33 and 74%, respectively. Dharmaputra *et al.* (2005b) also conducted a survey in Cianjur regency (West Java) to get information on aflatoxin B_1 contents of peanuts collected from farmers, collectors, wholesalers and retailers at traditional markets. The results showed that the ranges of aflatoxin B_1 contents at wholesaler (< 3.6 – 6065.9 ppb) and retailer (< 3.6 – 6073.0 ppb) levels were broader than those at farmer or collector levels. The percentage of raw kernel samples contaminated with aflatoxin B_1 (exceeding 15 ppb) collected at wholesaler and retailer levels was 80 and 75.6%, respectively. Results from the two surveys (Dharmaputra *et al.* 2005a,b) clearly indicated that inappropriate post-harvest handling methods employed prior to peanuts being delivered to retailers, and especially at the retailer level in traditional markets, will cause a severe impact on the level of aflatoxin contamination in peanuts.

At the retailers in traditional markets of Wonogiri regency and the city of Surakarta, the peanuts were stored in jute, polyethylene, polypropylene and plastic bags. Various containers were used when peanut sampling was conducted, i.e. bamboo basket, cartoon box, jute bag, polypropylene bag, plastic bag, winnowing tray and wash basin made from aluminum (Dharmaputra *et al.* 2005a). At the retailers in traditional markets of Cianjur regency, the peanuts were stored in jute and polypropylene bags. Various containers were used when peanut sampling was conducted, i.e. jute and polypropylene bags, round and rectangular plastic containers, wooden box and winnowing tray (Dharmaputra *et al.* 2005b).

To minimize or to reduce aflatoxin contamination, peanuts should be stored appropriately. The packaging of peanuts could protect the peanuts among others from environmental effects, microorganisms and dust. In supermarkets peanut kernels are generally packed in polyethylene bags.

The objective of this study was to investigate the effects of three types of plastic packaging materials on mould infection (including *A. flavus*) and aflatoxin B_1 contamination in peanut kernels stored under normal and low oxygen concentrations. The moisture contents and damaged kernels were also analyzed.

MATERIALS AND METHODS

Peanut variety

The peanuts used in this study were local variety, obtained from farmers at Jampang Kulon district, Sukabumi regency, West Java province in April 2005.

Methods of harvesting, drying and shelling of peanuts

The peanuts were harvested 100 days after sowing. The pods were stripped from plants and sun-dried on paved floor up to moisture contents of about 7%. The pods were shelled using a diesel powered sheller. Before storage, peanut kernels were fumigated with phosphine for 5 days at 2 grams/ton to control insects pest that may exist.

Packaging and storing of peanuts

Prior to packaging, damaged kernels (cracked, broken, mouldy and discoloured) were hand picked from the batch. Sound kernels were packed in three types of plastic packaging materials (1.5 kg/bag) under normal and low oxygen concentrations. Before storage, oxygen concentrations were about 21 and 10%, respectively. The peanuts were then placed randomly on wooden shelves and stored for one, two, three, four and five months under warehouse conditions. The codes for the three types of plastic packaging materials were OPP, NY80 and NY70. Their characteristics are presented in Table 1. The three plastic packaging materials were produced by PT Interkemas Flexipack in Tangerang, West Java.

Each type of plastic packaging material was used to pack peanuts with different oxygen concentrations, storage durations, and replications. Four replications were used for each treatment. Thus, the number of unit experiment was 3 x 2 x 6 x 4 = 144 (3 = types of plastic packaging material; 2 = oxygen concentrations; 6 = storage durations including at beginning of storage; 4 = replications).

The bags containing peanuts were placed on wooden shelves randomly. The ambient temperature and relative humidity of the storage room were recorded using a thermo-hygrograph at three different times of the day (08.00 am, noon, and 04.00 pm).

Sampling method

Samples were collected from each bag before storage and subsequently every month thereafter until 5 months of storage. Each sample was divided three times using a box divider to obtain working samples for moisture content, the percentage of damaged kernels, mould population and aflatoxin B_1 content. Damaged kernels are part of the physical quality of kernels.

Moisture content, damaged kernels, mould and aflatoxin B_1 analyses

Moisture contents of kernels (based on wet basis) were determined using oven method (AOAC 2000). Two replicates were used for each sample. The damaged kernels included discoloured and damaged caused by moulds. The percentage of damaged kernels was determined by counting them and dividing the total number of kernels in working samples for damaged kernels analysis.

Aspergillus flavus from each sample was isolated and enumerated using serial dilution method followed by pour plate method on *Aspergillus Flavus* and *Parasiticus Agar* (AFPA) (Pitt *et al.* 1983, 1992), while other mould species were isolated and enumerated on Dichloran 18% Glycerol Agar (DG18) (Pitt *et al.* 1980). Mould identification was conducted based on Samson *et al.* (1996), Pitt & Hocking (1997) using Czapek Yeast Extract Agar (CYA) and CYA containing 20% sucrose (CY20S). Aflatoxin B_1 contents in the kernels were determined using the ELISA method (Lee & Kennedy 2002), with two replicates used for each sample.

Statistical analysis

The data were analyzed using factorial design with repeated measures. The first and second factors were types of plastic packaging materials and oxygen concentrations, respectively.

RESULTS AND DISCUSSION

Moisture contents

Moisture content is the most important environmental factor that influences mould growth in stored grains (Christensen *et al.* 1992). During storage the moisture contents of peanuts fluctuated, but they were not significantly different (Figure 1).

The moisture contents of peanuts packed in NY70 under low oxygen concentration (6.66%) was lower and significantly different from those packed under normal oxygen concentration (6.77%) (Figure 2). The other plastic packaging materials (OPP and NY80) did not cause significant differences on moisture contents of peanuts packed under normal as well as low oxygen concentrations. The moisture contents of peanut kernels were considered safe for storage. SNI (1995) determined that the safe moisture content for storage of peanut kernels was 8%.

The highest moisture content (6.77%) was found in peanuts packed in NY70 under normal oxygen concentration. It was probably related with the water vapour transmission rate of NY70 (0.6340 g/m²/24 hr) which was higher than those of OPP (0.3053 g/m²/24 hr) and NY80 (0.4805 g/m²/24 hr) (Table 1). The lowest moisture content (6.66%) was found in peanuts packed in NY70 under low oxygen concentration (Figure 2).

Although storage duration did not give a significant effect on the moisture content of peanuts, there was a change in moisture content. According to Christensen (1992) the moisture content of kernels is in equilibrium with the relative humidity of the storage. Bala (1997) reported that the moisture content was also affected by the temperature of the storage. Range of temperature and relative humidity during storage are presented in Table 2.

Percentage of damaged kernels

The percentage of damaged kernels of peanuts packed in the three types of packaging materials under low oxygen concentration was not significantly different from those packed under normal oxygen concentration (Figure 3).

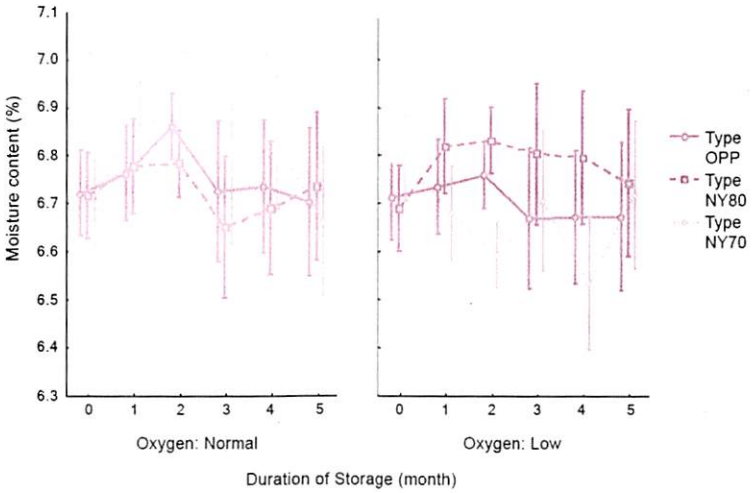

Figure 1. The effect of interaction among types of plastic packaging material, oxygen concentration and duration of storage on moisture content of peanuts.

Table 1. Laboratory analysis of plastic packaging material*

Product name	Code	Composition	Thickness (mm)	WVTR (Water Vapour Transmission Rate) ($g/m^2/24$ Hrs)	O_2TR (Oxygen Transmission Rate) ($cc/m^2/24$ Hrs)
TRL. VACUUM BAG 01	OPP	OPP 30/PE 15/LLDPE 80	0.1265	0.3053	37.6800
TRL. VACUUM BAG 02	NY80	NY 15/PE 15/LLDPE 80	0.1085	0.4805	2.2958
TRL. VACUUM BAG 03	NY70	NY 15/PE 15/LLDPE 70	0.0974	0.6340	1.8734

* Analyzed by Test and Calibration Laboratory, Institute for Chemical and Packaging, Jakarta, Indonesia

OPP : Oriented Polypropylene

LLDPE : Linear Low Density Polyethylene

Table 2. Range of temperature and relative humidity during storage

Duration of storage (month)	Temperature (°C)		Relative humidity (%)	
	Range	Mean	Range	Mean
0 - 1	25.8 - 28.1	27.0	67.5 - 79.0	72.4
1 - 2	25.8 - 27.1	26.4	63.5 - 80.0	71.8
2 – 3	25.5 – 26.4	26.0	62.8 – 74.0	68.9
3 – 4	26.0 – 27.3	26.4	64.1 – 74.5	69.3
4 – 5	26.0 – 27.6	26.6	65.0 – 76.3	71.5

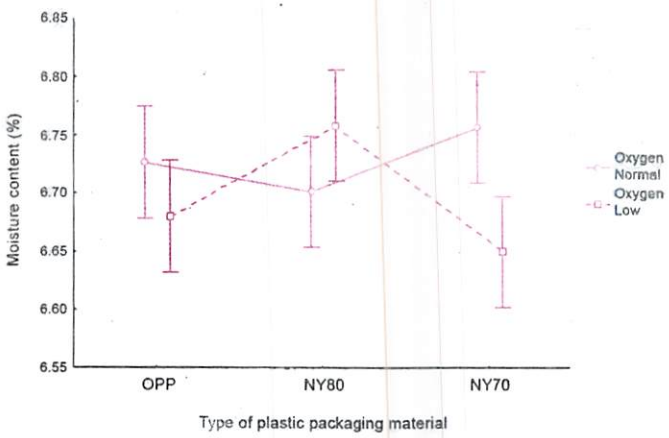

Figure 2. The effect of interaction between types of plastic packaging material and oxygen concentration on moisture content of peanuts.

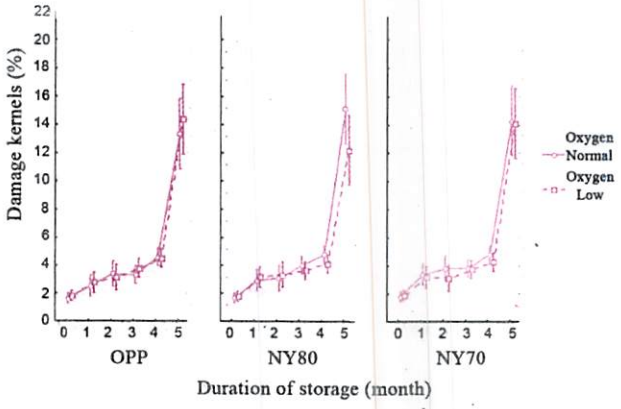

Figure 3. The effect of interaction among types of plastic packaging material, oxygen concentration and duration of storage on percentage of damaged kernels of peanuts.

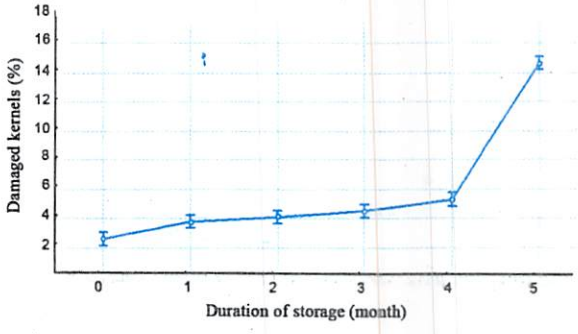

Figure 4. The effect of duration of storage on percentage of damaged kernels of peanuts.

The percentage of damaged kernels increased with the increase of storage duration. The percentage of damaged kernels after five months of storage was significantly different from those after one, two, three and four months of storage. The highest percentage of damaged kernels was found after five months of storage (Figure 4).

According to Christensen (1992) the increase in percentage of damaged kernels during storage among others was caused by mould infection. Dharmaputra *et al.* (1991) reported that *A. flavus* population in damaged kernels of peanuts collected from some traditional markets in Bogor was higher than that in intact kernels.

Total mould population

Total mould population of peanuts packed in the three types of packaging materials either under normal or low oxygen concentration were not significantly different (Figure 5). It showed that the moulds were capable to grow in the three different types of packaging materials (different in thickness, water vapor transmission rate and oxygen transmission rate).

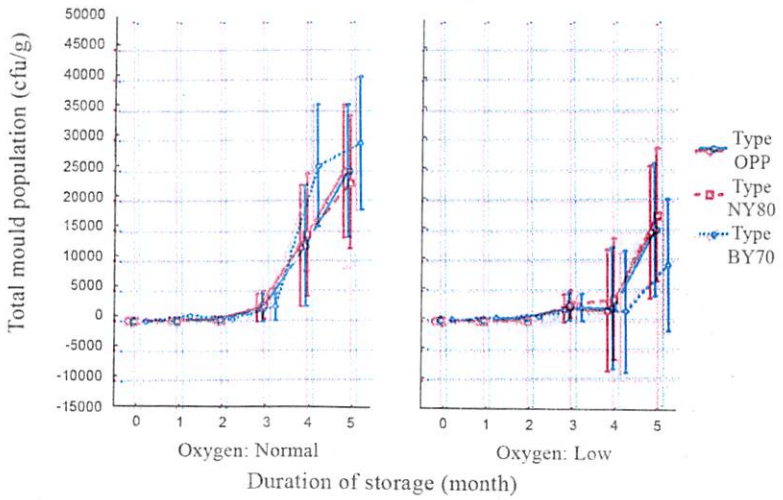

Figure 5. The effect of interaction among types of plastic packaging material, oxygen concentration and duration of storage on total mould populations in peanuts.

After four months of storage, total mould population in peanuts packed either under normal or low oxygen concentration increased. Nevertheless, total mould population in peanuts packed under normal oxygen concentration was higher and significantly different from those packed under low oxygen concentration (Figure 6). According to Dharmaputra *et al.* (2000) the total population of mould in maize with initial moisture contents of 14, 17 and 20% packed in polyethylene bags under airtight condition (oxygen concentration ± 1.4%) was lower than those packed under normal condition (oxygen concentration ± 21%).

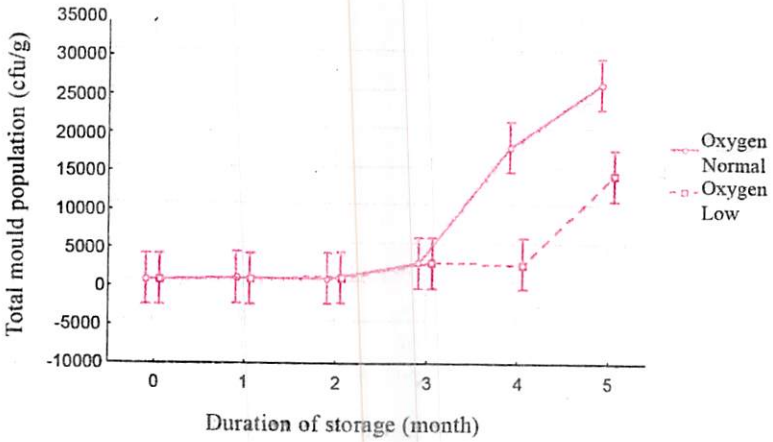

Figure 6. The effect of interaction between oxygen concentration and duration of storage on total mould populations in peanuts.

Moulds are aerob obligate microorganisms, therefore their growth will be inhibited under low oxygen concentration. In general mould growth increase with the increase of oxygen concentration (Garraway & Evans 1984). Nevertheless, oxygen concentration required for optimal growth of certain mould species could be low.

The total mould population in peanuts generally increased during storage, either under normal or low oxygen concentrations (Figure 6). Dharmaputra *et al.* (1993) reported that mould population tended to increase with the increase of storage duration.

There was no difference in the number of mould species in peanuts packed either under normal or low oxygen concentrations (Table 3). It was assumed that the moulds were capable to grow on a wide range of oxygen concentrations. Lacey & Magan (1991) stated that certain mould species were capable to grow under very low oxygen concentration. During five months of storage, nine mould species were isolated from all the treatments. They were *Aspergillus flavus*, *A. niger*, *A. penicillioides*, *A. tamarii*, *Eurotium chevalieri*, *Fusarium solani*, *Mucor hiemalis*, *Penicillium citrinum*, and *Syncephalastrum racemosum* (Table 3). *Aspergillus flavus* and *A. niger* were always isolated from all treatments during storage. Population of *A. penicillioides* started to increase after one month of storage and became the dominant mould species. According to Pitt & Hocking (1997) high population of *A. penicillioides* was found in various foodstuffs.

Population of *A. flavus*

Under low oxygen concentration *A. flavus* population in peanuts packed in OPP had the same pattern with those packed in NY80 during storage (Figure 7).

During storage *A. flavus* population in peanuts packed in the three types of packaging materials either under normal or low oxygen concentration fluctuated (Figure 7). It was probably due to the existence of antagonistic moulds to *A. flavus*. According to

Lacey & Magan (1991) the existence of *A. flavus* during storage was affected by temperature, water activity, gas composition, and interaction among microorganisms. Dharmaputra (2003) reported that *A. niger* was the most potential fungus in inhibiting the growth of aflatoxigenic *A. flavus*, compared with non-aflatoxigenic *A. flavus* and *Trichoderma harzianum*.

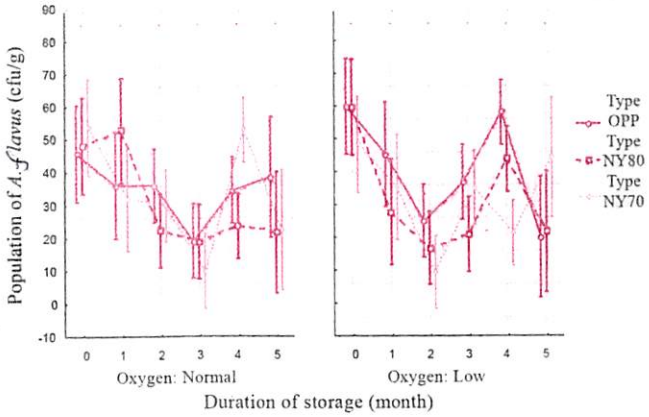

Figure 7. The effect of interaction among types of plastic packaging material, oxygen concentration and duration of storage on population of *A. flavus* in peanuts.

Peanuts packed in the three types of plastic packaging materials, either under normal or low oxygen concentrations were already infected by *A. flavus* before storage (Figure 7). The existence of *A. flavus* before storage may be due to its infection during post-harvest handling, i.e. drying and shelling.

Aflatoxin B_1 content

Aflatoxin B_1 content in peanuts packed under normal oxygen concentration was higher and significantly different from those packed under low oxygen concentration (Figure 8).

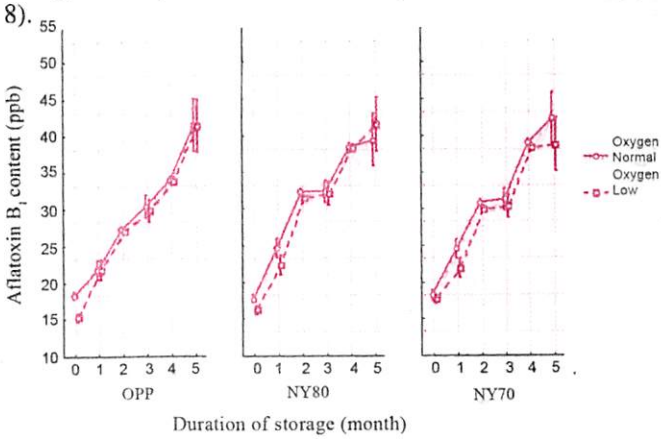

Figure 8. The effect of oxygen concentration on aflatoxin B_1 content of peanuts.

Table 3. Population of mould species in peanuts during storage

Duration of storage (month)	Treatment	Population of mould (cfu/g wet basis)									
		Aspergillus flavus	*A. niger*	*A. penicillioides*	*A. tamarii*	*Eurotium chevalieri*	*Fusarium solani*	*Mucor hiemalis*	*Penicillium citrinum*	*Syncephalastrum racemosum*	Total
0	K_1O_N	40	37	0	2	0	0	0	0	0	7.9×10
	K_1O_L	18	38	0	3	0	0	7	0	0	6.6×10
	K_2O_N	40	27	0	2	0	0	3	0	0	7.2×10
	K_2O_L	23	47	0	10	0	0	0	0	0	8.0×10
	K_3O_N	23	7	0	0	0	0	32	0	0	6.2×10
	K_3O_L	37	58	0	3	0	0	5	0	0	1.0×10^2
1	K_1O_N	55	23	23	65	0	5	0	0	0	1.7×10^2
	K_1O_L	49	18	20	57	0	50	0	0	0	1.9×10^2
	K_2O_N	50	18	10	43	0	12	0	0	0	1.3×10^2
	K_2O_L	95	43	10	23	0	0	0	0	0	1.7×10^2
	K_3O_N	58	32	633	12	0	38	0	7	5	7.9×10^2
	K_3O_L	53	77	137	8	0	13	0	12	10	3.1×10^2
2	K_1O_N	32	40	233	2	0	15	8	7	12	3.5×10^2
	K_1O_L	19	23	300	2	0	28	3	3	19	4.0×10^2
	K_2O_N	35	53	25	2	0	13	8	2	7	1.5×10^2
	K_2O_L	20	30	103	2	0	2	60	3	5	2.3×10^2
	K_3O_N	83	65	200	3	0	0	2	5	3	3.6×10^2
	K_3O_L	28	48	405	3	0	0	13	2	25	5.2×10^2
3	K_1O_N	44	40	1983	0	0	0	23	11	5	2.1×10^3
	K_1O_L	33	36	2055	4	0	1	13	6	8	2.2×10^3
	K_2O_N	28	25	2558	0	0	5	14	1	3	2.6×10^3
	K_2O_L	23	42	2883	3	0	0	6	3	13	3.0×10^3
	K_3O_N	15	26	2308	0	0	9	10	1	3	2.4×10^3
	K_3O_L	31	30	1895	2	0	4	28	2	3	2.4×10^3

Table 3. (Continued)

Duration of storage (month)	Treatment	Population of mould (cfu/g wet basis)									
		Aspergillus flavus	*A. niger*	*A. penicillioides*	*A. tamarii*	*Eurotium chevalieri*	*Fusarium solani*	*Mucor hiemalis*	*Penicillium citrinum*	*Syncephalastrum racemosum*	Total
4	K_1O_N	30	44	32333	2	3	17	158	14	110	3.3×10^4
	K_1O_L	54	43	1592	3	18	0	12	57	2	1.8×10^3
	K_2O_N	46	54	14192	5	3	3	8	23	6	1.4×10^4
	K_2O_L	61	47	3633	3	12	12	8	8	2	3.7×10^3
	K_3O_N	61	60	25583	20	10	10	18	16	2	2.6×10^4
	K_3O_L	68	26	1142	2	2	2	23	15	1	1.3×10^3
5	K_1O_N	43	43	24750	3	4	0	25	7	3	2.5×10^4
	K_1O_L	20	31	14833	2	6	0	5	13	12	1.5×10^4
	K_2O_N	22	40	23000	3	10	7	32	5	1	2.3×10^4
	K_2O_L	58	26	17667	3	8	0	23	3	3	1.8×10^4
	K_3O_N	23	24	29417	0	38	0	31	5	0	3.0×10^4
	K_3O_L	38	46	8667	3	8	68	111	35	3	9.0×10^3

Notes

K_1 = OPP
K_2 = NY80
K_3 = NY70
N = Normal oxygen concentration
L = Low oxygen concentration

According to Diener & Davis (1969) in natural substrates aflatoxin production was affected among others by the availability of oxygen. Dharmaputra *et al.* (2000) reported that the total aflatoxin B_1 contents in maize with initial moisture contents of 14, 17 and 20% and packed in polyethylene bags under airtight condition (O_2 concentration ± 1.4%) were lower than those under normal conditions (O_2 concentration ± 21%).

Aflatoxin B_1 content in peanuts packed in OPP was lower than those packed either in NY80 or NY70 during storage (Figure 9). It might be related with the water vapour transmission rate of OPP (0.3053 g/m²/24 hr) which was lower than those of NY80 (0.4805 g/m²/24 hr) and NY70 (0.6340 g/m²/24 hr) (Table 1). According to Diener & Davis (1969) the most important factor in growth and aflatoxin production by *A. flavus* is the moisture or relative humidity surrounding a natural substrate. Aflatoxin B_1 content in peanuts packed in NY80 had the same pattern with that packed in NY70.

During storage aflatoxin B_1 contents increased (Figure 9), but *A. flavus* population fluctuated (Figure 7). It indicated that the correlation between *A. flavus* population and aflatoxin B_1 content was not positive. Dharmaputra *et al.* (1991) reported that the high *A. flavus* populations in some peanut samples collected from some traditional markets in Bogor were not always followed by high aflatoxin B_1 contents. According to Pitt & Hocking (1997) aflatoxin production depended on certain strains of *A. flavus*. Dharmaputra *et al.* (2001) reported that *A. niger* and non-aflatoxigenic *A. flavus* were able to inhibit aflatoxin production of aflatoxigenic *A. flavus in vitro* as much as 80 and 61%, respectively. The increase of aflatoxin B_1 content during storage may be due to its accumulation, because the toxin cannot be degraded by other microorganisms.

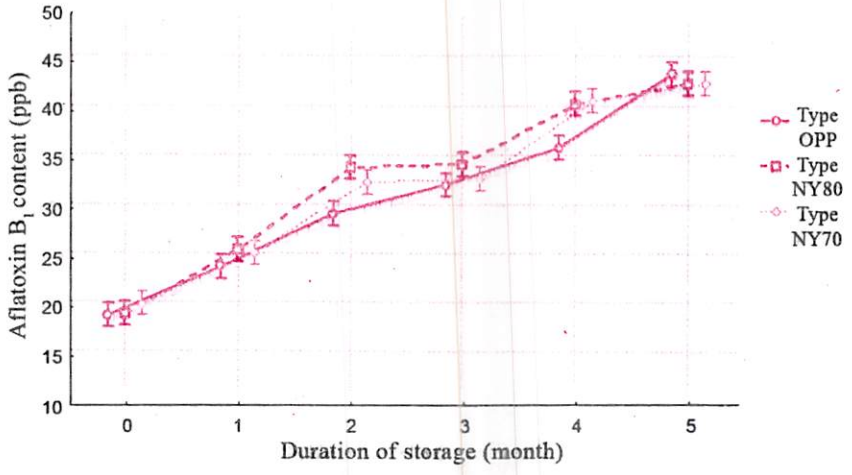

Figure 9. The effect of interaction between types of plastic packaging material and duration of storage on aflatoxin B_1 content of peanuts.

CONCLUSIONS

The moisture contents fluctuated during storage, but they were considered safe for storage (6.5 – 6.9%). The percentage of damaged kernels increased during storage. Total mould population of peanuts packed in the three types of packaging materials (OPP, NY80, and NY70) either under normal (6.7×10^3, 6.7×10^3, and 9.8×10^3 cfu/g, respectively) or low oxygen concentration (3.3×10^3, 4.2×10^3, and 2.2×10^3 cfu/g, respectively) were not significantly different. After four months of storage, total mould population in peanuts packed either under normal or low oxygen concentration increased. Nevertheless, total mould population in peanuts packed under normal oxygen concentration (7.7×10^3 cfu/g) was higher and significantly different from those packed under low oxygen concentration (3.2×10^3 cfu/g). *Aspergillus flavus* population in peanuts packed in the three types of packaging materials either under normal or low oxygen concentration fluctuated during storage.

Aflatoxin B_1 content in peanuts packed under normal oxygen concentration (32.06 ppb) was higher and significantly different from those packed under low oxygen concentration (31.14 ppb). During storage (0, 1, 2, 3, 4 and 5 months of storage) aflatoxin B_1 contents in peanuts packed in OPP (18.6, 23.6, 29.0, 32.0, 35.7, and 43.3 ppb, respectively) was lower than those packed either in NY80 (18.8, 25.4, 33.7, 34.1, 40.2, and 42.3 ppb, respectively) or NY70 (19.8, 25.0, 32.2, 32.6, 40.5, and 42.3 ppb, respectively). In fact, the content in OPP after 5 month of storage was higher than that in NY80 or NY70, but based on statistical analyses, they were not significantly different. During storage aflatoxin B_1 contents increased.

As total mould population of peanuts packed in the three types of packaging materials were not significantly different, while aflatoxin B_1 content of peanuts packed in OPP was the lowest, consequently OPP is recommended to be used as packaging material to store peanut kernels under low oxygen concentration.

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REFERENCES

[AOAC] Association of Official Analytical Chemist. 2000. Nuts and nut product. *In* Horwitz W (ed). Official Methods of Analysis of Food Composition. Gaithersburg: AOAC.

Bala, B.K. 1997. Drying and Storage of Cereal Grains. New Hampshire: Science Publishers.

Christensen, C.M., Miller, B.S. and J.A. Johnston. 1992. Moisture and its measurement. *In* Sauer DB (ed). Storage of Cereal Grains and Their Product. Ed ke-4. Minnesota: American Association of Cereal Chemist. p. 39-54.

Dharmaputra, O.S., Tjitrosomo, H.S.S. and H.H. Susilo. 1991. *Aspergillus flavus* and aflatoxin in peanuts collected from three markets in Bogor, West Java, Indonesia. *In* Naewbanij JO, (ed). Grain Postharvest Research and Development: Priorities for Nineteenth. Proceedings of the 12th ASEAN Seminar on Postharvest Technology; Surabaya, 29-31 Aug 1989. p. 110-124.

Dharmaputra, O.S., Halid, H. and H.H. Susilo. 1993. The effect of milling degree on fungal infection, protein, and total lipid contents of milled rice. *In* Naewbanij JO, Manilay AA, Frio AS, (eds). Increasing Handling, Processing and Marketing Efficiency in The Grain Postharvest System. Proceedings of the 16th ASEAN Seminar on Grain Postharvest Technology; Phuket, 24-26 Aug 1993. p. 177-195.

Dharmaputra, O.S., Amad, M., Retnowati, I. and S. Ambarwati. 2000. Airtright storage of maize: its effect on fungal infection and aflatoxin production. *In* Johnson GI, Le van to, Nguyen DD, (eds). Quality Assurance In Agricultural Produce. Proceedings of the 19th ASEAN and 1st APEC Seminar on Postharvest Technology; Ho Chi Minh, 9-12 Nov 1999. p. 474-482.

Dharmaputra, O.S., Putri, A.S.R., Retnowati, I. and S. Ambarwati. 2001. Soil mycobiota of peanut fields in Wonogiri Regency, Central Java: their effect on the growth and aflatoxin production of *Aspergillus flavus* in vitro. BIOTROPIA No.17. p. 30-59.

Dharmaputra, O.S. 2003. Antagonistic effect of three fungal isolates to aflatoxin-producing *Aspergillus flavus*. BIOTROPIA No. 21. p. 19-26.

Dharmaputra, O.S., Retnowati, I. and S. Ambarwati. 2005a. *Aspergillus flavus* infection and aflatoxin contamination in peanuts at various stages of the delivery chain in Wonogiri Regency, Central Java, Indonesia. Summary International Peanut Conference; Bangkok, 9-12 Jan 2005. p. 109-111.

Dharmaputra, O.S., Retnowati, I., Ambarwati, S. and E. Maysra. 2005b. *Aspergillus flavus* infection and aflatoxin contamination in peanuts at various stages of the delivery chain in Cianjur Regency, West Java, Indonesia. BIOTROPIA No. 24. p. 1-19.

Diener, U.L.and N.D. Davis. 1969. Aflatoxin formation by *Aspergillus flavus*. *In* Goldblatt LA, (ed). Aflatoxin: Scientific Background, Control and Implications. New York: Academic Pr. p. 13-54.

Garraway, M.O. and R.C. Evans. 1984. Fungal Nutrition and Physiology. New York: John Willey & Sons.

Lacey, J. and N. Magan. 1991. Fungi in cereal grain: their occurrence and water and temperature relationship. *In* Chelkowski J, (ed). Cereal Grain: Mycotoxins, Fungi and Quality in Drying and Storage. Amsterdam: Elsevier Science. p. 77-118

Lee, N.A. and I.R .Kennedy. 2002. Analysis of aflatoxin B_1 in peanuts. Bogor: SEAMEO BIOTROP.

Pitt, J.I., Hocking, A.D. and D.R. Glenn. 1980. Dichloran Glycerol medium for enumeration of xerophilic fungi from low-moisture foods. Appl. Environ. Microbiol., 39 (3): 488-492.

Pitt, J.I., Hocking, A.D. and D.R. Glenn. 1983. An improved medium for the detection of *Aspergillus flavus* and *A. parasiticus*. J. Appl. Bacteriol., 54: 109-114.

Pitt, J.I., Hocking, A.D, Samson, R.A. and A.D. King. 1992. Recommended methods for mycological examination of foods. *In*: Samson RA, Hocking AD, Pitt JI, King AD, (eds). Modern Methods in Food Mycology. Amsterdam: Elsevier. p. 365-368.

Pitt, J.I. and A.D. Hocking. 1997. Fungi and Food Spoilage. London: Blackie Academic & Professional.

Samson, R.A., Hoekstra, E.S., Frisvad, J.C. and O. Filtenborg. 1996. Introduction to Food-Borne Fungi. Baarn: Centraalbureau voor Schimmelcultures.

Sauer, D.B., Meronuck ,R.A.and C.M. Christensen. 1992. Microflora. *In*: Sauer DB, (ed). Storage of Cereal Grains and Their Product. Ed ke-4. Minnesota: American Association of Cereal Chemist. p. 313-340.

[SNI] Standar Nasional Indonesia. 01-39210-1995.1995. Kacang Tanah. Dewan Standardisasi Nasional.