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QUALITY PRESERVATION OF PEANUTS BY MEANS OF PLASTIC PACKAGING

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Peanuts packaged in polyethylene terephthalate coated with polyvinylidene chloride (KPET) and ethylene vinyl alcohol copolymer (EVAL) pouches under vacuum, by nitrogen gas replacement and with "free oxygen absorber" (FOA), were stored at 35° and 75-90% relative humidity for a period of 90 days. Controls were also packaged in KPET, EVAL and oriented polypropylene (OPP) pouches. EVAL proved to be the best film for packaging peanuts due to its low oxygen transmission rate. Vacuum and nitrogen gas replacement packaging techniques restrained the development of rancidity. However, these techniques were less effective in the pouches of KPET, a film with moderate oxygen permeability. FOA produced an anaerobic environment and maintained it over the total period of 90 days in EVAL, as well as, in KPET pouches. It thus prevented the development of rancidity and inhibited fungal growth.

INTRODUCTION

Peanuts is an important crop in Pakistan. In 1981-82, it was cultivated over an area of 31,250 hectares and the total production was 55,780 tons [1]. Peanuts are highly susceptible to oxidative rancidity due to the presence of polyunsaturated fatty acids [2]. The development of rancidity not only lowers the organoleptic status of peanuts, some of the products of lipid oxidation are also considered poisonous in nature [3]. Peanuts are also susceptible to fungal growth under hot and humid climates. Some of the fungi have been found to produce toxins (e.g. aflatoxins, the strongest carcinogens, produced by *Aspergillus flavus)* which are potent killers and cause extensive damage to the liver [4]. The packaging of peanuts for distribution in the consumers market in Pakistan has been inadequate. 14% of the peanut samples tested at the PCSIR Laboratories, Lahore were found to be contaminated with aflatoxin [5]. Improper storage and packaging has also led to quality loss and wastage. The present study was initiated to determine the suitable packaging methods so as to maintain the quality of peanuts over an extended period of storage. Peanuts were thus packaged using pouches of different materials and stored at 35° with 75-90% relative humidity for a period of three months. Peroxide values (POV) of peanuts were measured at suitable intervals of time. Head-space gases were also analysed simultaneously in order to correlate the composition of gases with the development of rancidity and to ascertain the adequacy of the packaging system. An attempt was made to identify the factors which would provide a suitable packaging environment to peanuts. In the present studies peanuts were packaged in three kinds of pouches, i.e. polyethylene terephthalate coated with polyvinylidene chloride (KPET), ethylene vinyl alcohol copolymer (EVAL), and oriented polypropylene (OPP). Peanuts were packaged in KPET and EVAL pouches under vacuum, by nitrogen gas replacement and with "free oxygen absorber" (FOA) [6]. Controls were also run for peanuts packaged in all three kinds of pouches without any treatment.

EXPERIMENTAL

Freshly roasted peanuts (POV~0) were directly purchased from the processor, Ikenobe Food Company in Ibaraki, Japan. 80 g (± 1 g) of peanuts were packaged in three types of pouches (130 x 95 mm). The ratio between the dimensions of the pouches, the weight of peanuts and the volume of head-space were kept the same as in commercial pouches containing peanuts available in the market. The compositions of the plastic laminated films used in the present studies are given in Table 1. KPET and EVAL pouches were divided into four sets each. In one set,

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Table 1. Composition of plastio laminates used

No.	Laminate film	Composition
1.	EVAL	PET 12μ/ EVAL 25μ/ PE 50μ
2.	K PET	K 3μ/ PET 25μ/ PE 50μ
3.	OPP	OPP 20μ/ PE 40μ

EVAL : Ethylene vinyl alcohol copolymer
PET : Polyethylene terephthalate (polyster)
PE : Polyethylene
K : Polyvinylidene chloride (PVDC)
OPP : Oriented polypropylene

peanuts were packaged under vacuum. In the second set, packaging was carried out by nitrogen gas replacement. The third set of pouches was packaged with peanuts in the presence of "free oxygen absorber" (FOA) AGELESS, Z-100 type, Mitsubishi Gas Chemical Co Ltd., (Tokyo [7], and the fourth set was used as control. Peanuts packaged in OPP pouches were also used as control. Moisture content of peanuts was determined by heating at 130^o for 3 hr [8]. Vacuum and gas replacement packaging were carried out using the machine fabricated by Nishihara Seisakusho Co. Ltd., Hiroshima, Japan. Oxygen permeabilities of the films used in this experiment were determined by oxygen permeability tester OX-TRAN 100, Mocon Modern Controls, Inc. Minnesota, U.S.A.

The pouches were placed in a constant temperature room at 35^o with 75-90% relative humidity. Physical examination of the samples was carried out daily. Determination of peroxide value (POV) and the analysis of head-space gases was carried out at regular intervals upto 3 months. Oil was extracted using ethyl ether containing 0.02% butyl hydroxy toluene (BHT) and POV was determined by the Official AOCS Method No. Cd 8-53 [9]. Head-space gas was analysed by gas chromatography using Shimadzu GC-3 AH (Shimadzu Seisakusho Co. Ltd.) equipped with a thermal conductivity detector and a 0.3 x 200 cm. WG-100 column (Gasukuro Kogyo Co.). The chromatograph was run isothermally at 70^o and argon at a flow rate of 40 ml/min was used as carrier gas. Retention times of the different gases were measured by using pure gases. The area under each peak was determined by an integrator and the percentage of each gas was determined using correction factors.

RESULTS AND DISCUSSION

Physical Examination. Pouches containing peanuts were examined daily. No microbial growth was observed on any of the pouches during a total period of 90 days. It was mainly due to low initial moisture content of the peanuts (1.84%) and low Water Vapour Transmission Rate (WVTR) of the films [10]. Pouches packaged under nitrogen gas replacement and the control pouches maintained their shapes, while pouches filled under vacuum and those containing "free oxygen absorber" (FOA) showed shrinkage. The latter shrinkage took place due to consumption of oxygen by FOA and by gas transmission through plastic film.

Peroxide Values. Peroxide values of the peanuts stored for a period of 90 days varied widely (1.0-31.9) depending upon the packaging material and the packaging method (Table 2.). As expected, POV of the control samples was higher than those packaged under vacuum, by nitrogen gas replacement of with FOA. Control samples packaged in EVAL, KEPT and OPP ponches had final POV of 16.0, 21.5 and 31.9 respectively. These values compared favourably with oxygen permeability rates of these films determined experimentally as given below:

Film	Oxygen transmission rate
EVAL	0.2 cc/m^2/24 hr @ 1 atmosphere
PET	18 cc/m^2/24 hr @ 1 atmosphere
OPP	1300 cc/m^2/24 hr @ 1 atmosphere

Another observation in this context was that POV tended to decrease after attaining a maximum both in EVAL and PET pouches. It may be attributed to the decomposition of peroxides in the pouches where the oxygen availability was depleted.

EVAL appeared to be the best film for packaging peanuts due to its low oxygen transmission rate. All the techniques applied (i.e. vacuum packaging, nitrogen gas replacement, "free oxygen absorber") were successful in restraining the development of rancidity during the storage period of 90 days. Maximum POV observed was 2.0. KPET restrained the development of rancidity initially, but comparatively higher oxygen transmission rate caused POV to increase more sharply as compared to samples packaged in EVAL. Peanuts packaged under vacuum and those packaged by nitrogen gas replacement showed POV values of 13.4 and 16.4 respectively after a storage period of 90 days. Packaging under vacuum was thus more effective than the gas replacement method. However, FOA restrained the development of rancidity during storage and

Table 2. Peroxide values of peanuts packaged under different packaging environments

Pouch material	Packaging environment	Number of days						
		5	15	30	45	60	75	90
1. EVAL	Vacuum	1.3	1.3	1.3	1.3	1.8	1.7	1.9
	Gas replacement	1.0	1.2	1.3	1.4	1.4	1.4	1.4
	Free oxygen absorber	1.0	1.0	1.2	1.2	1.2	1.9	2.0
	Control	7.2	13.8	17.3	17.5	17.2	16.2	16.0
2. PET	Vacuum	2.3	3.0	7.2	9.9	12.7	13.6	13.4
	Gas replacement	1.5	1.3	4.8	9.0	13.6	18.7	16.4
	Free oxygen absorber	0.9	1.0	1.1	1.5	1.1	1.0	1.0
	Control	7.1	16.5	21.1	21.8	25.9	22.5	21.5
3. OPP	Control	6.3	17.6	24.6	26.2	29.3	31.2	31.9

POV was only 1.0 after 90 days. Thus the insertion of FOA is the most effective method for packaging oxygen sensitive foods in low cost polyvinylidene chloride coated films like KOP, KPET, KON, K-cellophane etc. with moderate oxygen transmission rates (i.e. about 10-30 cc/m^2/24 hr @ 1 atmosphere). It has been already inferred that "free oxygen absorber" develops an oxygen free environment and maintains it over an extended period of time [11]. The highest POV (= 31.9) of peanuts stored in OPP pouches (control) was in agreement with the high oxygen transmission rates of the film (i.e. 1300 cc/m^2/24 hr @ 1 atmosphere). However, the permissible POV limit i.e. POV=50 (Japanese standard for fatty foods containing over 10% of fats and oils) was not crossed [12]. This could be attributed to the fact that the pouches were stored in the darkness and further that the low moisture content of peanuts was maintained due to the low water vapour transmission rate of the film.

Composition of Head-space Gases. Quite understandably, the analysis of head-space gases could not be carried out for samples packaged under vacuum. The data given in Tables 3–5 represent the percentage composition of the gases in head-space.

EVAL proved to be the best packaging material. Due to its low oxygen permeability, very low oxygen level was maintained in pouches packaged by nitrogen gas replacement as well as in the control samples (Table 3). It was also reflected in the low POV values of these samples (Table 2).

KPET pouches were more permeable to oxygen. Thus oxygen level was comparatively higher in pouches packaged by nitrogen gas replacement (Table 4) and it was also indicated by the much higher POV of these samples.

A comparision of the control samples packaged in these three types of pouches indicates the relative effectiveness of these packaging materials. In the case of EVAL, the percentage of oxygen dropped sharply to 2.79 due to the consumption of oxygen in the autoxidation process and then slowly increased to the final value of 8.70% (Table 3). POV of the samples showed a maximum of 17.5 after 45 days of storage and then gradually fell to 16.0 due to the decomposition of peroxides (Table 2). In KPET pouches, oxygen level never fell below 7.16% (Table 4) and the samples showed a maximum POV of 25.9 after 60 days, which slowly fell to a final value of 21.5 (Table 2). Oxygen level in the head-space in OPP pouches fell to a minimum of 18.91% after 5 days of

Table 3. Percentage composition of head-space gases of EVAL pouches containing peanuts

Pouch type	Gas	Number of days						
		5	15	30	45	60	75	90
Free oxygen absorber	Carbon dioxide (1.39)	2.92	0.65	0.54	–	–	1.40	–
	(1.7)	–	–	–	–	–	–	–
	Hydrogen (2.34)	0.87	1.17	1.38	1.31	1.09	0.90	0.72
	Oxygen (3.70)	4.26	0.33	–	0.25	–	0.18	0.50
	Nitrogen (5.45)	91.95	97.85	98.08	98.44	98.91	97.51	98.78
Gas replacement	Carbon dioxide (1.39)	2.87	–	0.41	–	–	–	–
	(1.7)	0.27	1.67	1.37	1.38	1.09	1.69	1.65
	Hydrogen (2.34)	–	–	–	–	–	–	–
	Oxygen (3.70)	3.32	0.17	1.00	1.80	1.04	0.14	0.17
	Nitrogen (5.45)	93.54	98.16	97.22	96.82	97.87	98.17	98.18
Control	Carbon dioxide (1.39)	2.14	–	–	–	–	–	–
	(1.7)	0.48	1.97	1.78	1.81	1.19	1.65	1.16
	Hydrogen (2.34)	–	–	–	–	–	–	–
	Oxygen (3.70)	16.18	5.96	2.79	5.92	6.33	8.22	8.70
	Nitrogen (5.44)	81.20	92.07	95.43	92.27	92.48	90.13	90.14

Values given in parenthesis are the retention times in min.

storage but then maintained a higher status for the rest of the storage period (Table 5). POV of the control samples packaged in OPP pouches gradually rose to a maximum of 31.9 (Table 2). It is thus indicated that the decomposition and the formation of peroxides took place simultaneously. However, at a lower level of oxygen, the decomposition superseded the production and the overall concentration of peroxides decreased.

The formation of carbon dioxide was observed in the initial stages of storage in all pouches irrespective of the nature of the pouch materials. Peanuts adsorbed carbon dioxide during roasting and previous storage. Desorption of the adsorbed gas might have taken place at a comparatively higher storage temperature, i.e. 35^{o}. However, carbon dioxide gradually disappeared at later stages in most of the pouches. That might have been caused by the permeation of the gas out of the pouches. It was interesting to note that the minor peak (retention time, 1.7′) which could not be identified, was not observed in pouches containing FOA. Thus it appears to be a volatile oxidation product which was not produced at extremely low oxygen levels.

Hydrogen has already been observed to be a product of the reactions involving FOA [13]. Thus, hydrogen was present in all pouches containing FOA, irrespective of the nature of the pouch or the period of storage.

In conclusion, the present studies indicate the effectiveness of different packaging systems to produce and maintain anerobic environment. EVAL proved to be the best packaging material in this respect. However, while

Table 4: Percentage composition of head space gases of KPET puuches containing peanuts

Pouch type	Gas	NUMBER OF DAYS						
		5	15	30	45	60	75	90
Free oxygen absorber	Carbon dioxide (1.39')	3.86	0.71	----	---	---	1.10	--
---	(1.7)	--	--	--	--	--	--	--
	Hydrogen (2.34)	0.77	0.27	0.30	0.28	0.27	0.28	0.27
	Oxygen (3.70)	0.31	0.72	0.15	--	--	--	0.76
	Nitrogen (5.45)	95.06	98.30	99.55	99.72	99.73	98.62	98.97
Gas replacement	Carbon dioxide (1.39)	4.16	--	0.06	--	--	--	--
	(1.7)	0.11	1.35	0.35	0.77	0.50	1.23	0.93
	Hydrogen (2.34)	--	--	---	---	--	--	--
	Oxygen (3.70)	5.77	1.47	3.14	6.23	6.20	6.65	7.35
	Nitrogen (5.45)	89.96	97.18	96.45	93.00	93.30	92.12	91.72
Control	Carbon dioxide (1.39)	2.29	--	0.09	--	--	--	--
	(1.7)	0.38	1.52	0.81	1.00	0.59	1.67	1.21
	Hydrogen (2.34)	--	--	--	--	--	--	--
	Oxygen (3.70)	16.27	7.16	8.33	10.41	9.81	7.77	8.18
	Nitrogen (5.45)	81.06	91.32	90.77	88.59	89.60	90.56	90.61

Values in parenthesis are the rentention times in min.

Table 5: Percentage composition of the head space gases of OPP pouches containing peanuts

Pouch type	Gas	Number of days						
		5	15	30	45	60	75	90
Control	Carbon dioxide (1.39)	2.86	0.32	---	---	0.40	0.86	--
	(1.7)	----	-----	-----	-----	------	-----	-----
	Oxygen (3.70)	18.91	19.48	20.33	20.52	21.09	20.95	20.81
	Nitorgen (5.45)	78.23	80.20	79.67	79.48	78.51	78.19	79.19

Values in parenthesis are retention times in min.

considering the merits of packaging plastic films, the economic aspects are also to taken into consideration. High cost of EVAL may be a limiting factor in its selection as a packaging film for peanuts. However, with improvement in the technology of its manufacture, a decrease in its cost of production is anticipated. FOA was able to produce an oxygen-free environment and maintain it over an extended period of time. Such an anaerobic environment would not only retard the process of autoxidation, it would also inhibit fungal growth as fungi are aerobic in nature [14]. It is interesting to note that, although FOA costs a few yens per pouch, its insertion needs additional manual labour. Therefore, huge establishments dealing with food packaging prefer to use more expensive films with better barrier properties. However, all small and medium level enterprises find the insertion of FOA more economical.

The present studies spotlight the need in improvement of packaging systems for snack foods containing high level of oils, i.e. peanuts, potato chips etc. to maintain their nutritional and organoleptic status over an extended period of time. These studies also indicate various possible packaging systems available for such a purpose and compare the merits and demerits of each system.

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