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FOOD QUALITY PRESERVATION BY MEANS OF PACKAGING

Abdus-Salam Sheikh*, Takashi Hirata and Takasuke Ishitani

National Food Research Institute, Ministry of Agriculture, Forestry and Fisheries, Yatabe-machi, Tsukuba-gun, Ibaraki, 305, Japan.

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Food quality preservation studies were carried out on five traditional sweets of Japan for a period of 15 days. These sweets were packaged in KOP/PE (a laminate of polyvinylidene-coated oriented polypropylene and polyethylene) and PE (polyethylene) pouches, with or without Free Oxygen Absorber (FOA) and stored for a period of 15 days at 25^{0} with Relative Humidity = 70-95%. Physical examination of the pouches was carried out daily. Head-space gas analysis was carried out at regular intervals of five days. KOP/PE pouches with oxygen absorber were found to be the best packaging system. Oxygen was totally removed from the pouches. Microbial growth was either totally inhibited or slight microbial growth was visible only after 13 days of storage. The pouches kept their shapes, the only exception being the package containing "Mizuyokan", which swelled up due to the formation of large volumes of carbon dioxide by anaerobic fermentation. In the absence of oxygen absorber, the KOP/PE pouch was not found preferable to the PE pouch. Swelling was caused in most of the samples due to the retention of carbon dioxide formed inside the pouch. However, KOP/PE packaging delayed the onset of microbial growth in some cases. Use of oxygen absorber in PE pouches caused extensive shrinkage of the pouches due to the absorption of oxygen and the elimination of nitrogen from the pouches due to its higher partial pressure than ambient.

INTRODUCTION

No studies have been carried out on the food quality preservation of Pakistani traditional sweets by packaging. The need for the extension of shelf life of these sweets is warranted by the changing dietary habits of the people and necessity for the expansion of the export market of these sweets. These studies were carried out keeping that demand in view. Traditional Japanese sweets were used in the present studies. However, the findings of the present investigation can be as well applied elsewhere. The purpose of food quality preservation is to preserve the quality of food without reducing its inherent value. Food additives have been developed to preserve the quality of food. However, most of them are synthetic chemicals and great concern is being shown about the risk in the use of these substances. Many permitted additives are being taken off the approved list by FDA every year [1]. Other techniques used for food preservation, such as vacuum packaging, gas replacement, aseptic packaging etc. are sophisticated techniques and would need considerable initial investment and technological know-how [2]. Free Oxygen Absorber (FOA) accomplishes the purpose of preserving the food quality by a simple method of merely placing within the packaging system [3]. It quickly removes oxygen from the pouch and protects the food from oxidation, insect attack and aerobic micro-organisms [4]. Many oxygen absorbers are available in the market labelled as Free Oxygen Absorber (FOA), Free Oxygen Remover (FOR) or Free Oxygen Scavanger (FOS). These may be inorganic (partially oxidised iron) or organic (carbohydrates with a catalyst) substances specially developed to absorb oxygen from a package. In the present studies KOP/PE (a laminate of polyvinylidene chloride coated, oriented polypropylene and polyethylene) and PE (polyethylene) used with or without the oxygen absorber. The effect of these films and the Free Oxygen Absorber (FOA) on the food quality preservation of traditional Japanese sweets was investigated for a period of 15 days.

EXPERIMENTAL

Freshly prepared samples of the following traditional sweets† were purchased from the market:

* United Nations University (UNU)-Fellow, PCSIR, Lahore-16, Pakistan.

† See Appendix I for their composition and other characteristics.

A: "Kimishigure",
B: "Nerikiri",
C: "Mizuyokan",
D: "Dorayaki" and
E: "Ayu".

Dry matter of these samples was determined under vacuum at $70^{o} \pm 2^{o}$ for a period of 18 hr. [5]. Water activities of the samples were also measured using Rotronic Hygroskop DT (Swiss-made). One piece each of the sweets was packaged in KOP/PE or PE pouches (14 x 20 cm), with or without the Free Oxygen Absorber (FOA) and hermetically sealed (in triplicate). The FOA used was of the Z-100 type (AGELESS, Mitsubishi Gas Chemical Co., Tokyo). The pouches were placed at 25^{o} with Relative Humidity = 70-95%. Physical examination of these pouches was carried out daily. Physical changes, aberrations and microbial growths, if any, were noted. The gas mixture occupying the pouches was analysed at 5-day intervals. One ml. of the gas mixture was analysed by gas chromatography using Shimadzu GC-3AH (Shimadzu Seisakusho Co.) equipped with a thermo-conductivity detector and a 0.3 x 200 cm Wg-100 column (Gasukurokogyo 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 for the different gases were measured using pure gases. Different peaks were identified using superimposition technique. The area under each peak was determined using an integrater and the percentage of each gas in the head space was determined.

RESULTS AND DISCUSSION

Approximate Composition. Approximate composition of three sweets is presented in Appendix 1. The composition of the other two is not available in literature. It should be appreciated that there is no law regulating the composition of these sweets, and therefore, small variations in the ratio of different ingredients and the final composition are possible.

Moisture Contents and Water Activities. Each sweet has an inner core and an outer crust, except for "Mizuyokan", which possessed a homogeneous texture. Moisture contents and water activities of the cores and crusts of these sweets show that only the core and crust of "ayu" had significant differences in their moisture contents and water activities (Table 1). The "ayu's" crust had the minimum moisture content (19.31%) and water activity (0.735) and "mizuyokan" gave the maximum values for moisture content (43.50%) and water activity (0.952). All other samples gave water contents (26.14-28.92%) and water activities (0.835-0.876) within small ranges.

Physical Examination. "Kimishigure" had a fragile texture. So its texture was lost on the fourth day, irrespective of the packaging environment (Table 2). Transitory (7th - 9th day) slight sweating was observed in KOP/PE pouches. No such phenomenon was observed in PE pouches due to higher moisture permeability of the pouch material. Shrinkage was observed in pouches containing FOA. The shrinkage was more intense in PE pouches, as oxygen was absorbed by the FOA and nitrogen was eliminated from the pouches because of its higher partial pressure than ambient environment [6]. Slight shrinkage was also observed in KOP/PE pouches without FOA due to oxygen uptake by the in-package food. Microbial growth was observed in PE pouch on the 11th day and in KOP/PE pouch on the 13th day, thereby showing better protective qualities of KOP/PE in this case. Only slight microbial growth was observed in pouches containing FOA. Thus FOA retarded the development of microbial growth.

Appendix 1. Reported* average composition of some Japanese sweets

No.	Sweet	Percentage composition g/100 g						Minerals mg/100g					
		Energy K cal/g	Water	Protein	Lipids	Carbohydrates Non-Fibrous	Carbohydrates Fibrous	Ash	Calcium	Phosphorus	Iron	Sodium	Potassium
1.	Dorayaki	284	31.5	6.0	2.6	58.5	0.6	0.8	21	90	1.1	130	55
2.	Mizuyokan	196	51.0	3.0	0.2	45.2	0.3	0.3	25	26	0.9	65	19
3.	Nerikeri	265	34.0	5.3	0.4	59.5	0.5	0.3	41	46	1.6	3	36

* Standard Tables of Food Composition in Japan, 4th Revised Edition, 1982.
Resources Council, Science and Technology Agency, Japan.

Table 1. Moisture contents and the water activities of traditional Japanese sweets

Sample	"Kimishigure"		"Nerikeri"		"Mizuyokan"	"Dorayaki"		"Ayu"	
Part	Core	Crust	Core	Crust	----	Core	Crust	Core	Crust
Moisture content(%)	28.43	28.00	26.38	26.46	43.50	28.92	27.25	26.14	19.31
Water activity	0.875	0.864	0.871	0.866	0.952	0.876	0.863	0.835	0.735

Table 2. Physical examination of pouches

Sample		A	B	C	D	E
Pouch	Observation made	Day of commencement				
KOP/PE +FOA	Microbial growth	13th (slight)	14th (slight)	––	––	13th (slight)
	Shrinkage	10th (slight)	10th (slight)	––	––	10th. (slight)
	Swelling	––	––	10th (slight)	––	––
	Sweating	7th-9th*	6th	4th	––	––
	Texture lost	4th	––	––	––	––
	Discoloration	––	4th	––	––	––
KOP/PE	Microbial growth	13th	13th	5th (extensive)	11th	12th
	Shrinkage	11th (slight)	––	––	––	12th
	Swelling	––	10th (slight)	4th (extensive)	5th (slight)	––
	Sweating	7th-9th*	6th	4th (extensive)	––	––
	Texture lost	4th	––	––	––	––
	Discoloration	––	4th	––	11th-12th (slight)	––
PE + FOA	Microbial growth	13th (slight)	13th (slight)	5th-9th (slight)	11th	––
	Shrinkage	9th (severe)	10th	9th	10th	8th
	Swelling	––	––	––	––	––
	Sweating	––	––	4th	––	––
	Texture lost	4th	––	––	––	––
	Discoloration	12th	4th	––	––	––
PE	Microbial growth	11th	13th	5th	10th	12th
	Shrinkage	––	––	––	––	14th (slight)
	Swelling	––	––	5th	–––	––
	Sweating	––	10th	4th	–––	––
	Texture lost	4th	––	––	––	––
	Discoloration	––	4th	––	10th	––

* Transitory

"Nerikiri" developed discoloration on the fourth day in all pouches (Table 2). Sweating was observed on the 6th and 10th days for KOP/PE and PE-pouches respectively. Only slight shrinkage was observed in KOP/PE pouches containing FOA. Shrinkage was more acute in PE-pouches containing FOA. KOP/PE pouches showed slight swelling on the 10th day due to the evolution of gases produced by the degenerative changes in the sample. It was observed that FOA retarded the microbial growth both in KOP/PE, as well as in PE pouches.

"Mizuyokan" showed the poorest storage life. Its high moisture content (43.50%) and water activity (0.952) made it most vulnerable to microbial attack (Table 1). Sweating started on the 4th day in all samples (Table 2). Swelling was observed in all pouches due to the fermentative process except in PE-pouch with FOA, which showed slight shrinkage due to higher gas permeability of the pouch material. As expected, swelling was more extensive in KOP/PE pouch and it was evidenced, as early as, on the fourth day. No apparent microbial growth was observed in KOP/PE pouch with FOA. However, swelling on the 10th day indicated the progress of anaerobic fermentative process. Heavy load of microbial growth was observed in KOP/PE pouches without FOA starting on the 5th day. It was more extensive even than the microbial growth in PE pouches without FOA. It was due to the low moisture permeability of KOP/PE pouches. Retention of moisture inside the pouch was more conducive to microbial growth. Although microbial growth was observed in all PE pouches on the 5th day, yet pouches containing FOA showed only slight growth till the 9th day of storage.

"Dorayaki" showed the best shelf life in KOP/PE pouches with FOA and showed no visually apparent aberration during the 15-day storage (Table 2). KOP/PE pouches without FOA, however, showed slight swelling (5th day), discoloration (11th day) and microbial growth (11th day). PE pouches with FOA showed shrinkage on the 10th day. Slight microbial growth was observed on the 11th day, which developed subsequently. The samples packaged in PE pouches without FOA showed discoloration, as well as microbial growth on the 10th day.

Shrinkage was observed in all pouches in the case of "ayu", thereby indicating higher rate of oxygen uptake by the in-package food (Table 2). As expected, samples packaged with FOA in PE pouches showed maximum shrinkage. There was no microbial growth on samples packaged with FOA in PE pouches. Only slight microbial growth was observed on the 13th day in samples packaged with FOA in KOP/PE pouches. Microbial growth was, however, observed on the 12th day on all packages containing no FOA.

Physical examination clearly showed that the storage life of traditional sweets depended upon: (a) the moisture content/water activity of the sample, (b) presence/absence of oxygen in the pouch, and (c) gas/water permeability of the pouch's film. Thus, it was observed that FOA not only delayed the onset of microbial growth, it also retarded the rate of microbial growth. FOA also prevented the swelling of packages in all cases, except in the case of "Mizuyokan", in which case it was only able to retard it. However, FOA was not helpful in avoiding deteriorative changes not involving oxygen, e.g. texture loss, non-oxidative discoloration, anaerobic fermentation etc.

In the absence of FOA, KOP/PE pouches did not show any special advantage over PE pouches in parameters determined during the present studies. Sweating was more extensive. Swelling was also observed in some cases. Microbial growth was even more pronounced in KOP/PE pouches containing "Mizuyokan", as compared with the corresponding PE pouches. PE pouches with FOA, however, showed pronounced shrinkage and disfigurement.

Composition of Head-space Gases. – The analysis of head-space gases as presented in Table 3 represents the percentage of the residual gases in the head space. It has different significance for KOP/PE pouches (low gas permeability) and PE pouches (high gas permeability). All the pouches initially had air in their head space with the following composition:

Nitrogen:	78.66%
Oxygen:	21.16%
Carbon dioxide:	0.18%

In all the KOP/PE pouches containing FOA, the level of oxygen fell below the detectable limits within the first 5 days, except in the cases of "Kimishigure", where the decrease was more gradual probably due to slow release of absorbed oxygen present in the sample. The presence of small amounts of residual oxygen in other samples after 10 days of storage was due to delayed release of absorbed oxygen due to the firm textures of those varieties. The percentage of nitrogen was raised above 97% in the first 5 days and this level was either maintained or improved on further storage in all cases except "Mizuyokan", in which case the percentage of nitrogen decreased due to the formation of large volumes of carbon dioxide by anaerobic fermentation. "Dorayaki" also produced small volumes of carbon dioxide. Thus, these two traditional sweets have compositions amenable to anaerobic fermentation, especially "Mizuyokan". Hydrogen was found present in the headspace of only these pouches as provide an anaerobic atmosphere. Generally speaking, the percentage of hydro

Table 3. Composition of the head space gases (%)

Sample		A			B			C			D			E		
POUCH	GAS	5	10	15	5	10	15	5	10	15	5	10	15	5	10	15
KOP/PE	O_2	2.14	0.53	0.16	—	1.04	Tr	—	0.08	—	—	0.34	—	—	—	—
+ FOA	N_2	97.48	98.78	98.97	99.59	98.32	99.21	99.45	69.41	21.40	99.32	98.72	98.99	99.27	99.13	99.61
	CO_2	—	—	—	—	—	—	—	30.51	78.60	0.24	0.32	0.35	—	—	—
	H_2	0.38	0.69	0.87	0.41	0.64	0.79	0.55	—	—	0.44	0.62	0.66	0.73	0.87	0.39
KOP/PE	O_2	20.78	20.35	18.80	21.03	21.01	20.83	13.47	—	Tr	18.74	15.83	15.40	20.30	19.97	20.28
	N_2	78.96	79.18	78.58	78.83	78.77	78.86	74.40	32.93	13.30	78.49	76.80	76.15	79.20	79.27	78.84
	CO_2	0.26	0.46	2.62	0.14	0.22	0.31	12.13	67.07	86.70	2.77	7.37	8.45	0.50	0.76	0.88
	H_2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
PE	O_2	4.71	19.25	19.36	2.47	19.97	21.14	3.52	2.81	5.12	2.94	16.47	18.54	3.55	18.16	19.40
+	N_2	95.29	80.75	79.92	97.53	80.03	78.86	95.56	59.73	61.30	96.98	83.38	80.60	96.45	81.84	80.41
FOA	CO_2	—	—	0.72	—	—	—	0.92	37.46	33.58	0.08	0.15	0.86	—	Tr	0.19
	H_2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
PE	O_2	21.21	21.09	20.92	21.20	21.15	21.11	17.77	7.34	9.49	20.83	20.75	20.50	21.17	21.09	20.45
	N_2	78.63	78.91	78.89	78.80	78.85	78.89	79.33	62.88	63.59	78.81	78.86	78.94	78.83	78.69	79.02
	CO_2	0.16	Tr.	0.19	Tr.	Tr.	—	2.90	29.78	26.92	0.36	0.39	0.56	Tr.	0.22	0.53
	H_2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Tr. = Trace.

gen was small and gradually increased with the passage of time.

Decrease in the percentages of oxygen and nitrogen in the headspaces of KOP/PE pouches (without FOA) appeared to be linked with the rate of carbon dioxide formation. All samples produced carbon dioxide, even those which could not produce carbon dioxide anaerobically (in the presence of FOA). The rates of formation of carbon dioxide in case of "Mizuyokan" and "Dorayaki" were also increased.

Due to high gas/moisture permeability of the pouch material, PE pouches gave a different picture of the composition of the headspace gases. As expected, the percentage of oxygen in pouches containing FOA first decreased and then increased due to a comparatively much faster elimination of nitrogen because of its higher partial pressure than ambient environment [6]. The only exception to this general phenomenon was observed in case of "Mizuyokan", where the oxygen was reduced due to the formation of large volumes of carbon dioxide. FOA was effective in restricting the formation of carbon dioxide in other cases.

Throughout the storage period, oxygen and nitrogen levels in the headspace of PE pouches (without FOA) were maintained at 21 and 79% respectively for all samples except "Mizuyokan". The reason for that anomaly has been already discussed. These samples had lower percentages of carbon dioxide in their headspaces as compared to the samples packaged in KOP/PE pouches. This was caused by permeation of carbon dioxide through the PE pouches.

In conclusion, it can be said that KOP/PE pouches with FOA protected the sweet samples best. Oxygen was totally removed from the pouches. The headspaces contained 99% nitrogen. Microbial growth was either totally absent or slight microbial growth was evidenced only after 13 days' storage. The pouches kept their shapes. The only exception was in case of "Mizuyokan", in which case large volumes of carbon dioxide were produced thus causing swelling. Small volumes of carbon dioxide were also produced in the pouch containing "Dorayaki", but that in no way affected the appearance of the pouches. KOP/PE pouches without FOA contained more carbon dioxide in the headspaces than the corresponding PE pouches without FOA at all intervals of time. Thus in the absence of FOA, KOP/PE pouches were not found preferable to PE pouches. The use of FOA in PE pouches caused extensive distortion of the shape due to shrinkage. Thus, KOP/PE in combination with FOA was found to be an ideal packaging system for the traditional Japanese sweets.

A new and novel system has been tried for the packaging of traditional sweets. Further work in this direction would open new vistas in the field of packaging of traditional sweets.

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