Storage of Green Tea by the Use of Various Packaging

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Great changes have been occurring in the marketing and form of consumption of foods according to changes in the mode of living. Changes in the food packaging are particularly remarkable due to the development of packaging materials and machines. As to the tea packaging in retail sales, the traditional use of paper bags or tea cans has decreased while the use of plastic films has increased (Plate 1). Materials for packaging films are cellophane, paper, polyethylene, polypropylene, polyvinylidene chloride, vinylon, aluminum foils, etc. Each of them has its own merit and demerit, so that they are used as laminated forms, with combinations complementing each other. As a result, there are so many kinds of packaging films. Therefore, in selecting the film for use, preservation of tea quality and economic aspects have to be taken into consideration. With the purpose of selecting plastic films suitable for packaging green tea, (1) damp-proofness, (2) nitrogen gas permeability, (3) odor permeability, etc. were examined. The result will be reported below:

Plate 1. Plastic film pouches for tea packaging

Damp-proof packages by various films

It is known that moisture contents as well as temperature changes exert the greatest influence to the quality deterioration of green tea[1]. Therefore, the practical damp-proofness was examined with films now being commercially used as well as those possibly to be used, such as multi-layer film laminated with aluminum foil, polypropylene film coated with polyvinylidene chloride, and cellophane-polyethylene lamination film (Table 1). Bags with surface area of 45 cm^2 were made with these films, and high-grade green tea of 45 g was put into each of these bags and sealed. After the storage for 1, 2 and 3 months under the condition of 25°C and 80% relative humidity, quality assessment was made by sensory tests and analysis for water content and vitamin C.

Result is shown in Table 2. The quality preservation was best with multi-layer film laminated with aluminum, followed by polypropylene film coated densely with polyvinylidene chloride. Cellophane-polyethylene lami-

Table 1. Composition of plastic films

Film number	Composition
1	$OPP_{20\mu}/E_{15\mu}/AL_{7\mu}/E_{40\mu}$
2	P 58. 18 g/m^2/$AL_{10\mu}$/PC 20 g/m^2 coating
3	$OPP_{15\mu}/E_{13\mu}/AL_{7\mu}/E_{13\mu}$/P 45 g/m^2/$E_{25\mu}$
4	$C_{\#300}/AL_{9\mu}/E_{40\mu}$
5	$C_{\#300}/AL_{112\mu}/E_{40\mu}$
6	$C_{\#300}/AL_{15\mu}/E_{40\mu}$
7	$OPP_{20\mu}/PC_{2\mu}$ coating/$E_{20\mu}$
8	$OPP_{20\mu}/PC_{2\mu}$ coating/$E_{60\mu}$
9	P 64. 8 g/m^2/PC_4 28. 2 g/m^2 coating
10	$C_{30\mu}$/P 40 g/m^2/PC 25 g/m^2 coating
11	$C_{30\mu}/E_{13\mu}$/P 40 g/m^2/$E_{20\mu}$
12	$C_{30\mu}/OPP_{30\mu}/E_{20\mu}$
13	$C_{30\mu}/E_{13\mu}$/P 55 g/m^2/$E_{20\mu}$
14	$C_{30\mu}/E_{13\mu}$/P 40 g/m^2/$E_{20\mu}$

AL: Aluminum foil, C: Cellophane, E: Polyethylene, OPP: Biaxially oriented polypropylene, P: Kraft paper, PA: Nylon, PC: polyvinylidene chloride, PET: Polyester, PVA: Vinylon.

Table 2. Average of panel score for the quality of film-packed tea

Film number	30 days' storage	60 days' storage	90 days' storage
1	−0.6	−0.7	−0.6
2	−0.6	−0.5	−0.7
3	−0.5	−1.0	−1.3
4	−0.9	−1.2	−1.1
5	−1.0	−1.4	−1.4
6	−0.6	−1.2	−1.0
7	−0.7	−0.9	−1.6
8	−0.8	−1.9	−2.1
9	−0.7	−0.9	−1.2
10	−1.2	−1.7	−2.3
11	−1.1	−1.8	−2.8
12	−0.9	−1.8	−2.4
13	−1.8	−3.5	−4.0
14	−1.7	−2.9	−3.8

Note: Scoring scale for sensory test:
+1.0 slightly good
0 indistinguishable from the standard*
−1.0 slightly poor
−2.0 moderately poor
−3.0 very poor
−4.0 extremely poor
* The standard was nitrogen-packaged tea stored in a can at 5°C.

nation film was least effective: the quality deteriorated at about 1 month, and some of the samples became not suitable for drinking after 3 months. As this experiment simulated the storage during the unfavorable rainy season of Japan, the storage period may become longer under a low temperature and low humidity condition.

Samples, which were assessed that no quality change occurred by the sensory test, showed water contents less than 5.5% (5.0% after 1 month) and rates of residual vitamin C content more than 70%. On the other hand, samples assessed to be deteriorated in quality, showed water contents more than 6.0% and rates of residual vitamin C less than 70% There is a high correlation between residual vitamin C and quality change of sample tea as shown in Fig. 1, suggesting that the residual vitamin C can be used as a quantitative criterion for expressing quality deteriolation. A high correlation is also observed between residual vitamin C and water contents.

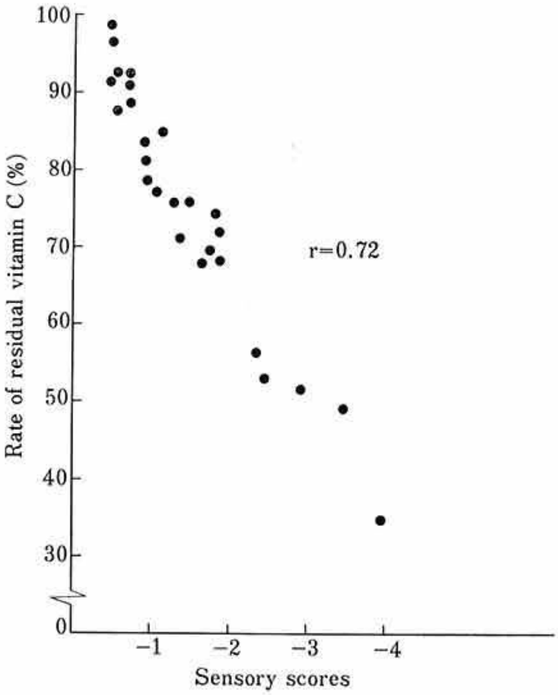

Fig. 1. Correlation between quality of tea and rate of residual vitamin C content

Table 3. Shelf-life of tea packed in plastic films

Shelf-life	Film number	Main component of film
Less than 10 days	13, 14	C, E
Less than 30 days	8	OPP, PC
	10	C, PC
	11	CE
	12	C, OPP, E
Less than 60 days	3	OPP, E, AL
	7	OPP, PC
	9	PC
Less than 90 days	1	OPP, PC, AL
	2	AL, PC
	4, 5, 6	AL, E

From these results, it can be said that moisture absorption is one of the cause of quality deterioration, and the moisture permeability of packaging materials is an important factor. In designing the damp-proofness, it may be enough to select films that can keep the moisture content of tea lower than 5.5% for a given storage period[2]. Table 3 shows performance of films used in the experiment. The most suitable one for green tea packaging is multi-layer film laminated with aluminum foil, and the next one is polypropylene film densely coated with polyvinylidene chloride. Cellophane-polyethylene film is not suitable except for a very short period packaging. In addition to these materials, 35 different plastic films were examined similarly and similiar result was obtained[3].

Nitrogen gas enclosed by flexible packaging materials

Green tea is refrigerated after manufactured, and consumed from time to time within a period of 1 year. It is said that the period from packaging to consumption is about 3 months. To keep the quality unchanged during this marketing period, not only the damp-proof management and temperature management, but also the prevention of oxidation of tea

Table 4. Composition of plastic films

Film number	Composition
1	$C/AL_{9\mu}/E_{40\mu}$
2	$C/AL_{12\mu}/E_{40\mu}$
3	$C/AL_{15\mu}/E_{40\mu}$
4	OPP/PC coating $_{22\mu}/E_{40\mu}$
5	P 49.1 g/m^2/$E_{15\mu}$/OPP/PC coating $_{18\mu}$ /$AL_{7\mu}/E_{50\mu}$
6	P 58.1 g/m^2/$E_{15\mu}$/OPP/PC coating $_{22\mu}$ /$AL_{7\mu}/E_{40\mu}$
7	$OPP_{15\mu}/PVA_{20\mu}/E_{40\mu}$
8	$PET_{12\mu}/E_{60\mu}$
9	$PA_{15\mu}/E_{60\mu}$

are necessary. The lower the oxygen tension in packages, the less is the quality change[4]. As a method for preventing the oxidation, it is generally practiced to substitute the air in packages by inert gases (N_2 gas, CO_2 gas, etc.). Metallic cans without gas permeability have been used as vessels, but they have economic and operational problems.

Therefore, an experiment was carried out, using plastic films which seem to have relatively low gas permeability: multi-layer film laminated with aluminum foil, vinylon film, polypropylene film coated with polyvinylidene chloride, etc. (Table 4). Bags with the surface area of 45 cm^2 were produced with these films, and 45 g of green tea were enclosed in each of them. Nitrogen gas was enclosed in the bags by using a machine shown in Plate 2. After the storage for 3 months at 25°C and 80% relative humidity, oxygen contents in the bags and moisture contents of tea samples were determined in order to examine the possibility of plastic film package containing nitrogen gas.

Oxygen contents in bags and water contents in tea are shown in Table 5 and 6, respectively. Almost no gas permeability was observed with multi-layer film laminated with aluminum foil, followed by multi-layer vinylon film and polypropylene film coated with polyvinylidene chloride. But all the films, except multi-layer film laminated with aluminum, foil, are considered not suitable for the use in this case

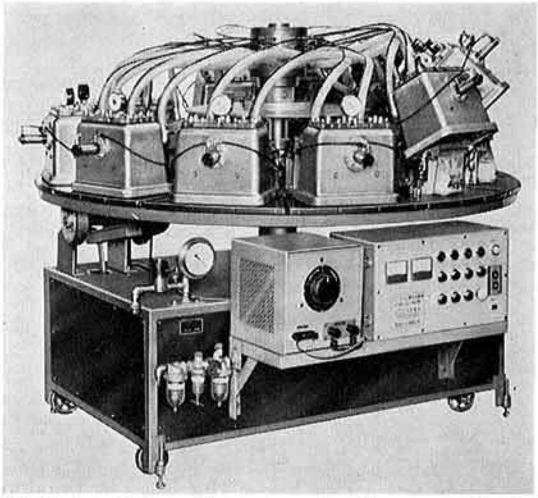

Plate 2. Automatic vacuum and gas packaging machine

Table 5. Moisture contents of stored tea

Film number	Storage period (days) 15	30	60	90
	%	%	%	%
1	3.0	3.0	3.0	3.0
2	3.1	3.1	3.1	3.1
3	3.1	3.1	3.0	3.1
4	3.3	3.9	4.3	4.7
5	3.1	3.1	3.1	3.0
6	3.1	3.1	3.1	3.0
7	3.1	3.5	4.1	4.3
8	3.1	3.9	4.7	5.2
9	3.0	3.5	4.5	5.1

Initial content = 3.00%

Table 6. Oxygen contents of head space gas in packages

Flim number	Storage period (days) 15	30	60	90
	%	%	%	%
1	0	0.2	0	0
2	0	0	0	0
3	0	0	0.1	0
4	0.4	1.1	1.5	2.0
5	0.2	0	0	0
6	0	0	0	0
7	0	0.2	0.2	0.6
8	6.3	9.3	10.6	13.1
9	7.0	9.3	11.5	13.6

that a long period storage is expected, because of their moisture permeability.

Even with the multi-layer film laminated with aluminum foil, which showed a good performance in the above test, there still remains a problem that the simple structured one has a fear of pinholes. The another experiment shows that 7μ in the aluminum foil thickness is good enough.

Large bags for transport use were made with films No. 5 and 6 in Table 4, that showed the best result in the above experiment. Using these bags, fall-down tests and transport tests by trucks (400 km) were carried out with the result of no trouble at all[5]. At present, this method is spreading rapidly for practical use.

Odor permeability of packaging films[6]

Consumers enjoy the flavor of tea, but the tea flavor is quite mild and apt to be spoiled by other odor. As a matter of fact, many examples have been known that the marketing

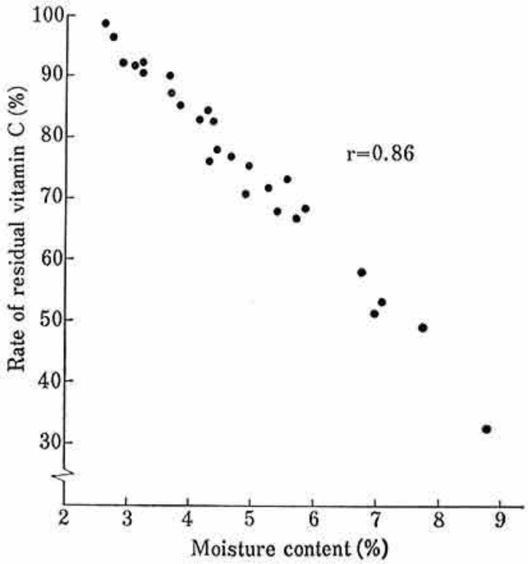

Fig. 2 Correlation between rate of residual vitamin C content and moisture content

Table 7. Olfactory evaluation for the ordor of n-butyl acetate in film-packed tea after 25 days' storage (6 judges and 2 replicates for each treatment)

Odor of n-butyl acetate	Film number*		
	1	2	3
None	12	11	
Slight		1	1
Moderate			3
Pronounced			8

* Film number 1 = P 58. 18 g/m^2/$E_{15\mu}$/(OPP/PC coating)$_{22\mu}$/$AL_{7\mu}$/$E_{49\mu}$
2 = $OPP_{20\mu}$/$PC_{2\mu}$ coating/$E_{60\mu}$
3 = $C_{18\mu}$/$E_{60\mu}$

value of tea was spoiled by being contaminated by fruit flavor. Therefore, the odor permeability is considered as an important factor in selecting packaging materials for green tea[7].

Samples of green tea were enclosed in bags made of multi-layer film laminated with aluminum foil, polypropylene film coated with polyvinylidene chloride, or cellophane-polyethylene lamination film, which showed best, better, and poor performance in the above experiment. These bags containing green tea were placed in desiccators together with butyl acetate at 25°C for 25 days. Gas in the head space of bags was analysed by gas-chromatograph and the odor of butyl acetate transferred to the tea sample was examined by sensory tests.

Gas chromatogram of head-space gas is shown in Fig. 3, which indicates no odor permeability of multi-layer film laminated with aluminum foil, and a few permeability of polypropylene film coated with polyvinylidene chloride, whereas an apparent peak with cellophane-polyethylene lamination film.

Results of the sensory tests are given in Table 7. No transfer of butyl acetate odor

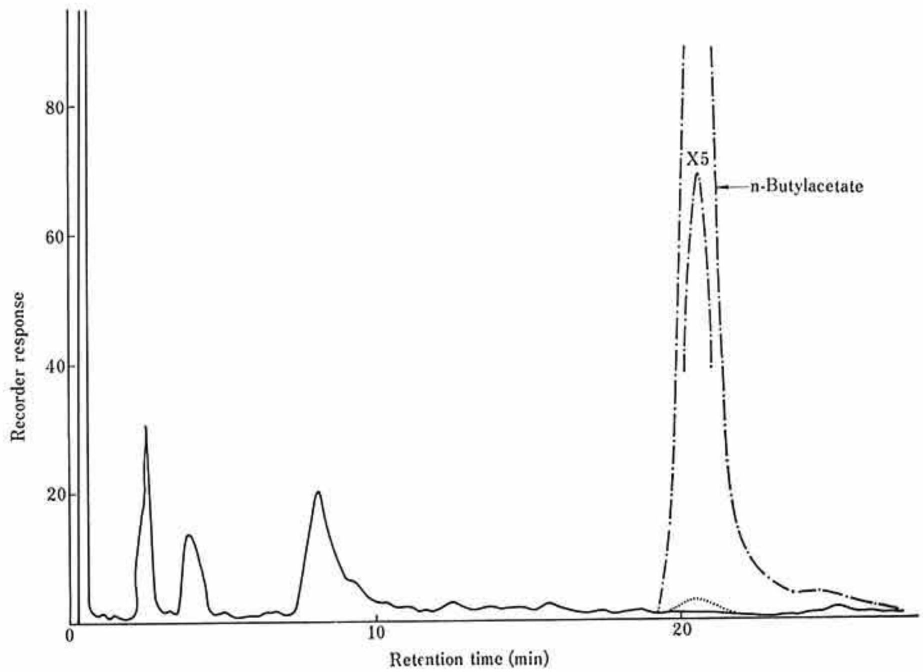

Fig. 3. Gas chromatogram of head-space gas of film-packed tea after 25 days' storage

———— : No. 1 film; .... : No. 2 film; —-—-—- : No. 3 film
Gas chromatograph: Hitachi K-53; Detector: FID; Column: PEG 1,000 3 mm × 2 m stainless steel; Column temperature: 70°C; Carrier gas: Helium 2.2 kg/cm^2.

was recognized with multi-layer film laminated with aluminum foil, almost no transfer with polypropylene film coated with polyvinylidene chloride but all test members recognized the odor not specific to tea with cellophane-polyethyleen lamination film. Thus, the use of the last film is risky and needs careful attention.

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