Organoleptic Evaluation Of Vacuum and Non - Packaged Frozen, Stored Beef Patties and Relationship Of These With the Fat Oxidation and Lipid Soluble Carbonyls

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SUMMARY

Some sensory characteristics, namely; general colar appearance and degree of freezer burn of raw, and flavor, rancidity, odor and general acceptability of very lean (7.5 %) beef patties were studied after frozen storage and cooking. Meat sample was obtained from a closely trimmed **semimembranosus** muscle of a normal fattaned, two years old steer carcass. Meat was ground and patties in 1.5-2.0 cm thickness were made by hand, and then vacum (VP) or non-packaged (NONP) and stored 3 days, 1.5, 3 and 4.5 monhts at -23$\mp$1°C. At the end of the each storage intervals evaluations were done by trained panel.

Sensory panel evaluation results indicated a steady decline in the acceptance of the beef patties during the frozen storage. However, mean value of the 8 trained judges for each characteristic never fell under the mid-point of 5 on the sensory scale of 1 to 9. The present work, ant the others previously reported elsewhere, indicated that hig quality ground beef, with the low fat percentage (7.5 %), could be stored at the freezing temperature of -23°C for up to 4.5 monhts, without any drastic changes in the sensory evaluation results. The sensory panel results of flavor, rancidity, odor and general acceptability of the NONP samples were not greatly different from the VP ones. But, the darkening of the color and high percentage of the surface freezer burn, especially after the 1.5 monhts of the frozen storage were the limiting factors of the storage period of the NONU beef patties.

1. INTRODUCTION

Much of the meat flavor and odor research with beef has been associated with either fresh and/or short term frozen storage. However, a significant portion of beef are frozen a year or longer. Research concerning the stability of the different lipid classes, their fatty acid composition, oxidation, accumulation of lipid soluble carbonyls, fatty acid percentages and their relation with the sensory evaluation of bovine muscle tissue during the frozen storage is very limited (Gokalp **et al.**, 1981 and 1983; Igene **et al.**, 1980; Kirova and Peshevska, 1982). The effects of lipid autoxidation and accumulation of lipid-soluble carbonyls on the flavor, odor, rancidity and general acceptability of the very lean red beef tissue during prolonged frozen storage, thawing and cooking have not been studied in detail either (Jakobsson and Bengstsson, 1972; Keller and Kinsella, 1973; Igene **et al.**, 1980).

Various workers have stated that tissue lipids are stable during frozen storage (**Keskinel et al.**, 1964; Witte **et al.**, 1970), however oxidation and breakdown of the neutral lipids (NL) and phopholipids (PL) have been observed in frozen muscle held at various temperatures for various storage times (Bosund and Ganrot, 1969; Keller and Kinsella, 1973; Gokalp **et al.**, 1981 and 1983). Keller and Kinsella (1973) and Igene **et al** (1980) suggested that changes in especially polyunsaturated fatty acids of PL fraction may result in the development of rancidity and serious flavor problems during frozen storage and subsequent cooking of meat and meat products. Although the percent of PL in beef muscle tissue is quitle low, but the susceptibility to autoxidation and development of oxidative rancidity makes them important in governing the quality i.e. off-flavor, off-odors and discoloration of beef tissue (Chipault and Hawkins, 1971; Igene **et al.**, 1980; Nakanishi and Suzama, 1967; Watts, 1962).

General color apperance, pigment oxidation and occuring of surface freezer burn are very important quality attributes in the frozen stored fresh meat and they are interchangeable related to the other quality characteristics. Workers (Greene, 1969; Igene **et al.**, 1980) have studied the pigment changes and lipid oxidation in frozen meats. Freezer burn is one of the principal problems in frozen meat. This is dehydration of the exposed surfaces and fading of the color (Cahil **et al.**, 1971). Frozen animal tissue sometimes produces a brightening of the color that changes with progressive storage from a whitish to an unsightly grayish-yellow apperance caused by alteration of the tissue to a condition described as spangy or corky and called freezer burn. The presence of even the early stages of freezer burn depreciates quality, later stages of it represent irreversible damage that remains after thawing but usually disppears after cooking, but might cause off-flavors and denaturation of the proteins (Snyder, 1965). If the freezer burn is more severe, it is then irreversible because of damage to the muscle enzyme systems and concentration of the tissue salts (Kaess and Weidemann, 1967).

The increased freezer-burned area of the tissue favors oxidative rancidity of the fats and the products of the fat oxidation may accelerate the oxidation of the heme pigments (Snyder, 1965). The higher freezing and storing temperatures produce high, high intensity of buarn, weight loss and evaporation, in comparison with the lower temperatures (Zachariah and Satterlee, 1973). The degree of freezer burn can suggest the approximate percent weight loss in stored meat. Weight loss during storage and extent of freezer burn are positively correlated (Kaess and Weidemann, 1967; Gokalp **et al.**, 1979). Significant positive correlations between freezer burn and 2-thiobarbituric acid (TBA) values (r= 0.74) off - glovor (r= 0.78) and significant negative correlation with flavor scores (r= 0.71) were found (Gokalp **et al.**, 1978 and 1979).

In the present investigation, the objective was to study and evaluate some sensory characteristics, namely; general color apperance and degree of freezer burn of raw, and flavor, rancidity, odor and general acceptability of coooked product and determine the correlations of these sensory evaluations with some aspects of fat oxidation, lipid soluble carbonyls and TBA values in choice grade muscle tissue converted into very lean beef patties and frozen stored under vacuum packaged (VP) and non-packaged (NONP) conditions.

In this work a great emphasis was given to organoleptic evaluations of the patties. Many quality attributes of food items could be effectively measured and determine by the physical and chemical analysis, but, yet there have not been any instruments developed to replace the human senses in evaluation of the certain quality characteristics i.e. color, flavor, odor, rancidity, texture, general acceptability, etc. (Deatherage, 1977). In the evaluation of the certian quality characteristics of food both objective and organoleptic analysis should be accomplished simultaneously, since, food is processed for human consumption (Gokalp **et al.**, 1979).

2. MATERIAL and METHODS

2.1. Materials

The present study was conducted concurrently with the research works, previously reported, qualitative alteration of PL (Gokalp **et al.**, 1981), fatty acids of NL and PL (Gokalp **et al.**, 1983) and lipid soluble carbonyl values (Gokalp, 1984); and used the same meat samples. The experimental design of these research projects was the same with the exception of four patties were assigned to each packaging treatment in the organoleptic evaluations and carbonyl works.

The **semimembranosus** muscle was removed from the round of a Choice Grade two years old steer carcass at I day postmortem. The internal temperature of the round had ceached 5±1°C. After removal of the external fat, the muscle was ground through a 0.32 cm plate. The fat percentage of this ground product was 7.5 % (ether extract). Removal of the outside fat layer increased the relative percentage of the intramuscular fat which is richer in PL than regular ground meat. Patties approximately 1.5 to 2.0 cm in thickness and weighing 200 g were formed by hand and randomly assigned to one of the experimental treatment, VP and NONP and frozen storage intervals of 3 days, 1.5, 3 and 4.5 months. The experimental design was a 2x4x4 factorial arrangement, total of 16 patties (4 replicates, each analyzed in duplicate) were stored for each packaging method, thus a total of 32 patties were worked on them.

Patties for VP were immediately placed in a single layer into Barrier Bags (Cry-O-Vac B-620). A vacuum of 560-610 mm. Hg was applied to gently draw the air from the bags and sealed with clips. All samples, VP and NONP, were placed in a single layer in cardboard boxes which had the bottom lined with freezer paper. Boxes were then placed in a -23 ± 1°C laboratory-type upright freezer.

2.2 Thawing of the Samples

At the end of the storage time intervals, patties from both packaging treatment were removed from the freezer and thawed in a 3 ± 1°C refrigerator. The NONP samples were thawed in unsealed barrier bags. Thawing was completed in 24 - 28 hr.

2.3 Color and Organoleptic Evaluation

Thawed samples were taken from the bags, exposed to air under laboratory conditions to «bloom» 30 min. Samples were randomly arranged on a white paper for the Judges' evaluation. Each sample was scored by 8 trained Judges for color and percent of surface discoloration (primarily freezer burn) using the Hedonic type scoring system (Figure 1).

After the color evaluation patties were placed on small aluminum foil trays and cooked in an electric oven (165-170°C), Juice was retained in the trays during cooking. The patties were cooked to an internal temperature of 68°C which resulted in an interior color of light brown, and an exterior showing some browning. After cooking, one patty was removed from the oven and served while still warm. The other patties were held in the open oven and quickly served while they were still warm. Each patty was cut lengthwise once and crosswise 3 times to obtain 8 pieces for 8 panel members. The samples were evaluated on a 9 point scale for flavor, rancidity, odor and general acceptability (Figure 2). For the sensory panel evaluation, different code numbers were used for patty identification so that the Judges would not be influenced by the appearance of the uncooked samples.

3. RESULTS and DISCUSSION

3.1 Visual Evaluation of Colorand Freezer Burn

The mean values of visual color evalution results for each packaging method at the various frozen storage intervals are displayed in Figure 3. The mean value for each packaging method did not show a big difference at the end of 3 days storage. The vlriation among the two packages increased as the storage time progressed. From the analysis of variance results, a highly significant ($P < 0.01$) storage time X packaging method (T X P) interaction was observed. While the color scores of VP showed a stability throughout the frozen storage period. NONP samples indicated a darkening and unacceptable beef patty appeareances at the 45 days of storage and continued to give almost the same undesirable color scores at the 90 and 135 days of storage period. Oxygen impermeable film and application of vacuum reduced the direct tension of atmospheric oxygen and so reduced pigment oxidation in those samples (Chipault and Hawkins, 1971).

There were significant ($P < 0,05$) correlations between the color scores and total unsaturated fatty acid (UFA) of NL ($r = -0.48$), and highly significant ($P < 0.01$) with total UFA of PL ($r = -0.55$) These negative correlations indicated that while the percent of UFA become smaler due to the autoxidatian, the color scores yield higher values of dark and unacceptable appearance. Many researchers (Hirano and Olcott, 1971; Love and Pearson, 1974) have pointed out that the autoxidation of meat pigment and lipids were interrelated chemical reactions, but the exact pattern needs more studying. There were highly significant correlations between panel color and flavor, rancidity, general acceptability and TBA values but was not bet ween color and odor scores (Table 1 and 2). In the tables, some of the correlations between the color, freezer burn and other quality attribuates gave negative values because of the construction of the visual appearance scale and sensory evaluation sheets.

FROZEN BEEF PATTY EVALUATION

Judge's Name : ____________ Sample No : ____________ Date : ________

Uncooked Product

Color

Dark, not desirable — Cherry red, desirable — Very ligh, not desirable

9 8 7 6 5 4 3 2 1

Surface freezer burn

No burn — Very intense burn

0 % 25 % 50 % 75 % 100 %

Comments : ____________

Figure 1. Color evaluation score sheet.

FROZEN BEEF PATTY EVALUATION

Judge's Name : ____________ Sample No : ____________ Date : ________

Flavor

Desirable — Not desirable

9 8 7 6 5 4 3 2 1

Rancidity

No rancidity — Extra rancid

9 8 7 6 5 4 3 2 1

Odor

Desirable — Non desirable

9 8 7 6 5 4 3 2 1

General Acceptability

Very acceptable — Non-acceptable

9 8 7 6 5 4 3 2 1

Comments ____________

Figure 2. Sensory panel evaluation score sheet.

The data obtained from the evaluation of the percent surface freezer burn are presented in Figure 4. As in seen from the percent of freezer burn area is larger in the NONP sample than the VP at any given storage period. No freezer burn area was observed in the VP samples compared to a 32.90 % in the NONP samples at 45 days of storage. After 45 days, the percent area of freezer burn increased almost linearly and reached a value of 47.14 % and 24.72 % respectively in the NONP and VP beef patties. The F - test indicated a significant ($P < 0.05$) effect of T X P interaction of the freezer burn. Since, freezer burn is the dehydration of the exposed surface and fading of the color of frozen meat vida oxidation (Cahill **et al.**, **1971**), the VP with a very low water vapor transmission film minimized the sublimation and accumulation and the oxidation of the pigment at the surface of the meat and more effectively controlled the freezer burn.

Some of the important correlations between freezer burn and other quality characteristics are shown in Table 1. The significant correlations between freezer burn and total lipid - soluble carbonyls ($r = -0.63$), monocarbonyls ($r = -0.43$), rancidity ($r = -0.77$) and TBA ($r = 0.52$) are the indication of the affect of the pigment regression on lipid oxidation in the frozen meat. There were also highly significant ($P < 0.01$) correlations between freezer burn area and total UFA of PL ($r = -0.70$) and total UFA of NL ($r = -0.63$) (Table 2). The increased freezer burned area of the tissue allows oxygen penetration and favors autoxidation of lipids, and the products of fat oxidation may accelerate the oxidation of the heme pigments (Greene, 1969; Snyder. 1965; Watts, 1962).

3.2. Sensory Panek Evaluation of Flavor

Mean values of the 8 judges for flavor scores are graphed in Figure 5. There is a steady decrease in flaver scores for both samples, VP and NONP, from 3 days to 135 days of storage. The result of F - test indicated that there was a highly significant ($P < 0.01$) packaging effect on flavor scores. The mean values of VP patties, at any storage time, were always higher and indicating more acceptable flavor attributes than the NONP patties. As seen from the figure, the effect of storage time in linear and highly significant at the $P < 0.01$ level.

There were highly significant ($P < 0.01$) correlations between flavor and other sensory characteristics of the patties (Table 1). The flavor scores were significantly ($P < 0.05$) correlated with TBA values ($r = -0.55$), but odor, rancidity and general acceptability scores were not significantly ($P < 0.05$) correlated with the TBA values. In Table 2 some significant correlations between flavor and some UFA of NL and PL are shown. These positive correlations, between the percent of UFA and flavor, indicate that while the percent of UFA, especially in the PL fraction become lower the flavor acceptability of the beef patties declined.

3.3. Sensory Panel Evaluation of Rancidity

Figure 6 displays the panel rancidity scores. Declining of the scores at the end of the storage, which is the indication of the higher rancidity than the beginning, is quite similar to the flavor scores. However, there is a sharp decline after the 90 days of storage. These effects of the storage time on the rancidity scores were found to be significant ($P < 0.05$). The NONP samples always gave lower mean values and so indicating higher rancidity than the VP samples at every storage intervals, but these differences were not found to be significant at $P < 0.05$ level.

Some of the important correlations with the rancidity scores are listed in Table 1 and 2. As seen from the tables, total carbonyls, monocar - bonyls and methyl ketones were significantly correlated with the rancidity scores. Total UFA of PL ($r = 0.77$) and NL ($r = 0.63$) were significantly ($P < 0.01$) correlated with the rancidity scores. There correlations indicate while the percent of these UFA decreased the intensity of the undesirable rancid flavor increased.

3.4. Sensory Panel Evaluation of Odor

Mean values of the sensory panel odor evaluation are seen in Figure 7. As can be seen from the figure, the packaging methods did not show a significant ($P < 0.05$) effect on the odor scores. The NONP samples gave slightly higher acceptable odor responses comparing to the VP samples at 90 and 135 days of storage. The reason for these is unclear to us at this point, but in could be caused by the predominant multiplication of facultative anaerobes and so deterioration of certain quality attributes and increase of off - odors and off - flavors (Christopher **et al.**, 1979). On the odor scores, the relative concentration of methyl ketones which showed the similar trend with the odor scores in the VP and NONP samples (Gokalp, 1984) and gives the minty, fruity, sweet and oily taste and odor, could be an influential factor too. A highly significant ($P < 0.01$) effect of storage time was observed on the odor scores. The desirability of the odor responses of the both samples, VP and NONP, declined from 3 days to 135 days of storage.

For some of the correlations, between the odor scores and the other quality characteristics, see Table 1 and 2.

3.5. Sensory Panel Evealuation of General Acceptability

The sensory panel data for general acceptability are presented in Figure 8. The general acceptibility of the two packaging methods followed almost the same trend as odor scores (Figure 7). A highly significant ($P < 0.01$) quadratic effect of storage time was observed on the general acceptability scores, but packaging method did not significantly ($P < 0.05$) influence on the general acceptability of these beef patties.

If we consider 5 as the mid - point between the acceptable and unacceptable phenomena for the sensory panel evaluation scores, none of the panel quality characteristics; flavor, odor, rancidity and general acceptability fell below this critical point of 5 at any storage intervals.

The correlations between general acceptability and some other characteristics are given in Table 1 and 2. The decreases in the percent of $C_{18:1}$ and $C_{20:4}$ fatty acid of PL and $C_{18:1}$ of NL were significantly correlated with the general acceptability values. The total UFA of PL and NL levels were also significantly correlated with the general acceptability scores too.

3.6. Conclusion

Sensory panel evaluation for flavor, rancidity, odor and general acceptability results indicated a steady decline in the acceptance of the beef patties during the frozen storage period. However, mean value of the 8 Judges for each characteristic never fell under the mid - point of 5 on the sensory scale of 1 to 9.

The present work and the others previously reported elsewhere (Gokalp **et al.**, 1981 and 1983; Gokalp, 1984) indicated that high quality ground beef with the low fat content (7.5 %) could be stored at the freezing temperature of —23°C for up to 4.5 monhts, without any drastic changes in the sensory

Table 1. Simple Correlations Among Some Of The Dependent Variables of Beef Patty Quality Attributes

	Color	Freezer burn	Flavor	Rancidity	Odor	General acceptability
2, 4 - dienals	0.40*	0.16	—0.09	0.09	0.05	0.20
Methyl ketones	—0.07	—0.36	0.46*	0.48*	0.50*	0.55**
Monocarbonyls	—0.31	—0.43*	0.48*	0.59**	0.43*	0.60**
Total carbonyls	—0.45*	—0.63**	0.74**	0.69**	0.73**	0.67**
General acceptability	—0.41*	0.72**	0.90**	0.95**	0.95**	
Odor	—0.39	—0.71**	0.91**	0.93**		
Rancidity	—0.52**	—0.77**	0.92**			
Flavor	—0.65**	—0.86**				
Freezer burn	0.87*					

** : Highly significant ($P < 0.01$)
* : Significant ($P < 0.05$)

panel evaluation of the cooked product. The sensory panel results of flavor, rancidity, odor and general acceptability of the NONP samples were not greatly different from the VP ones, But the darkening of the color and high percentage of the surface freezer burn especially after the 1.5 monhts of the frozen storage, and possible higher weight loss due to thl sublimation during the entire storage (Gokalp **et al.**, 1979) were the limiting factors of the storage period of the NONP samples.

We believe more research work are still needed in some chemical quality characteristics as well as in the sensory panel characteristics of the frozen stored beef patties containing varying amount of fat and stored for different period. The different kind of packaging film with and without vacuum application, controlled atmosphere packaging and the longer frozen storage time than the ones used here should be studied on the beef patty storage works.

Table 2. Simple Correlations Of Some Fatty Acids Of NL And PL With Some Visual And Sensory Attributes Of Beef Patties

	Color	Freezer burn	Flavor	Rancidity	Odor	General acceptability
N. C14:1	—0.41*	—0.58**	0.66**	0.51*	0.53**	0.48*
N. C16:1	—0.36	—0.70**	0.85**	0.80**	0.81**	0.81**
N. C18:1	—0.34	—0.36	0.26	0.32	0.28	0.25
N. C18:2	—0.23	—0.29	0.42*	0.26	0.31	0.20
N. C18:3	0.14	0.22	—0.19	—0.27	—0.18	—0.35
N. Total UFA	—0.48*	—0.63**	0.64**	0.63**	0.62**	0.55**
P. C16:1	—0.53**	—0.44**	0.42*	0.24	0.24	0.09
P. C18:1	—0.41*	—0.60**	0.76**	0.71**	0.76**	0.68**
P. C18:2	—0.07	—0.07	0.22	0.12	0.11	0.01
P. C18:3	—0.42*	—0.57**	0.69**	0.64**	0.76**	0.64**
P. C20:3	—0.38	—0.45*	0.39	0.25	0.34	0.32
P. C20:4	—0.56**	—0.71**	0.66**	0.48**	0.56**	0.54**
P. Total UFA	—0.55**	—0.70**	0.77**	0.63**	0.65**	0.59**

N = neutral, P = phospho, UFA = unsaturated fatty acid

** : Highly significant ($P < 0.01$)

* : Significant ($P < 0.05$)

ÖZET

Vakum (VP) uygulanarak paketlenmiş ve paketlenmemiş (NONP) ve —23∓ 1C° de 3 gün, 1.5, 3 ve 4.5 ay süre ile depolanmış, iyi kalitede ve düşük yağ oranlı (% 7.5) sığır kıymasından yapılmış hamburgerlerin, pişirilmeden önce genel renk görünümleri ve yüzeysel don yanığı dereceleri ve pişirildikten sonra ise, tat, yağ oksidasyonundan dolayı olan acılaşma (rancidity), koku ve genel kabullenme değerleri, 8 kişilik eğitilmiş panel tarafından değerlendirilmiştir. Et örneği orta derecede yağlı 2 yaşlı tosun karkasının **semimembranosus** kasından sağlanmış, kas üzerindeki fazla yağ iyice ayrılmış, kıyma haline getirilmiş ve 1.5 - 2.0 cm kalınlıkda hamburgerler yapılmıştır.

Panel neticeleri, depolama süresince hamburgerlerde ransiditenin devamlı yükseldiğini, tat, koku ve genel kabullenmenin ise devamlı düşüş gösterdiğini belirtmiştir. Fakat bu özellikler, 1'den 9'a kadar verilen rakamsal değerlerde hiçbir zaman orta değer olan 5'in altına düşmemiştir. Bu çalışma ve buna paralel olarak yürütülen ve neticeleri başka yerlerde açıklanan çalışmaların sonuçları, düşük yağ oranlı ve iyi kaliteli sığır kıymasından yapılmış hamburgerlerin —23 ∓ 1°C de 4.5 ay süreye kadar özelliğinde pek büyük değişiklik olmadan depolanabilieceğini göstermektedir. Fakat, paketlenmemiş örneklerde oluşan renk bozuklukları ve ileri derecedeki yüzeysel don yanığı ve oluşacak yüksek fire düzeyi bu hamburgerlerin depolanma süresini limitliyen en önemli faktörlerdir. Bu nedenle, uygun bir paketlemeye ihtiyaç duyulacaktır.

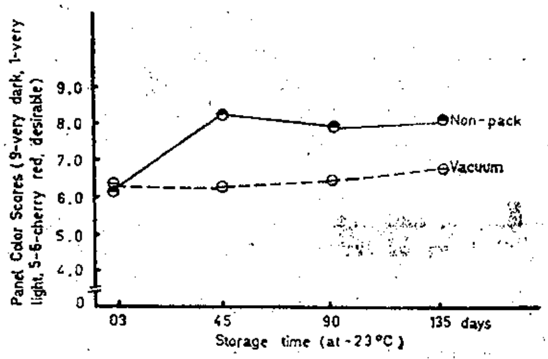

Figure 3. Effect of packaging on color during storage as measured by panel.

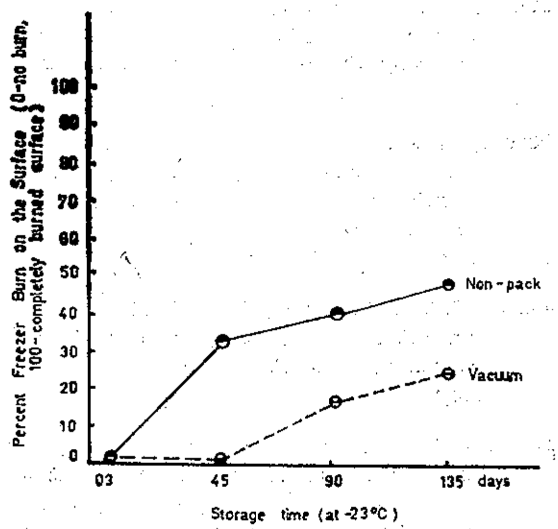

Figure 4. Effect of packaging on surface freezer burn during storage as measured by panel.

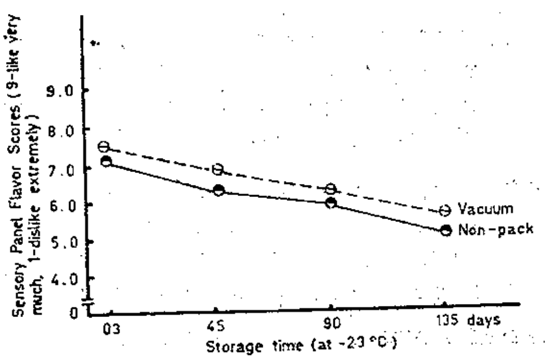

Figure 5. Effect of packaging on flavor during storage as measured by panel evaluation.

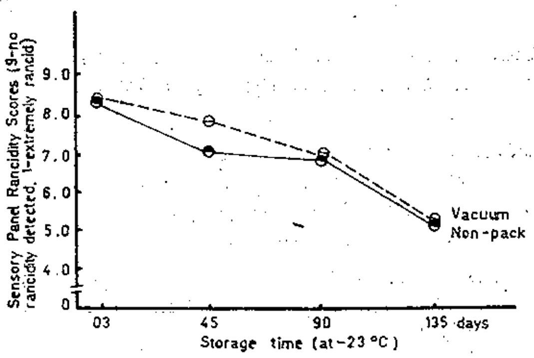

Figure 6. Effect of packaging on rancidity scores during storage as measured by panel.

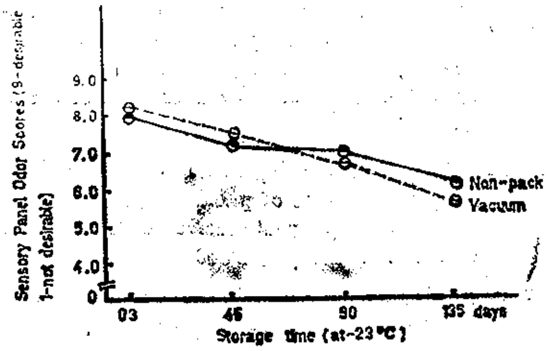

Figure 7. Effect of packaging on odor scores during storage as measured by panel.

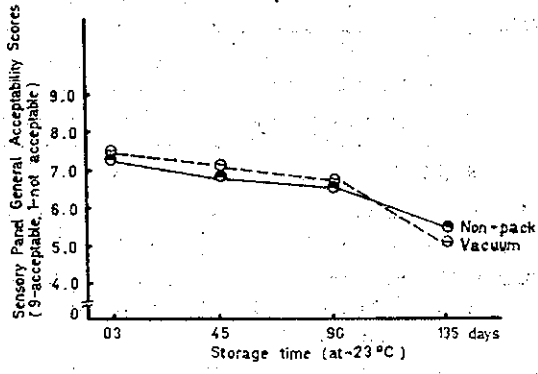

Figure 8. Effect of packaging on general acceptability during storage as measured by panel.

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