EFFECT OF VARIOUS HOME FREEZER WRAPS ON FROZEN GROUND PORK

by

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INTRODUCTION

Freezer storage of meats has become an important method used by consumers to preserve the quality of purchased meats. According to Williams (1966) about 80% of all red meat bought in the supermarket is later frozen at home. Many types of wraps designed for use in the freezer have been developed as a result of this trend.

During frozen storage chemical and physical changes may occur in meats. These changes include the development of oxidative rancidity, moisture loss, changes in pH, and color changes often associated with freezer burn or oxidation.

A major problem in meats is the development of oxidative rancidity which is caused by the accumulation of carbonyl compounds formed during autoxidation of muscle lipids (Ackman et al., 1967; Awad et al., 1968 and 1969). During oxidative decomposition of highly unsaturated fatty acids, aldehydes and acids of lower molecular weight are formed. Malonaldehyde, a three carbon compound resulting from such a breakdown, reacts with thiobarbituric acid to give a red pigment (Sinnhuber et al., 1958). This reaction allows us to test for malonaldehyde in meat products, thus determining the amount of rancidity. The thiobarbituric acid (TBA) test is quite useful as it can be correlated well with sensory evaluations (Sidwell et al., 1955; Turner et al., 1954; Younathan and Watts, 1959).

Color is known to develop through definite changes depending upon the status of the pigment myoglobin (Mb) (Brooks, 1929). Immediately after a cut surface is exposed to air, the purple-red color of deoxymyoglobin is seen. Upon exposure to air, the meat surface will become increasingly red in color; this form of the pigment is known as oxymyoglobin (MbO_2). The pigment eventually will oxidize to metmyoglobin (Mb+) which is a brown or gray color. A HunterLab Spectrophotometer may be used to measure color by selecting an illuminant to compute color values. The L, a, and b scales give measures of color in units of approximate visual uniformity throughout the solid color. L measures lightness and varies from 100 for perfect white to 0 for black. The a-scale measures redness when positive, gray when zero, and greeness when negative. The b-scale measures yellowness when positive, gray when zero, and blueness when negative. The CIE L-, a-, and b-scale is a simplified cube root version of the Adams-Nickerson space that is produced by plotting in rectangular coordinates the quantities of CIE L-, a-, and b-values (Instruction Manual, HunterLab, 1979).

Packaging material is used as a protective device for meats in frozen storage. Without a suitable packaging material oxidative rancidity, moisture loss, and changes in color may occur. A freezer wrap often used is a moisture-vapor-proof type of material. This type of wrap acts as a barrier between the meat and the freezer environment. The moisture-vapor-proof wrapping material prevents moisture from the meat from being lost into the environment (Palmer et al., 1953) and excludes oxygen in the environment from coming in contact with the meat (Hiner et al., 1951). The exclusion of oxygen should slow down oxidative rancidity as well as the pigment changes mentioned above.

Little work has been found on the effectiveness of recently developed freezer packaging materials in protecting meats during freezer storage. The purpose of this study was to investigate the effectiveness of selected packaging materials on the protection of ground pork with regards to oxidative rancidity, changes in pH, changes in color, and total moisture content over selected periods of time at a constant temperature.

LITERATURE REVIEW

OXIDATIVE RANDICITY

Oxidative rancidity can be affected in several ways. Rhee et al. (1983) found that regardless of the storage temperature, sodium chloride and magnesium chloride increased rancidity of both raw and cooked samples of ground pork. TBA values of samples containing chloride salts were 15 to 40 times higher than those of control samples with no chloride salt added. The prooxidant effect of salt is indeed well known (Chang and Watts, 1959; Ellis et al., 1968; Judge and Aberle, 1980).

Maraña et al. (1980) found that storage temperatures affected rancidity development in selected pork cuts packaged in polyethylene bags without vacuum. At 4.4° C minimal oxidation and hydrolysis of the unsaturated fatty acids occurred during the first four days, but those changes became prominent during the later stages of storage. All pork cuts, including ground pork, stored at temperatures of -7°C and -18°C did not exhibit significant changes in rancidity development until the sixth month of storage. At fluctuating temperature storage (-18 to 27°C), free fatty acid values and peroxide values increased, suggesting that lipolysis and lipoxidation advanced with prolonged storage. Earlier,Simpson and Chang (1954) found that a low freezer temperature slowed the development of rancidity.

High pH is associated with inhibition of lipid oxidation in stored meat (Keskinel et al., 1964; Owen and Lawrie, 1975). Yasosky et al. (1984) found that samples from pigs receiving antemortem epinephrine injections (to manipulate ultimate post-mortem pH) had a high pH (>6.10). The samples, which were ground, had lower TBA values than did low pH samples. Evidence suggests that the inhibition of oxidative rancidity may be the result of pH effects on metal catalysts (Liu and Watts, 1970; Love and Pearson, 1974; Tay et al., 1983). Wills (1965) showed that iron, manganese, cobalt, and copper, all of which are present in varying concentrations in muscle tissue, are catalysts of lipid oxidation.

Younathan and Watts (1959) found that the oxidative reaction is greater in cooked uncured meat than in cured meats. They found that cured meats could be held at refrigerator temperatures for a longer period of time before tissue rancidity was noted. Younathan and Watts (1959) suggested that the ferric form of the hemochromogen is the active catalyst in tissue rancidity. Just after curing all pigment is present in the ferrous form. Earlier work reviewed by Watts (1954) showed that the catalytic effect of hemoglobin and other iron porphyrins on the oxidation of lipids resulted in the destruction of pigments present as well as oxidation of the fat. Judge and Aberle (1980) found that dark porcine muscle had higher TBA numbers after storage than did light porcine muscle. They suggested that the heme proteins are major catalysts to lipid oxidation. Tappel (1952), Watts (1954), Younathan and Watts (1959), and Maier and Tappel (1959) agreed with this. The higher quantity of pigments in dark muscle over light muscle could explain the result. However, Allen et al. (1967) reported that dark porcine muscles exceeded light muscles in content of phospholipids, the major contributor of oxidized flavor in cooked meat (Igene and Pearson, 1979). This, too, could be a reason. Yasosky et al. (1984) concluded that metmyoglobin was not an active catalyst of lipid oxidation in a high pH raw meat system, because the inhibition of oxidation was apparently a direct result of high pH rather than the reduction of metmyoglobin to the non-catalytic myoglobin form. The data also cast doubt on the proposition that metmyoglobin catalyzed lipid oxidation in fresh, refrigerated meat products.

Keskinel et al. (1964) found that grinding of meats increased TBA numbers. This was attributed to the increase in surface area and the incorporation of air into the meat during grinding.

Oxidative rancidity occurs quite often in ground pork stored in the freezer (Naumann et al., 1951; Simpson and Chang, 1954; Hiner et al., 1951; Turner et al., 1954). However, like any other chemical reaction, the oxidation rate would be expected to be lower than for meat stored at refrigerator temperature. Keskinel et al. (1964) attributed this to the better passage of dissolved oxygen in unfrozen tissue fluids than in the frozen flesh. Hiner et al. (1951) found samples of meat protected from air by vacuum packaging at all temperatures had small and nearly equal decreases in desirability of flavor of the fat and the lean.

COLOR

Color is often the characteristic consumers will notice first about a cut of meat. If the meat has an abnormal color in the consumer's eye, it will not be consumed. Meat color is considered a surface phenomenon of a non-metallic opaque object (Hunt, 1980). Light striking meat surfaces is either absorbed or reflected. The surface of meat reflects light at many angles creating diffuse reflectance, a direct function of the object's color. Shiny or glossy objects reflect incidental light at a 90° angle known as spectral reflectance. The extent of the glossy appearance of meat is related to the thin aqueous layer on the surface, the muscle's pH, water holding capacity, structure, and fiber orientation (Hunt, 1980).

There are several methods available to measure color. The transmission method of muscle extracts overestimated $Mb+$ and MbO_2 and underestimated Mb content (Dean and Ball, 1960). In the opinion of Hunt (1980), the changes in pigment forms during extraction, along with sample destruction, deciding what volume of surface to sample, and solution turbidity problems preclude the use of extraction techniques and transmission spectrophotometry for measuring pigment chemical states. Reflectance spectrophotometry eliminates the need for extraction and allows the pigment to be evaluated in its natural enivironment (Franke and Solberg, 1971). According to Clydesdale (1969), color measuring instruments are used best to estimate color differences between samples and are misused when they are employed to measure the absolute color of a sample.

Color is the quality trait of meat that is the most sensitive to the environmental conditions of storage (Lanier et al., 1977). The rate of color change is affected by several factors such as the partial pressure of oxygen in the environment as influenced by meat wraps, bacterial growth or artificial atmospheres (Robach and Costilow, 1961; Ledward, 1970), temperature (Govindarajan, 1973), tissue lipid oxidation (Greene, 1969; Greene et al., 1971) and possible drying of the meat surface (Ledward, 1971).

Lanier et al. (1977) reported that in exposed, lean beef surfaces under cold storage the rate of Mb+ formation or browning increased with increasing temperature and air velocity. Low relative humidity did not promote Mb+ formation. The lightness index of beef was highly correlated with water loss and initial pigment concentration. Relative humidity near 90%, air velocity near 0.5 mps, and near freezing temperatures appeared to represent the best environment for beef color maintenance.

Rhee et al. (1983) found that Hunter color "a" values (redness) were significantly and negatively correlated with TBA values ($r = -0.91$; $p < 0.005$). This suggested that TBA increased as "a" values decreased during frozen storage of raw samples. Pigment oxidation could be a possible cause. Pigment oxidation is catalyzed in several ways such as light, temperature, and pH.

Brown and Dolev (1963) observed that the autoxidation rates for both tuna and bovine MbO_2 were greater at freezing temperatures when compared to temperatures just above freezing. Satterlee and Zachariah (1972) found this to occur when porcine and ovine MbO_2 were frozen also. Porcine MbO_2 had the fastest autoxidation rate and ovine and bovine MbO_2 the slowest (Zachariah and Satterlee, 1973). A storage temperature of -11 to -12°C resulted in a less stable pigment. Storage below -17 to -18°C was recommended. Ramsbottom (1947) stored fresh beef in darkness at six different temperatures ranging from -20°F to 26°F (-28.8°C to -3.3°C) in DuPont 300 M.S.A.T. No. 87 cellophane. The product was discolored in 30 days at 26°F (-3.3°C), whereas in the product stored at -20°F (-28.8°C) color and appearance were still acceptable after one year's storage. Tressler and Evers (1947) stated that frozen meat changed in color from the red to brown color at a higher temperature of storage. Townsend and Bratzler (1958) reported that repeated freezing and thawing in an oxygen impermeable wrapper had a marked effect on frozen meat color. An alternate increase and decrease of percent Mb+ formation with alternate thawing and freezing cycles were reported. Samples stored under fluorescent light at 0°F showed less discoloration and Mb+ formation than did samples stored in darkness in a self-service case in which there was considerable temperature fluctuation.

PACKAGING MATERIAL

Packaging material was found to influence pigment change by Pirko and Ayres (1957). A direct relationship was found to exist between maxima in Mb+

formation and the gas permeability of the packaging material. Those materials that were oxygen impermeable permitted the least amount of Mb+ formation at $6^{\circ} \pm 1^{\circ}C$ held for 14 days. The workers found that pigment of beef packaged in this wrap still had the ability to return to MbO_2 after 14 days, whereas beef in other more oxygen permeable material did not. Gokalp et al. (1979) studied the effect of packaging methods and storage time on several quality characteristics of frozen beef muscle tissue which had been stored at $-22.3 \pm 1^{\circ}C$ for up to 9 months. They found that color, surface discoloration, off-flavor, TBA, tenderness, total weight loss, and general acceptability were affected by the different treatments. Overall, results indicated that the use of a medium density polyethylene film to package frozen bovine muscle tissue resulted in a product equal to, or superior to, CO_2-altered atmosphere, vacuum induced package cling and far superior to unwrapped samples at the 3-, 6-, and 9-month frozen storage periods. Similar findings were reported earlier by Tressler and DuBois (1940) for pork.

Jeremiah (1980) evaluated the effect of frozen storage in various protective wraps upon the cooking losses and palatability of various fresh and cured pork cuts. Flavor and overall palatability of both fresh and cured cuts decreased during frozen storage at $-30^{\circ}C$ up to 196 days. The deterioration was attributed to the development of oxidative rancidity. There were no significant differences among protective wraps evaluated in this study for any of the traits measured. This agreed with Lentz (1971) and Hiner et al. (1951). Since one of the films was oxygen permeable, the findings disagree with Enser (1974) who recommended the use of gas-impermeable wrap to delay the development of oxidative rancidity. Palmer et al. (1953) also found that differences in packaging materials affected the development of oxidative rancidity in pork. Pork wrapped in waxed paper had a higher level of rancidity than did the sample wrapped in laminated paper.

TOTAL MOISTURE CONTENT

Packaging materials also have an effect on the total moisture content of the protected material. Palmer et al. (1953) found that meat packaged in waxed paper had more than five times greater dehydration loss than that packaged in laminated paper. A severe freezer burn was found in the ground pork stored in the waxed paper. Steinberg et al. (1949) also noted freezer burn in samples where water was lost. Baldwin et al. (1972) found wax paper to be less effective against water loss than were moisture-vapor-proof wraps. Simpson and Chang (1954) found that moisture loss was insignificant at any temperature when aluminum foil, polyethylene-coated paper, or glassine-laminated paper were used. However, samples in butcherwrap showed a rapid loss of moisture at 0°F (-17°C). Nobel and Hardy (1954) double-wrapped pork roasts in moisture-vapor-proof paper and found moisture loss to be quite small (between 1 and 3%).

Cooper (1970) reported unwrapped bacon sides shrank 3.1% after two month's storage, while bacon sides wrapped in polyethylene lost no weight. Hiner et al. (1951) found that vacuum-packed pork loin samples had no moisture loss at 0°F (-17°C). A moisture-vapor-proof wrap appears to be essential to prevent significant weight loss in meats.

MATERIALS AND METHODS

SOURCE OF MATERIALS

Ground pork with a fat content of 25% was obtained from the Kansas State University Department of Animal Sciences and Industry. Before freezing the ground pork samples were analyzed for pH, color, and total moisture content. Immediately after these analyses, the ground pork was packaged in various wraps in 250-gram quantities. Wrapping materials included Saran Wrap®, Handi Wrap II with Cling Plus®, Oster® sealing bags, Dazey® sealing bags, Ziploc® freezer bags, Glad SnapLock Storage® bags, Glad Food Storage® bags, Reynolds Wrap® heavy duty aluminum foil, and bread bags (donated by KSU Dept. of Grain Science and Industry). The packaged pork was held at -17°C (0°F) for 13 and 26 weeks. Each of four replications was placed in an upright home-style, Hotpoint freezer at two-week intervals for ease of analysis. After the designated storage time, the packages of ground pork were thawed overnight at refrigerator temperature (4.4°C) and separately analyzed as outlined below.

pH AND TOTAL MOISTURE CONTENT

A portion of each sample was used for pH and total moisture determinations. Duplicate pH measurements were made of a slurry of ten grams of ground pork and 25 ml distilled water (Rogers, 1967).

Total moisture content was measured by drying ten grams of ground pork for two hours in a C.W. Brabender Semi-Automatic Rapid Moisture Tester set at 130°C. Total moisture content was determined by weight loss. Care was taken to calibrate the balance for each use to insure an accurate reading.

SPECTRAL REFLECTANCE

For measurement of color, each thawed sample of ground pork was wrapped in a clear, plastic wrap before analysis on a Hunter D54 Lab Spectrophotometer. The surfaces of the samples were placed over the optical opening and readings were taken. Each sample was rotated 180° and read again. Readings were taken every ten nanometers. Values were determined for illuminant A, L-, a-, and b-values and CIE L-, a-, and b-values. The equation %R 630 - %R 580nm was used to estimate the bright red color of MbO_2.

THIOBARBITURIC ACID ANALYSIS

After 13 and 26 weeks, thawed samples were analyzed for lipid oxidation according to the 2-thiobarbituric acid test (Tarladgis et al., 1960) modified by Tellefson (1980).

WRAP THICKNESS

Wrap thickness was measured with the use of a Kennedy guage (in mils). Each sample was measured ten times at random points.

STATISTICAL ANALYSIS

Results were analyzed using a two way analysis of variance for a randomized complete block design. To determine significant ($p<0.05$) differences among specific treatment means, the T-test was applied to the data (Snedecor and Cochran, 1980).

RESULTS AND DISCUSSION

WRAP THICKNESS

Wrapping materials utilized for this study can be found in Table 1.

Table 1 Wrapping Materials Utilized

Aluminum foil, heavy duty (Reynolds Wrap)®
Glad Food Storage® bags , 11.5 x 12.5"
Bread bags (St. Regis)
Glad SnapLock Storage® bags, 7 x 8"
Dazey Seal-A-Meal® bags, 8 x 12"
Oster® Continuous-Roll Boilable-Freezer bags
Saran Wrap®
Handi Wrap II with Cling Plus®
Ziploc Heavy Duty Freezer® bags

The mean thickness of each wrapping material can be found in Table 2. Ziploc® freezer bags were found to have the greatest thickness followed by the Dazey R bags, Oster® bags, SnapLock® bags, bread bags, Glad Food Storage® bags, and aluminum foil. Each wrapping material was different ($p<0.05$) from the others with the exception of Saran Wrap® and Handi Wrap®, which were the least thick.

Table 2 F-value and Least Square Means[1] for Thickness of Wraps in Mils[2]

F-value = 749.03***

Wrap	Least Square Mean
Ziploc® bags	2.660 [a]
Dazey® bags	2.345 [b]
Oster® bags	2.113 [c]
SnapLock Storage® bags	1.675 [d]
Bread bags	1.163 [e]
Glad Food Storage® bags	0.855 [f]
Aluminum foil	0.705 [g]
Saran Wrap®	0.598 [h]
Handi Wrap II with Cling Plus®	0.513 [h]

[1] Mean of ten determinations
[2] Mil = .001 inch
***, $p<0.001$
abcdefgh Means with different letters are significantly different ($p<0.05$)

OBJECTIVE PARAMETERS

There were no significant differences among the wrapping materials themselves for any of the objective tests measured. Significant differences were found, however, when storage periods of 13 and 26 weeks were compared (Table 3). This agrees with Jeremiah (1980). There were no significant differences among wrapping materials utilized for the traits tested in this study, but Jeremiah found that over a period of 196 days, raw pork cuts held at -30 C decreased in flavor and palatability due to the development of oxidative rancidity. The differences occurred not between wraps but over a period of time. These findings also agree with studies done by Lentz (1971) and Hiner (1951). A study by Enser (1974) disagrees with the results as he found that a gas impermeable wrap was more effective in the prevention of oxidative rancidity. Palmer et al. (1953) also found packaging material to affect the development of oxidative rancidity. There were no significant differences between pH values or percent moisture values at 13 and 26 weeks (Table 3). This agreed with findings for moisture loss of Simpson and Chang (1954), Nobel and Hardy (1954), Hiner (1951), and Cooper (1970). Significant differences ($p<0.001$) were found for TBA values; %R630 -%R580nm; L-, a-, and b-values; and CIE L-,a-, and b-values (Table 3).

Table 4 shows the F-values and the mean values of the objective parameters grouped with a t-test at 13 and 26 weeks. The TBA value increased from 1.472 to 3.032 mg malonaldehyde per 1000 g meat. This indicates a significant ($p<0.05$) increase in the amount of rancidity in the ground pork. Marana (1980) also found that significant changes in rancidity developed at the sixth month of storage. The %R630 - %R580nm significantly decreased from 13 to 26 weeks. The %R630 - %R580nm was used as an indicator of red color in the ground pork.

Table 3 Means[1] and F-values of Objective Parameters over Time (13 and 26 weeks)

	Mean	F-value
%Moisture	55.546	0.01
pH	5.836	0.61
%R630 - %R580nm	22.838	25.85***
L-value	62.792	39.04***
a-value	18.504	16.34***
b-value	7.259	29.44***
CIE L-value	68.777	39.77***
CIE a-value	18.487	7.12***
CIE b-value	16.494	16.76***
TBA value[2]	2.252	33.94***

[1] Mean, averaged across all wrapping materials over time

[2] mg malonaldehyde per 1000 g meat

***, $p<0.001$

During the prolonged period of storage, the decrease in %R630 - %R580nm appeared to accelerate during the 26 week time period as only a slight decrease from the control mean of 28.084 was noted after 13 weeks. The L-value (lightness) was higher at 13 weeks than at 26 weeks. The 26 week value was similar to the control. This could be attributed to the development of oxidation in the samples. Hunt (1980) noted that the glossy appearance of meat is related to a thin aqueous layer on the surface. Perhaps this had some effect on the lightness value. Lanier (1977) found the lightness index of beef was highly correlated with water loss and initial pigment concentration. Moisture was lost in this study from the control to the 13 week time period (Table 8). The a-value (redness) decreased from 23.423 to 19.693 at 13 weeks and to 16.796 at 26 weeks. The difference between 13 and 26 weeks was significant ($p<0.05$). The b-value (yellowness) decreased ($p<0.05$) from the 13-week time period to the 26-week one. This could be attributed to a change in color due to the development of oxidation. CIE L-,a-, and b-values followed along the similar trends as did the L-, a-, and b-values. All CIE L-, a-, and b-values decreased ($p<0.05$) from the 13 week period of time to the 26 week period of time.

Table 4 F-values and T-tests for Selected Objective Parameters Compared Over 0, 13, and 26 Weeks of Frozen Storage

	F-value	Control Mean[1]	13 Weeks Mean	26 Weeks Mean
TBA value [2]	33.94***		1.472[a]	3.032[b]
%R630-%R580nm	24.53***	28.084	27.637[a]	17.455[b]
L-value [3]	37.06***	55.669	70.393[a]	55.983[b]
a-value [3]	15.61***	23.423	19.693[a]	16.769[b]
b-value [3]	28.03***	6.613	7.976[a]	6.613[b]
CIE L-value [3]	37.76***	62.488	75.501[a]	62.752[b]
CIE a-value [3]	6.83**	23.894	18.958[a]	17.415[b]
CIE b-value [3]	16.03***	15.722	17.376[a]	15.698[b]
pH	0.63	5.830	5.824[a]	5.849[b]

[1] Mean of 4 replications

[2] mg malonaldehyde per 1000 g ground pork

[3] Measured by a HunterLab Spectrophotometer

[ab] Means with the same letter in the same horizontal line are not significantly different ($p<0.05$)

**, $p<0.01$; ***, $p<0.001$

Data indicate that as TBA values increase, a-values, CIE a-values, and %R630 - %R580nm decrease (Table 4). This agrees with Rhee (1983) who found that Hunter color a-values were significantly and negatively correlated with TBA values. The oxidation of pigments could be a possible cause of this trend. Watts (1954) showed that the catalytic effect of hemoglobin and other iron porphyrins on the oxidation of lipids resulted in the destruction of the pigments present as well as the oxidation of the fat. Greene (1969) and Greene et al. (1971) also noted that the color of meats was affected by tissue lipid oxidation.

WRAPPING MATERIALS

Table 5 shows the means of the TBA values. All of the values were similar except for the ground pork samples stored in Saran Wrap® and Handi Wrap II®. The Saran Wrap® samples had a significantly ($p<0.05$) lower TBA value than did the Handi Wrap II® samples. The Saran Wrap® samples were not significantly different from any of the other samples tested. Saran Wrap® and Handi Wrap II® were not significantly different in thickness; however, Handi Wrap II® is oxygen permeable while Saran Wrap® is not. This could account for the difference in the amount of rancidity present in these ground pork samples.

Table 6 shows the mean %R630 - %R580nm values of ground pork samples stored in each type of wrapping material. Over the entire 26-week storage period ground pork stored in aluminum foil had the highest %R630 - %R580nm. This value was significantly different ($p<0.05$) only from the samples stored in the Dazey® or Oster® bags. The aluminum foil appeared to protect the red color of the ground pork better than did the Dazey® or Oster® wrapping materials.

Table 5 T-test Comparing TBA[1] Means[2] of Ground Pork Stored in Various Wrapping Materials for 13 and 26 Weeks

Wrapping Material	Mean
Handi Wrap II with Cling Plus®	3.0026 [a]
Glad SnapLock Storage® bags	2.4614 [ab]
Oster® bags	2.4046 [ab]
Ziploc® bags	2.2033 [ab]
Dazey® bags	2.1754 [ab]
Glad Food Storage® bags	2.1523 [ab]
Bread bags	2.1353 [ab]
Aluminum foil	2.0089 [ab]
Saran Wrap®	1.7228 [b]

[1]mg malonaldehyde per 1000 g ground pork

[2]Means of all values (8) for both time periods

[ab]Means with the same letter are not significantly different ($p<0.05$)

Table 6 T-test Comparing %R630 - %R580nm Means[1] of Ground Pork in Different Wrapping Materials

Wrapping Materials	Mean
Aluminum foil	27.936 [a]
Glad Food Storage® bags	23.872 [ab]
Bread bags	23.487 [ab]
Handi Wrap II with Cling Plus®	23.405 [ab]
Ziploc® bags	22.780 [ab]
Saran Wrap®	22.675 [ab]
Glad SnapLock Storage® bags	21.588 [ab]
Dazey® bags	18.797 [b]
Oster® bags	18.375 [b]

[1]Mean of all values (8) for both time periods

[ab]Means with the same letter are not significantly different ($p<0.05$)

Table 7 shows the mean a-values of ground pork stored in different wrapping materials. As with %R630 - %R580nm, aluminum foil protected the red color of the ground pork better than did the Dazey® or the Oster® bags. There were no differences among the other wrapping materials.

CIE a-value means of ground pork stored in various wrapping materials also are shown in Table 7. Aluminum foil again showed the greatest protection of the red color of the ground pork. The aluminum foil-wrapped samples had higher ($p<0.05$) CIE a-values than did the Saran Wrap®-, Dazey bag®-, or Oster® bag-protected ground pork samples. The Oster® bag ground pork samples also were significantly lower in CIE a-value than were the Glad Food Storage® bag samples and the bread bag samples. The Oster® bags appeared to offer less protection against the loss of the red color of the meat than did most of the other materials utilized.

Table 7 T-test Comparing a-value[1] Means[2] of Ground Pork and CIE a-value Means of Ground Pork Stored in Various Wrapping Materials

Wrapping Material	a-value Mean	CIE a-value Mean
Aluminum foil	20.572[a]	20.395[a]
Glad Food Storage® bags	18.973[ab]	18.884[ab]
Bread bags	18.806[ab]	18.765[abc]
Handi Wrap II with Cling Plus®	18.609[ab]	18.522[abc]
Ziploc® bags	18.564[ab]	18.532[abc]
Saran Wrap®	17.991[ab]	17.872[bc]
Glad SnapLock Storage bags®	17.974[ab]	17.975[abc]
Dazey® bags	16.444[b]	16.571[bc]
Oster® bags	16.145[b]	16.161[c]

[1] Measured by a HunterLab Spectrophotometer

[2] Mean of all values (8) for both time periods

[abc] Means with the same letter in the same column are not significantly different ($p<0.05$)

There were no significant differences noted in samples stored in the various wrapping materials when the values were averaged together for percent moisture, pH, L-value,b-value, CIE L-value, or CIE b-value.

WRAPPING MATERIALS DIVIDED INTO CONTROL, 13 AND 26 WEEK MEANS

No significant differences were found between the control value mean, the 13-week mean value, and the 26-week mean value for the pH of the samples of ground pork (Table 4).

Table 8 shows the mean moisture content of each sample of ground pork at 13 and 26 weeks of storage in each type of wrapping material. The means have been compared to the control mean moisture content. There were no significant differences between the moisture contents of any of the ground pork samples stored 13 and 26 weeks in any of the wrapping materials. However, when compared to the control mean moisture content, the 13- and 26-week stored Oster® samples and the 13- and 26-week stored Saran Wrap® samples were most different ($p<0.001$). All other samples differed at the 0.01 level. This would indicate that moisture was lost during the first 13 weeks of storage and then stabilized. This could be attributed to the freeze - thaw cycle that the 13 and 26 week samples underwent.

Table 9 illustrates a comparison between TBA or rancidity development in ground pork stored in various wrapping materials for 13 and 26 weeks. At 13 and 26 weeks of storage there was no significant difference in rancidity development in ground pork stored in aluminum foil, Handi Wrap II®, Dazey® bags, Saran Wrap®, or bread bags. Samples stored in Oster® bags, SnapLock Storage® bags, Glad Food Storage® bags, and Ziploc® bags showed a significant increase in the amount of rancidity present from the 13-week storage period to the 26-week period. The 13-week TBA numbers from the Ziploc® bag, Oster® bag, and Saran Wrap® samples were significantly lower ($p<0.05$) than those from the 26 week bread bag, Oster® bag, and SnapLock® bag samples but were no different from the other wrapping materials at 13 weeks or aluminum foil and Saran Wrap® after 26 weeks of storage. TBA values of samples stored in Glad SnapLock® bags, Oster® bags, Ziploc® bags, or Handi Wrap II® were significantly higher after 26 weeks of storage than were all samples in wraps stored at 13 weeks except for the 13-week Handi Wrap II® sample which had a high TBA number indicating a rapid rate of oxidative rancidity development.

Table 8 T-test Comparing the Moisture Content Means[1] of Ground Pork in Different Wrapping Materials at 13 and 26 Weeks and to the Control

% Moisture Control Mean = 62.375

Wrapping Material	Mean	Comparison to Control
Dazey® bags		
13 wks	56.762[a]	**
26 wks	55.775[a]	**
Bread Bags		
13 wks	56.200[a]	**
26 wks	55.625[a]	**
Glad Food Storage® bags		
13 wks	55.125[a]	**
26 wks	55.787[a]	**
Aluminum foil		
13 wks	55.550[a]	**
26 wks	55.262[a]	**
Handi Wrap II®		
13 wks	55.300[a]	**
26 wks	55.475[a]	**
Ziploc® bags		
13 wks	55.050[a]	**
26 wks	55.150[a]	**
Glad SnapLock Storage® bags		
13 wks	54.850[a]	**
26 wks	55.112[a]	**
Oster® bags		
13 wks	54.250[a]	***
26 wks	54.200[a]	***
Saran Wrap®		
13 wks	53.725[a]	***
26 wks	53.800[a]	***

[1]Mean of 4 replications

[a]Means with the same letter are not significantly different ($p<0.05$)

**, $p<0.01$; ***, $p<0.001$

Saran Wrap® protected against rancidity development better than the other wraps tested as the TBA numbers for those samples were the lowest at both 13 and 26 weeks of storage. Initially the Ziploc® bags and the Oster® bags offered good protection against rancidity, but after 26 weeks of storage, their TBA numbers were among the highest. Aluminum foil-wrapped samples showed little rancidity development from 13 week period to the 26 week period. When comparing the wrapping materials individually over time, one can see that those

Table 9 T-test Compaing the TBA[1] Number Means[2] of Ground Pork in Different Wrapping Materials at 13 and 26 Weeks

Wrapping Material	Mean
Glad SnapLock Storage® bags	
13 wks	1.4004[bcd]
26 wks	3.5223[a]
Oster® bags	
13 wks	1.2952[d]
26 wks	3.5140[a]
Handi Wrap II®	
13 wks	2.7422[abcd]
26 wks	3.2630[a]
Ziploc® bags	
13 wks	1.1924[d]
26 wks	3.2142[a]
Glad Food Storage® bags	
13 wks	1.3356[cd]
26 wks	2.9690[ab]
Dazey® bags	
13 wks	1.4043[bcd]
26 wks	2.9465[a]
Bread bags	
13 wks	1.3325[cd]
26 wks	2.9381[abc]
Aluminum foil	
13 wks	1.3652[bcd]
26 wks	2.6527[abcd]
Saran Wrap®	
13 wks	1.1812[d]
26 wks	2.2643[abcd]

[1]mg malonaldehyde per 1000 g ground pork

[2]Mean of 4 replications

[abcd]Means with the same letter are not significantly different ($p<0.05$)

materials that are oxygen impermeable protect the ground pork from rancidity development better than those wrapping materials that are not. This agrees with the findings of Enser (1974).

Table 10 T-test Comparing the %R630 - %R580nm Means[1] of Ground Pork in Different Wrapping Materials at 13 and 26 Weeks and to the Control

%R630 - %R580nm Control Mean = 28.084

Wrapping Material	Mean	Comparison to Control
Aluminum foil		
13 wks	32.572[a]	
26 wks	23.299[abcde]	
Glad Food Storage® bags		
13 wks	30.219[ab]	
26 wks	17.526[cde]	
Saran Wrap®		
13 wks	29.834[abc]	
26 wks	15.516[e]	*
Handi Wrap II®		
13 wks	29.169[abcd]	
26 wks	17.641[cde]	
Bread bags		
13 wks	28.872[abcd]	
26 wks	18.102[bcde]	
Ziploc® bags		
13 wks	28.129[abcd]	
26 wks	17.432[de]	
Glad SnapLock Storage® bags		
13 wks	25.070[abcde]	
26 wks	18.106[bcde]	
Dazey® bags		
13 wks	23.170[abcde]	
26 wks	14.424[e]	*
Oster® bags		
13 wks	21.702[abcde]	
26 wks	15.047[e]	*

[1]Mean of 4 replications

[abcde]Means with the same letter are not significantly different ($p<0.05$)

*, $p<0.05$

Table 10 shows a comparison of %R630 - %R580nm values for the ground pork samples stored for 0, 13, and 26 weeks in different wrapping materials. All of the samples held for 13 weeks had significantly higher ($p<0.05$) %R630 - %R580nm values than did all the samples held for 26 weeks except for the aluminum foil samples. Those samples were not significantly different between the two time periods. This would indicate that the time the samples were held was more important than the wrapping materials used with the exception of aluminum foil. When comparisons were made between the stored samples and the control or fresh sample, only the Saran Wrap®, Oster® bag, and Dazey® bag ground pork samples stored for 26 weeks differed significantly from the control ($p<0.05$). After 13 weeks the samples stored in aluminum foil showed the highest %R630 - %R580nm values, and the samples stored in the Oster® bags had the lowest. At 26 weeks of storage aluminum foil-wrapped samples again had the highest %R630 - %R580nm values; and the samples stored in the Dazey® bags, the lowest. The control mean %R630 - %R530nm value was 28.084. This was lower than some of the stored samples, however, not significantly so.

Table 11 shows the comparisons of the L-values of the ground pork samples stored 0, 13, 26 weeks. All variously wrapped samples stored for 13 weeks of time had higher ($p<0.05$) L-values than did the samples stored for 26 weeks. L-values of the samples stored for 13 weeks also were significantly higher ($p<0.05$) than were the control. This could be attributed to the freeze - thaw cycle that the samples underwent. The 26-week sample means did not significantly differ from the control. Of the ground pork samples stored 13 weeks, the samples stored in the Oster® bags had the highest L-value and the samples stored in the Ziploc® bags, the lowest. When the samples stored in the same type of material were compared for differences over time, only the samples stored in Glad Food Storage® bags, Glad SnapLock Storage® bags, Ziploc® bags, and Saran Wrap® showed no significant difference in lightness. The same trends are seen when the mean CIE L-values of the samples are examined. Table 12 shows the mean CIE L-values of samples of ground pork stored in various home wrapping materials. The samples stored 13 weeks had, overall, significantly higher ($p<0.05$) values than either the samples stored 26 weeks or the control value. The samples stored 13 weeks in Handi Wrap II®, aluminum foil, Oster® bags, Dazey® bags, and bread bags had higher ($p<0.05$) CIE L-value means than the samples stored 26 weeks in the same wrapping materials.

Table 11 T-test Comparing the L-value[1] Means[2] of Ground Pork Stored in Different Wrapping Materials at 13 and 26 Weeks and to the Control

L-value Mean = 55.669

Wrapping Material	Mean	Comparison to Control
Oster® bags		
13 wks	71.580[a]	*
26 wks	56.437[cdef]	
Handi Wrap II®		
13 wks	71.384[ab]	*
26 wks	55.739[ef]	
Aluminum foil		
13 wks	71.284[ab]	*
26 wks	56.192[cdef]	
Dazey® bags		
13 wks	70.419[abc]	*
26 wks	54.547[f]	
Bread bag		
13 wks	70.334[abc]	*
26 wks	55.737[ef]	
Glad Food Storage® bags		
13 wks	69.985[abcd]	*
26 wks	56.234[cdef]	
Glad SnapLock Storage® bags		
13 wks	69.837[abcde]	*
26 wks	56.019[def]	
Saran Wrap®		
13 wks	69.506[abcde]	*
26 wks	57.237[bcdef]	
Ziploc® bags		
13 wks	69.209[abcde]	*
26 wks	55.700[ef]	

[1] Measured by a HunterLab Spectrophotometer

[2] Mean of 4 replications

[abcdef] Means with the same letter are not significantly different ($p<0.05$)

*, $P<0.05$

Table 12 T-test Comparing the CIE L-value[1] Means[2] of Ground Pork Stored in Different Wrapping Materials at 13 and 26 Weeks and to the Control

Mean CIE L-value = 62.488

Wrapping Material	Mean	Comparison to Control
Oster® bags		
13 wks	76.517[a]	*
26 wks	63.191[cdefg]	
Handi Wrap II®		
13 wks	76.385[ab]	*
26 wks	62.516[fg]	
Aluminum foil		
13 wks	76.292[ab]	*
26 wks	62.959[defg]	
Dazey® bags		
13 wks	75.521[abc]	*
26 wks	61.399[g]	
Bread bags		
13 wks	75.436[abcd]	*
26 wks	62.493[fg]	
Glad Food Storage® bags		
13 wks	75.167[abcde]	*
26 wks	62.999[defg]	
Glad SnapLock Storage® bags		
13 wks	75.005[abcde]	*
26 wks	62.779[efg]	
Saran Wrap®		
13 wks	74.732[abcdef]	*
26 wks	63.936[bcdefg]	
Ziploc® bags		
13 wks	74.455[abcdef]	*
26 wks	62.493[fg]	

[1]Measured by a HunterLab Spectrophotometer

[2]Mean of 4 replications

[abcdefg]Means with the same letter are not significantly different ($p<0.05$)

*, $p<0.05$

Mean a-values for ground pork generally were highest in samples stored for the shorter period of time (Table 13). The highest a-value was found in the control sample. After 13 weeks of storage, the ground pork samples stored in the heavy duty aluminum foil had the highest mean a-value. The ground pork samples stored in aluminum foil for 26 weeks also had the highest a-value of all samples stored 26 weeks. There was no significant difference between the control sample and samples stored 13 weeks in aluminum foil, or between the control and the samples stored 26 weeks in aluminum foil. This would indicate that aluminum foil protects the red color of ground pork over a period of time. Ground pork held in Saran Wrap® for 13 weeks had a significantly higher ($p<0.05$) a-value than did the samples held 26 weeks. The samples held 13 weeks in Saran Wrap® were not significantly different from the control samples; however, the samples held 26 weeks in Saran Wrap® were greatly different ($p<0.001$) from the control. After the 13-week period, the red color appeared to deteriorate rapidly in this set of samples. The ground pork samples stored in Glad Food Storage® bags for 13 weeks had significantly higher ($p<0.05$) a-values than did the samples stored in the same wrapping material for 26 weeks. The samples stored for 13 weeks were not significantly different from the control however, the samples stored 26 weeks were significantly different ($p<0.01$) from the control. The ground pork samples stored in Oster® bags did not differ significantly from 13 to 26 weeks, but the samples stored 13 weeks differed from the control at the 0.001 level and those stored 26 weeks differed from the control at the 0.001 level. The same results were true of the ground pork samples stored in the Dazey® bags. The 13- and 26-week ground pork samples stored in Handi Wrap II®, Glad SnapLock Storage® bags, bread bags, or Ziploc® bags did not differ significantly over the 13 and 26 week time periods. Of these samples, those stored 13 weeks did not differ significantly from the control. However, the samples stored for 26 weeks differed ($p<0.01$) from the control. These results indicate a general loss in the red color over time with some significant loss occurring after 13 weeks for samples stored in Glad SnapLock Storage® bags and Dazey® bags. Most of the significant loss occurred after 26 weeks of storage. Only the ground pork samples stored in aluminum foil showed no significant loss in red color after 26 weeks of storage. The mean CIE a-values followed along the same lines.

CIE a-value means of all of the ground pork samples were significantly lower than the control CIE a-value (Table 14). When the ground pork samples were compared at 13 and 26 weeks, the only significant difference between samples in the same wrapping material was found in the samples stored in Saran Wrap®. The samples held 13 weeks in Saran Wrap® had significantly higher CIE a-values than the samples held 26 weeks. As can be seen, there was a considerable decrease in the values with time. A genereal decrease in the CIE a-values continued upon storage of all other samples but not at a rate that was significantly different. The ground pork samples stored in the Oster® bags and in the Dazey® bags showed a dramatic decrease from the control in CIE a-values ($p<0.001$). The CIE a-values for the ground pork stored in these materials were lower at 13 weeks than many of the ground pork samples stored in other materials for 26 weeks. After the initial decrease from 0 to 13 weeks, there was no significant decrease in CIE a-values at 26 weeks.

The ground pork stored in aluminum foil had the smallest decrease in CIE a-values when compared to the control. Ground pork samples stored for both 13 and 26 weeks in aluminum foil were different ($p<0.05$) from the control, but those samples were not significantly different from each other. The ground pork samples stored 26 weeks in aluminum foil had a mean CIE a-value higher than many of the samples stored for 13 weeks. Thus, aluminum foil appears to protect ground pork from a loss of red color better than do many of the other wrapping materials utilized in this study.

Table 13 T-test Comparing the a-value[1] Means[2] of Ground Pork Stored in Different Wrapping Materials at 13 and 26 Weeks and to the Control

Mean a-value = 23.423

Wrapping Material	Mean	Comparison to Control
Aluminum foil		
13 wks	21.411[a]	
26 wks	19.734[abcd]	
Glad Food Storage® bags		
13 wks	21.296[ab]	
26 wks	16.560[cde]	**
Saran Wrap®		
13 wks	20.580[abc]	
26 wks	15.402[de]	***
Bread bags		
13 wks	20.347[abc]	
26 wks	17.264[abcde]	**
Ziploc® bags		
13 wks	20.237[abc]	
26 wks	16.891[bcde]	**
Handi Wrap II®		
13 wks	20.201[abc]	
26 wks	17.016[bcde]	**
Glad SnapLock Storage® bags		
13 wks	18.685[abcde]	**
26 wks	17.264[abcde]	**
Dazey® bags		
13 wks	17.429[abcde]	**
26 wks	15.459[de]	***
Oster® bags		
13 wks	17.051[abcde]	**
26 wks	15.238[e]	***

[1] Measured by the HunterLab Spectrophotometer

[2] Mean of 4 replications

[abcde] Means with the same letter are not significantly different ($p<0.05$)

**, $p<0.01$; ***, $p<0.0001$

Table 14 T-test Comparing the CIE a-value[1] Means[2] of Ground Pork Stored in Different Wrapping Materials at 13 and 26 Weeks and to the Control

Mean CIE a-value = 23.894

Wrapping Material	Mean	Comparison to Control
Aluminum foil		
13 wks	20.519[a]	*
26 wks	20.272[ab]	*
Glad Food Storage® bags		
13 wks	20.491[a]	*
26 wks	17.277[abcde]	***
Saran Wrap®		
13 wks	19.782[abc]	**
26 wks	15.961[de]	***
Bread bags		
13 wks	19.574[abc]	**
26 wks	17.956[abcde]	***
Ziploc® bags		
13 wks	19.489[abcd]	**
26 wks	17.576[abcde]	***
Handi Wrap II®		
13 wks	19.350[abcde]	**
26 wks	17.694[abcde]	***
Glad SnapLock Storage® bags		
13 wks	18.037[abcde]	***
26 wks	17.913[abcde]	***
Dazey® bags		
13 wks	16.904[bcde]	***
26 wks	16.237[cde]	***
Oster® bags		
13 wks	16.475[cde]	***
26 wks	15.847[e]	***

[1]Measured by a HunterLab Spectrophotometer

[2]Mean of 4 replications

[abcde]means with the same letter are not significantly different ($p<0.05$)

*, $p<0.05$; **, $p<0.01$; ***, $p<0.001$

The mean b-values were all very similar (Table 15). The ground pork samples wrapped in the various materials for 13 weeks had higher ($p<0.05$) b-values than did the samples held 26 weeks. The only significant differences between wraps occurred in ground pork samples held in Handi Wrap II® and in Glad Food Storage® bags. The ground pork samples held in these two wrapping materials for 13 weeks had significantly higher b-values than either the control sample or the sample held 26 weeks. There was an increase in yellow color from the time the control value was measured up to 13 weeks of storage. After that point, a decrease in the b-value was seen; however, the differences were not significant except where noted above. This also could be attributed to the formation of oxidation in the samples.

As can be seen in Table 16, there were few significant differences in CIE b-values between the control and the samples stored 13 weeks or between those samples stored 13 and 26 weeks. The ground pork samples stored 13 weeks in Handi Wrap II® and Glad Food Storage® bags had higher ($p<0.05$) CIE b-value than did their counterparts stored 26 weeks. The ground pork samples stored 13 weeks in Glad Food Storage® bags and Handi Wrap II® also had a significantly higher CIE b-value than did the control sample. The samples stored 13 weeks had higher CIE b-values than did the samples stored 26 weeks, although not significantly so in most of the samples. Apparently, yellowness of ground pork samples undergoes very little change during freezer storage.

Table 15 T-test Comparing the b-value[1] Means[2] of Ground Pork Stored in Different Wrapping Materials at 13 and 26 Weeks and to the Control

Mean b-value = 6.613

Wrapping Material	Mean	Comparison to Control
Glad Food Storage® bags		
13 wks	8.350^{a}	*
26 wks	6.556^{bc}	
Handi Wrap II®		
13 wks	8.324^{a}	*
26 wks	6.715^{bc}	
Ziploc® bags		
13 wks	8.029^{ab}	
26 wks	6.654^{bc}	
Saran Wrap®		
13 wks	7.945^{abc}	
26 wks	6.507^{bc}	
Glad SnapLock Storage® bags		
13 wks	7.920^{abc}	
26 wks	6.730^{bc}	
Aluminum foil		
13 wks	7.919^{abc}	
26 wks	6.703^{bc}	
Bread bags		
13 wks	7.918^{abc}	
26 wks	6.703^{bc}	
Oster® bags		
13 wks	7.760^{abc}	
26 wks	6.488^{bc}	
Dazey® bags		
13 wks	7.623^{abc}	
26 wks	6.460^{c}	

[1]Measured by a HunterLab Spectrophotometer

[2]Mean of 4 replications

[abc]Means with the same letter are not significantly different ($p<0.05$)
*, $p<0.05$

Table 16 T-test Comparing the CIE b-value[1] Means[2] of Ground Pork Stored in Different Wrapping Materials at 13 and 26 Weeks and to the Control

Mean CIE b-value = 15.722

Wrapping Material	Mean	Comparison to Control
Glad Food Storage® bags		
13 wks	18.344[a]	*
26 wks	15.520[bc]	
Handi Wrap II®		
13 wks	18.130[a]	*
26 wks	16.036[abc]	
Ziploc® bags		
13 wks	17.617[ab]	
26 wks	15.897[abc]	
Saran Wrap®		
13 wks	17.392[abc]	
26 wks	15.092[c]	
Glad SnapLock Storage® bags		
13 wks	17.272[abc]	
26 wks	16.037[abc]	
Bread bags		
13 wks	17.230[abc]	
26 wks	16.057[abc]	
Aluminum foil		
13 wks	17.126[abc]	
26 wks	15.895[abc]	
Oster® bags		
13 wks	16.727[abc]	
26 wks	15.281[bc]	
Dazey® bags		
13 wks	16.540[abc]	
26 wks	15.465[bc]	

[1]Measured by a HunterLab Spectrophotometer

[2]Mean of 4 replications

[abc]Means with the same letter are not significantly different ($p<0.05$)

*, $p<0.05$

SUMMARY

Ground pork with a 25 percent fat content was analyzed for pH, color, and total moisture content. The pork was then packaged in 250-gram quantities in the following wrapping materials: Handi Wrap II with Cling Plus®, Saran Wrap®, Oster® sealing bags, Dazey® sealing bags, Ziploc® freezer bags, Glad SnapLock Storage® bags, Glad Food Storage® bags, heavy duty aluminum foil, and bread bags. All wrapping materials were measured for thickness. The packaged pork was held at -17° C (0° F) for 13 and 26 weeks in an upright home-style freezer. After the designated period of time, the packages of ground pork were thawed overnight at 4.4° C (40° F) and then analyzed for total moisture content, pH, oxidative rancidity (using the TBA test), and color. Values measured for color include L-, a-, and b-values, CIE L-, a-, and b-values under Illuminant A, as well as a calculation for indication of redness (%R 630 - %R 580nm).

Results were analyzed using a two way analysis of variance with the T-test applied.

Wrap thickness varied with each product. Only Saran Wrap® and Handi Wrap II® with Cling Plus® were similar in thickness.

Time of storage appeared to have more of an effect on the ground pork than did the individual wrapping materials. There were no differences noted for any of the objective parameters tested among wrapping materials; however, when the 13 and 26 week time period values were averaged together across all wrapping materials and were compared, differences were found in TBA values; %R630 - %R580nm values; L-, a-, and b-values; and CIE L-, a- and b-values. Moisture content and pH values remained stable.

Upon application of the T-test to the various values for wrapping materials averaged across all time periods, Saran Wrap® protected against rancidity better than did Handi Wrap II® but not significantly better than any of the other materials tested. The red color of the ground pork appeared to be protected best by heavy duty aluminum foil and least by the Dazey® or Oster® bags.

Moisture content appeared to be lost between 0 and 13 weeks of storage. After 13 weeks, the loss stabilized. The ground pork samples stored in Oster® bags, Glad SnapLock Storage® bags, Glad Food Storage® bags, and Ziploc® bags had significantly higher amounts of rancidity present from 13 to 26 weeks. Saran Wrap® and aluminum foil samples had the lowest overall TBA numbers and, thus, the least amount of oxidative rancidity. All ground pork samples held in aluminum foil had the highest %R630 - %R580nm values, a-values, and CIE a-values. When compared to the control, there was no significant difference between the control and samples held 13 weeks or the samples held 26 weeks. All samples held 13 weeks had significantly higher L-values than the control value or the L-values of those samples held 26 weeks. The 26 week samples were no different from the control. The CIE L-values followed the same trends. There was little difference between the b-values for samples stored 0, 13, and 26 weeks or for the CIE b-values stored 0, 13, and 26 weeks, but overall the samples increased in the amount of yellow color present over time.

CONCLUSIONS

Under the conditions of this study:

1. Storage time appears to have more of an effect on frozen ground pork than do individual wrapping materials utilized.
2. Rancidity increases in ground pork from 13 to 26 weeks of storage. Of the wrapping materials used, Saran Wrap® and aluminum foil offered the best protection.
3. Redness of color in ground pork decreases over time and of the wraps tested, only aluminum foil appeared to retard this loss.
4. Wrapping materials and time appear to have no effect on pH, but moisture is lost in ground pork from 0 to 13 weeks of frozen storage regardless of type of wrap.

5. The utilization of Saran Wrap® and aluminum foil together to wrap ground pork for frozen storage could protect it from rancidity and color loss.

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APPENDIX

2-THIOBARBITURIC ACID ANALYSIS (TBA)

Reagents and equipment

1. 9% perchloric acid solution (150 ml 60% perchloric acid/liter)- Keep refrigerated.
2. 0.02 M TBA reagent-

   1.4415 g 2-thiobarbituric acid/500 ml

   Dilute to volume with distilled water. Use a hot plate on low heat and a magnetic stirrer to dissolve TBA. Place an inverted beaker over top of the flask to let steam escape. Refrigerate, after TBA dissolves, until used. Prepare fresh every time before use.
3. Virtis mixer with tall jar.

Procedure

1. 10.0 g raw ground pork (chilled) was placed in the Virtis jar.
2. 15 ml of cold 9% perchloric acid and 10 ml of cold, distilled water were added.
3. Blend at about 23,000 rpm for 10 seconds.
4. Transfer the blended sample to a 100 ml beaker. Rinse the virtis jar with 5 ml distilled water and add to the sample to bring the volume to 50 ml.
5. Filter through Whatman No. 2v filter paper into 50 ml erlenmeyer flasks.
6. Pipette 5 ml filtrate into a test tube and add 5 ml 0.02 M TBA reagent. Mix the solutions.
7. Cover, mix and store in the dark for 15 hours (15-17 hrs.)
8. Determine absorbance on spectrophotometer at 529. 5 nm.

Standards

1. Prepare stock solutions of TEP (1,1,3,3-tetraethoxy propane)

   Weigh 0.233 g TEP into a small glass beaker. Quantitatively transfer the TEP to a 1000 ml volumetric flask with several washings of distilled water. Dilute to volume with distilled water. This is a 1×10^{-3} M TEP solution. Transfer 10 ml of 1×10^{-3} TEP solution to a 500 ml volumetric flask and dilute to volume with distilled water. This stock solution contains 1×10^{-7} moles TEP/5 ml and is the one used for standards each time. Keep both TEP solutions refrigerated.

2. With each group of meat samples, run TEP standards with concentrations of 0, 1, 2, 4, 6, and 8×10^{-8} moles TEP/5 ml. Other concentrations may be used as necessary. If 10 ml graduated test tubes are used, pipette the appropriate amount of the 1×10^{-7} moles TEP/5 ml solution into the tubes and fill to the 5 ml mark. (1 ml of the stock solution diluted with distilled water to 5 ml is equal to 2×10^{-8} moles TEP/5 ml). If plain test tubes are used, transfer 5 ml of the stock solution to a 50 ml volumetric and dilute to volume with distilled water for a 1×10^{-8} moles TEP/5 ml solution and make other appropriate dilutions.
3. To 5 ml TEP solution in a test tube, add 5 ml TBA reagent.
4. Cover, mix and store in the dark for 15 hrs.
5. Read the absorbance on a spectrophotometer.

Calculations

1. Using the concentrations and absorbances of the standards, determine the regression equation for the standard curve with a computer. The equation is: sample concentration[a] = (absorbance - intercept estimate)/ concentration estimate.
2. From the regression equation, determine the concentration of each sample.

3. Multiply the sample concentration by 0.72 to determine mg malonaldehyde (MA)/1000 g meat. The factor of 0.72 was derived from hydrolysis (100%) of TEP to MA, which weighs 72 g/mole. The 5 ml filtrate analyzed is equivalent to 1 g meat, so X (sample concentration) x 10^{-8} moles MA can be converted to X x 10^{-5} moles MA/100 g meat. Changing moles MA/1000 g meat to g MA/1000 g meat yields 72 X x 10^{-5} g MA/1000 g meat. After converting g to mg, the equation becomes 72 X x 10^{-2} mg MA/1000 g meat or .72X mg MA/1000 g meat. TBA numbers are equivalent to mg MA/1000 g meat.

Sample concentration in the calculations is the concentration (2 decimal places) with the 10^{-8} dropped for easier recording and figuring.

EFFECT OF VARIOUS HOME FREEZER
WRAPS ON FROZEN GROUND PORK

by

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ABSTRACT

During frozen storage, chemical and physical changes including the development of oxidative rancidity,moisture loss, changes in pH, and color changes associated with freezer burn, may occur in ground pork. To protect meat from detrimental changes during frozen storage, packaging materials are used. The purpose of this study was to investigate the effectiveness of selected packaging materials on the protection of ground pork in conditions similar to home storage with regards to oxidative rancidity, changes in pH, changes in color, and total moisture content over selected periods of time at a constant temperature.

Ground pork with a 25 percent fat content was analyzed for pH, color, and total moisture content. The pork was then packaged in 250-gram quantities in the following wrapping materials: Handi Wrap II with Cling Plus®, Saran Wrap®, Oster® sealing bags, Dazey® sealing bags, Ziploc® freezer bags, Glad SnapLock Storage® bags, Glad Food Storage® bags, heavy duty aluminum foil, and bread bags. All wrapping materials were measured for thickness. The packaged pork was held at -17°C (0°F) for 13 and 26 weeks in an upright home-style freezer. After the designated period of time, the packages of ground pork were thawed overnight at 4.4°C (40°F) and then analyzed for total moisture content, pH, oxidative rancidity (using the 2-thiobarbituric acid test), and color. Values measured for color include L-, a-, and b-values, CIE L-, a-, b-values under Illuminant A, as well as a calculation for an indication of redness (%R 630 - %R 580 nm).

Results were analyzed using a two way analysis of variance with the T-test applied.

Wrap thickness varied with each product. Only Saran Wrap® and Handi Wrap II with Cling Plus® were similar in thickness.

Time of storage appeared to have more of an effect on the ground pork than

did the individual wrapping materials. There were no differences noted for any of the objective parameters tested among wrapping materials; however, when the 13 and 26 week time period values were averaged together across all wrapping materials and were compared, differences were found in TBA values; %R630 - %R580nm values; L-, a-, and b-values; and CIE L-, a-, and b-values. Moisture content and pH values remained stable.

Upon application of the T-test to the various values for wrapping materials averaged across all time periods, Saran Wrap® protected against rancidity better than did Handi Wrap II® but not significantly better than any of the other materials tested. The red color of the ground pork appeared to be protected best by heavy duty aluminum foil and least by the Dazey® or Oster® bags.

Moisture content appeared to be lost between 0 and 13 weeks of storage. After 13 weeks, the loss stabilized. The ground pork samples stored in Oster® bags, Glad SnapLock Storage® bags, Glad Food Storage® bags, and Ziploc® bags had significantly higher amounts of rancidity present from 13 to 26 weeks. Saran Wrap® and aluminum foil samples had the lowest overall TBA numbers and, thus, the least amount of oxidative rancidity. All ground pork samples held in aluminum foil had the highest %R630 - %R580nm values, a-values, and CIE a-values. When compared to the control, there was no significant difference between the control and the samples held 13 weeks or the samples held 26 weeks. All samples held 13 weeks had significantly higher L-values than the control value or the L-values of those samples held 26 weeks. The 26 week samples were no different from the control. The CIE L-values followed the same trends. There was little difference between the b-values for samples stored 0, 13, and 26 weeks or for the CIE b-values stored 0, 13, and 26 weeks, but overall the samples increased in the amount of yellow color present over time.