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# COMPARISON OF TP CAN AND FLEXIBLE POUCH ON PHYSICOCHEMICAL, MICROBIAL AND SENSORY PROPERTIES OF MASHHAD BLACKCHERRY PRESERVES AT DIFFERENT STORAGE CONDITIONS

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## ABSTRACT

Packaging is one of the most important and effective factors on quality, appearance and marketability of food products. In this study, the effects of two types of packaging materials, i.e., tinplate (TP) can and flexible pouch (FP), on physicochemical, microbial and sensory properties of cherry preserves during 0, 30, 60 and 90 days of storage under 4, 23, 35 and 40C were investigated. The results revealed that both packaging materials have similar effects on microbial and physicochemical properties (pH and acidity), but better color attributes were observed in FP samples compared with the preserves packed in TP. Packaging type had a significant effect on trace element concentration at $\alpha = \%5$. Mean values of iron, lead and tin were 4.858 ppm, 38.459 ppb and 500.203 ppb, respectively, in TP cans with an ascending pattern during storage, but constant level of these metals was observed in FP. All sensory properties were scored as acceptable in FP.

## PRACTICAL APPLICATIONS

We compare two types of conventional packaging for fruit preserves and our results show that preserves filled in FP packages were similar to TP cans in many aspects of physicochemical, microbial and sensory properties, and in some cases such as color and trace metal content were better than TP, which are important in marketing and also the safety and health of consumers.

## INTRODUCTION

Cherry (*Prunus avium L.*) is generally cultivated in Iran as a native plant since many years ago, and Iran is considered one of the greatest cherry producers in the world with 225,000 mt/year. Different varieties of cherry exist in the world, namely Ferrovia, Lambert, Van, Lapins, Turfanda, Karabodur, Stella, Bing, Ziraat, Noir De Guben, Sciazza, etc. (Goharkhaye 1992; Rahemi 1997).

In Iran, cultivated areas of cherry are often scattered in the provinces of Khorasan, Tehran, Esfahan, Urmia and East Azerbaijan. Some native cultivars are Hajyousefi, Sefid Rezaeiye, Shabestar, zard daneshkade and Mashhad blackcherry. Among these, Mashhad blackcherry is one of the most desirable varieties, which is serotinous but has the best quality and high yield. Its color is red to hepatic and the mean weight of fruit is about 7 g. The harvest season is around May and June (Goharkhaye 1992).

In order to expand cherry supply for year-round and to preserve surplus cherry for a long time, canning industry has been developed and flourished in the region. Cherry preserve is often produced in tinplate (TP) cans, but the main problems of this kind of packaging are heavy weight, high price and aggregation of some trace elements such as iron, tin and lead in food content as a result of internal wall corrosion.

High iron content of food product causes undesirable changes in color, taste (metallic taste) and transparency.

Permissible level of iron in canned fruits, according to Iranian Institute of Standard and Industrial Research (ISIRI) and also joint FAO/WHO Codex Alimentarius Commission (1978), food standards is determined as 15 mg/kg (ISIRI 2007, No: 9720).

Although tin is not poisonous, high aggregation of tin in canned food especially in unlacquered cans (about 0.1–1 g/lit) impresses food taste and causes diarrhea and other gastrointestinal disorders in consumers. Also, some studies reported anemia, tumors and undesirable pathologic effects such as diminished absorption of Ca, Cu and Zn in animal tissues. Permissible level of tin in canned fruits according to ISIRI and joint FAO/WHO food standards is 150 mg/kg (Benoy *et al.* 1971; Blunden and Wallace 2003; Manzoori *et al.* 2006).

Lead frequently enters the human body via food, potable water and polluted air. Furthermore, lead probably leaks into food content especially in acidic food from lead-soldered metal cans. Major health problems attributed to lead aggregation in the body are chronic intoxication, cancer, reduced fertility period, neonatal low birth weight, decreased level of hemoglobin in blood and renal diseases. Maximum acceptable level of lead is determined to be 0.3 ppm in food such as preserves and 50 ppb in potable water (Maduabuchi *et al.* 2006 and ISIRI 2007, No. 9720).

Considering the problems mentioned above, packaging industry is always looking for suitable substitute for metal cans. Nowadays, flexible pouches (FPs) are among the most desirable packages in the world with different types and applications. Benefits such as good appearance, low price, lightness, printability, low cost of conveying and storage, diversity and flexibility of shape and size, etc. make them suitable in packaging of any kinds of food such as preserves (Emami-Khansari *et al.* 2005).

Many researchers studied some aspects of the relationship between packaging type and food characteristics including pH, acidity, color and metal content (Salunkhe *et al.* 1979; Nagy *et al.* 1980; Seow *et al.* 1984; Ochoa *et al.* 2001; Clark *et al.* 2002; Emami-Khansari *et al.* 2005; Maduabuchi *et al.* 2006).

The main objective of the present study was to investigate the suitability of FPs as cherry preserve container and to evaluate its effects on physicochemical, microbial and sensory properties of the product during 90 days of storage at different temperatures compared with samples packed in conventional TP cans.

## MATERIALS AND METHODS

### Materials

Mashhad black cherries were collected from a local garden in Shandiz suburb of Mashhad, Iran, in May 2007.

Laminated FPs were unprinted with $100 \times 143$ mm dimensions and consist of three layers, polyethylene (100 μ), aluminum foil (9 μ) and polyester (12 μ), provided from Shahdiran Co., Mashhad, Iran.

Cans were lacquered tinplate (Epoxy phenolic lacquer) with impervious lids supplied by Container Corporation of Mashhad, Iran.

All solvents, chemical reagents and microbial culture media were of analytical grade (Merck, Germany).

### Preparation of Cherry Preserve

Identical procedure was used in processing of cherry before filling in both packages. Cherries were completely washed in cold water; their stems and surplusages were removed and manually filled in the packages. Equilibrium Brix of syrup (mixture of sugar, citric acid and water) was adjusted to %17, fruit/syrup ratio was 50:50 and the pH of syrup was about 3.8. TP-packed samples were pasteurized at 92C for 30 min, whereas the FP-packed samples were treated at 88C for 45 min. Samples were stored at 4, 23, 35 and 40C and all following tests were performed 0, 30, 60 and 90 days after production.

### Methods

PH was determined by Metrohm pH meter at ambient temperature. Soluble solid content (°Brix) was measured by manual refractometer (model 330).

Total acidity was determined by titration with NaOH (0.1 N) and total free acid content in 1 mL syrup was expressed as citric acid.

The color change in cherry syrup was measured by UV-visible spectrophotometer (UV-160A model, Shimadzu Corporation, Kyoto, Japan). Samples were diluted with distilled water up to 0.1 and their absorbance was measured at 515 nm as color index.

Atomic absorption spectrophotometer (AA670 model, Shimadzu Corporation) equipped with air-acetylene flame was used for determining iron in samples. Samples were mixed and homogeneous, then digested using sulfuric acid and nitric acid before metal measurement according to the approved method of AOAC (AOAC International 2005, No. 999.11). A calibration curve was constructed for iron standard solution by plotting the absorbance of each solution at 248.33 nm versus concentration. Then the concentration of the unknown iron samples was determined.

Tin and lead content were also determined by using atomic absorption spectrophotometer equipped with graphite furnace at 224.6 and 283.30 nm, respectively (AOAC International 2005, No. 972.25, 980.19).

**TABLE 1.** MEAN VALUES OF CHERRY PRESERVE CHEMICAL PROPERTIES IN TWO KINDS OF PACKAGING

| | TP can | FP package |
|---|---|---|
| pH | 3.988[a] | 3.990[a] |
| Soluble solid (°Brix) | 16.990[b] | 17.491[a] |
| Acidity* | 0.253[a] | 0.255[a] |

* Expressed as citric acid.
Values within the same row with the different superscript meant significant difference ($P < 0.05$).
TP, tinplate; FP, flexible pouch.

In microbiological assays, media, namely yeast extract glucose chloramphenicol (YGC) and orange serum agar (OSA), were used to detect acidophilic bacteria, yeasts and spore-forming bacteria, respectively. Culture media were then inoculated by diluted homogenous samples using pour plate and direct surface methods. OSA plates were incubated at 37C for 48 h and YGC samples at 25C for 3–5 days. After incubation periods, colony development in all plates was investigated (ISIRI 2007, No: 2326).

Sensory properties of all samples were evaluated by six trained panelists. Fruit color, transparency and color of syrup, aroma, texture and overall acceptance were the selected sensory characteristics. A 5-point hedonic numerical scale was used to indicate the differences in samples packed in two types of packages under different storage conditions. Samples were scored as follows: 1 = extremely unacceptable, 2 = unacceptable, 3 = acceptable, 4 = good, 5 = extremely good. Acceptance point was considered as 3 (Drake 2007).

### Statistical Analysis

All the above experiments were performed in triplicate and the data obtained were analyzed using split plot design analysis with temperature in the main plot and combination of packaging type and time in the subordinate plot factor. One-way analysis of variance (ANOVA-1) using MSTAT-C software was then performed and the significant means were separated using the Duncan's multiple range test at 5% probability.

## RESULTS AND DISCUSSION

### Effect of Packaging Materials and Storage Conditions on Chemical Tests

The results showed that packaging type has no significant effect on pH in cherry preserve, as the mean values of pH were 3.988 and 3.99 in TP cans and FPs, respectively (Table 1).

Among all temperatures, storage at 40C caused a significant decrease in pH value. This might be associated to sugar decomposition in higher temperatures and acidic condition (Table 2).

PH value of samples increased significantly up to 60 days of storage, which might be due to the acidic compounds being expelled from fruit into syrup. No such trend was observed during the remaining storage period (Table 2).

According to the results, samples in FP had higher Brix value than TP cans; in other words, packaging type caused significant changes in Brix value (Table 1). Because pouches have more surface contact area than cans, it is possible that the content of pouches gets more impression from the environmental processing and storage conditions, which accelerate the expelling of solid matter leakage from fruits to syrup and increasing Brix consequently.

In both packaging types, the lowest and highest values of Brix during 90 days of storage were observed at 4 and 40C, respectively. This might be attributed to textural changes in fruits and increasing the rate of solid matters exchange in higher temperatures (Table 2).

Packaging type had no significant effects on acidity changes. Acidity increased gradually in samples stored at 40C as shown in Table 2.

### Effect of Packaging Materials and Storage Condition on Metal Content

According to the results obtained from metal measurement in samples (Table 3), type of packaging had meaningful effect on iron content of all samples ($P < 0.05$).

Mean contents of iron in cherry preserves in TP cans and FP were 4.858 and 3.161 mg/kg, respectively.

**TABLE 2.** MEAN VALUES OF CHERRY PRESERVE CHEMICAL PROPERTIES IN TESTED TEMPERATURE AND TIME

| | Temperature (C) | | | | Time (day) | | | |
|---|---|---|---|---|---|---|---|---|
| | 4 | 23 | 35 | 40 | 0 | 30 | 60 | 90 |
| pH | 4.02[a] | 4.03[a] | 4.00[a] | 3.94[b] | 3.89[c] | 3.99[b] | 4.05[a] | 4.06[a] |
| Soluble solid (°Brix) | 17.21[a] | 17.44[a] | 17.63[a] | 17.68[a] | 16.40[b] | 17.85[a] | 17.83[a] | 17.89[a] |
| Acidity* | 0.237[b] | 0.238[b] | 0.238[b] | 0.301[a] | 0.218[b] | 0.249[b] | 0.268[ab] | 0.285[a] |

* Expressed as citric acid.
Values within the same row with the different superscript meant significant difference ($P < 0.05$).

**TABLE 3.** MEAN VALUES OF IRON CONTENT IN CHERRY PRESERVES FILLED IN TP AND FP PACKAGES UNDER TESTED TEMPERATURE AND TIME (mg/kg)

| | Time (day) | Temperature (C) | | | |
|---|---|---|---|---|---|
| | | 4 | 23 | 35 | 40 |
| TP can | 0 | 2.33 | 2.33 | 2.33 | 2.33 |
| | 30 | 3.92 | 4.25 | 4.60 | 4.93 |
| | 60 | 4.38 | 5.54 | 5.52 | 7.87 |
| | 90 | 4.56 | 6.06 | 7.12 | 9.64 |
| FP package | 0 | 2.75 | 2.75 | 2.75 | 2.75 |
| | 30 | 3.14 | 3.07 | 2.88 | 3.26 |
| | 60 | 3.24 | 3.12 | 3.07 | 3.62 |
| | 90 | 3.31 | 3.41 | 3.34 | 4.08 |

TP, tinplate; FP, flexible pouch.

**TABLE 4.** MEAN VALUES OF TIN CONTENT IN CHERRY PRESERVES FILLED IN TP AND FP PACKAGES UNDER TESTED TEMPERATURE AND TIME (µg/kg)

| | Time (day) | Temperature (C) | | | |
|---|---|---|---|---|---|
| | | 4 | 23 | 35 | 40 |
| TP can | 0 | 348.7 | 348.7 | 348.7 | 348.7 |
| | 30 | 350.3 | 385.2 | 421.9 | 629.5 |
| | 60 | 360.0 | 457.1 | 465.7 | 865.5 |
| | 90 | 460.9 | 482.7 | 585.5 | 1,135.0 |
| FP package | 0 | 313.0 | 313.0 | 313.0 | 313.0 |
| | 30 | 373.9 | 387.0 | 400.6 | 356.8 |
| | 60 | 414.6 | 432.2 | 401.4 | 412.3 |
| | 90 | 420.6 | 449.5 | 477.6 | 424.4 |

TP, tinplate; FP, flexible pouch.

In TP cans, difference of iron content at 23 and 35C was not statistically significant, but 4 and 40C caused meaningful effects on the iron content. Samples stored at 4 and 40C had the lowest and highest iron content, respectively. Iron content of preserves in TP cans increased during storage period, which was statistically significant ($P < 0.05$).

In contrast to the results of TP cans, mean iron content of samples packed in FP showed negligible increase during the storage period at all tested temperatures, which was not statistically significant ($P > 0.05$).

This is in agreement with the findings of other researchers, e.g., Seow *et al.* (1984) determined the iron content of three different juices (apple juice, grape juice and tomato juice) packed in TP cans. Their results showed that more than 56% of all examined samples had more than 15 mg/kg iron content, which is considered as maximum permissible level of international standards. They also elucidated that iron content of juices filled in TP cans increased as the storage temperature increased. They concluded that the corrosion of internal wall of TP packages as a function of temperature and time might be a main factor for increasing iron content of samples.

Nagy *et al.* (1980) studied the effect of storage temperature on orange juice filled in cans. They found that changes in temperature affect the iron content of samples and increase it as the temperature increases.

As shown in Table 4, packaging had a meaningful effect on tin content ($P < 0.05$). Mean content of tin in TP cans was 500.203 ppb, which is significantly higher than FP samples (387.978 ppb) ($P < 0.05$).

The results also indicated that increasing the storage temperature causes significant differences in tin content in TP can preserves ($P < 0.05$). Samples stored at 40C had the highest tin content. In contrast, mean changes in tin content in FP at different temperatures were not statistically significant ($P > 0.05$).

Some researchers had determined the tin content in different foods filled in lacquered cans, e.g., Seow *et al.* (1984) reported that tin content of apple and tomato juices filled in lacquered cans was negligible and in grape juice was 6 ppm.

Qiong *et al.* (1999) mentioned that the tin content in pear preserves filled in lacquered cans was 40 ppb.

Results of lead content measurement in cherry preserves are shown in Table 5.

Lead content of TP cans was higher than FP packages and their differences were statistically meaningful ($P < 0.05$).

Tested temperatures did not cause significant changes in lead content of samples ($P > 0.05$), but counter-effect of storage temperature and packaging type on lead content was meaningful ($P < 0.05$), as the highest lead content was seen in TP cans stored at 40C, and the lowest one in preserves filled in FP stored at 4C. Mean values of lead content in TP cans and FPs were 38.459 and 33.993 ppb, respectively. The results also demonstrated that during three months of storage, mean contents of lead content in samples were increased gradually ($P < 0.05$).

Maduabuchi *et al.* (2006) measured the lead content migrated from can to content of 50 different beverages by

**TABLE 5.** MEAN VALUES OF LEAD CONTENT IN CHERRY PRESERVES FILLED IN TP AND FP PACKAGES UNDER TESTED TEMPERATURE AND TIME (mg/kg)

| | Time (day) | Temperature (C) | | | |
|---|---|---|---|---|---|
| | | 4 | 23 | 35 | 40 |
| TP can | 0 | 13.96 | 13.96 | 13.96 | 13.96 |
| | 30 | 26.42 | 36.19 | 30.70 | 43.41 |
| | 60 | 39.34 | 35.71 | 50.60 | 60.10 |
| | 90 | 47.51 | 52.35 | 54.75 | 82.43 |
| FP package | 0 | 13.63 | 13.63 | 13.63 | 13.63 |
| | 30 | 29.96 | 32.68 | 38.19 | 35.50 |
| | 60 | 32.70 | 46.82 | 41.85 | 49.82 |
| | 90 | 33.91 | 42.33 | 52.11 | 53.50 |

TP, tinplate; FP, flexible pouch.

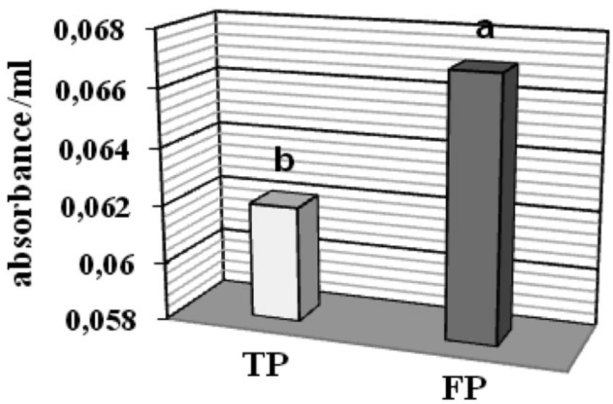


**FIG. 1.** EFFECT OF PACKAGING ON MEAN VALUES OF COLOR CHANGES (ABSORBANCE)
TP, tinplate; FP, flexible pouch.

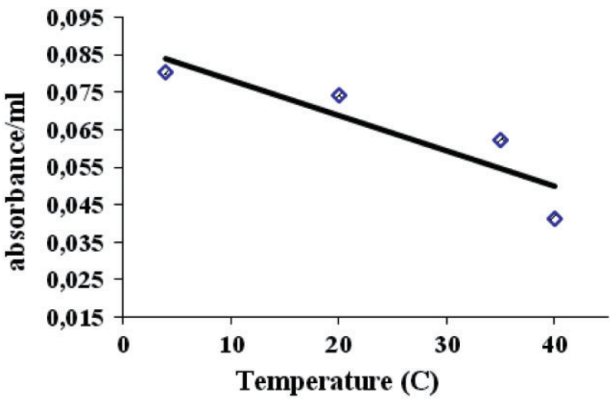


**FIG. 2.** MEAN VALUES OF COLOR CHANGES (ABSORBANCE) AT DIFFERENT TEMPERATURES

atomic absorption spectrophotometer and reported that the mean lead content in all samples ranged between 2 and 73 ppb.

## Microbiological Experiments

No yeast, acidophilic and spore-forming bacteria were detected on samples throughout 90 days of storage period. As expected, samples in both packages were completely pasteurized and no leakage and microbial contamination occurred during the study.

## Color Changes during Storage

Results of ANOVA table and mean comparison showed that preserves filled in FP packages had higher absorbance at 515 nm than samples filled in TP cans ($P < 0.05$). Thus, FP packages maintained better color quality of cherry preserves (Fig. 1)

Color value changes in samples in different storage temperatures were statistically significant ($P < 0.05$). Samples stored at 4C had the highest absorbance whereas samples stored at 40C had the lowest absorbance value, respectively.

High stability of anthocyanins and better color quality of samples in FP packages might be due to lower content of metallic ions (i.e., iron) in this type of packages. Furthermore, decomposition of anthocyanin pigments might occur at higher storage temperatures and suppress the color value of samples.

The results of this study are in agreement with the other findings on color change procedure of fruit preserves during storage at different temperatures.

Salunkhe *et al.* (1979) evaluated the color of pineapple preserves filled in flexible retortable pouches during storage at 4.4, 21.1 and 37.8C. They found that increasing temperature could accelerate color changes in samples and decrease the shelf life of products, respectively.

Ochoa *et al.* (2001) studied the color changes in sweet cherry, sour cherry and raspberry preserves at 4, 20 and 40C storage and reported that samples stored at 4C had the best color quality and minimal color changes.

Clark *et al.* (2002) investigated the color change in pear preserves filled in flexible retortable pouches during storage

**TABLE 6.** MEAN VALUES OF COLOR CHANGES (ABSORBANCE) IN CHERRY PRESERVES UNDER TESTED PACKAGING, TEMPERATURE AND TIME (mg/kg)

| | Temperature (C) | Time (day) 0 | 30 | 60 | 90 |
|---|---|---|---|---|---|
| TP can | 4 | 0.033 ± 0.001 | 0.088 ± 0.014 | 0.095 ± 0.014 | 0.092 ± 0.002 |
| | 23 | 0.033 ± 0.001 | 0.075 ± 0.005 | 0.081 ± 0.009 | 0.087 ± 0.001 |
| | 35 | 0.033 ± 0.001 | 0.063 ± 0.005 | 0.071 ± 0.008 | 0.059 ± 0.003 |
| | 40 | 0.033 ± 0.001 | 0.041 ± 0.006 | 0.050 ± 0.014 | 0.052 ± 0.007 |
| FP package | 4 | 0.041 ± 0.002 | 0.095 ± 0.005 | 0.098 ± 0.009 | 0.098 ± 0.003 |
| | 23 | 0.041 ± 0.002 | 0.080 ± 0.034 | 0.093 ± 0.010 | 0.090 ± 0.003 |
| | 35 | 0.041 ± 0.002 | 0.095 ± 0.003 | 0.077 ± 0.022 | 0.060 ± 0.008 |
| | 40 | 0.041 ± 0.002 | 0.026 ± 0.008 | 0.040 ± 0.004 | 0.051 ± 0.003 |

TP, tinplate; FP, flexible pouch.

**TABLE 7.** MEAN SCORES OF SENSORY PROPERTIES OF CHERRY PRESERVE IN TESTED PACKAGES

| Sensory properties | Fruit color | Transparency and color of syrup | Aroma | Texture | Overall acceptance |
|---|---|---|---|---|---|
| FP package | 3.1 ± 0.75 | 3.7 ± 1.40 | 3.2 ± 1.00 | 3.0 ± 1.01 | 3.1 ± 1.05 |
| TP can | 3.2 ± 1.03 | 3.7 ± 1.09 | 3.4 ± 0.98 | 3.1 ± 0.75 | 3.3 ± 0.63 |

TP, tinplate; FP, flexible pouch.

at 4.4, 26.7 and 37.8C, and reported that the best color quality was kept at lower temperatures.

By fitting the data obtained from color changes measurement of samples in different temperatures (Fig. 2), linear regression model could be suggested to predict color change in preserves at different temperatures (Eq. 1). In this model, strong correlations are observed between X (temperature of storage [C]) and Y (absorbance change [absorbance/mL]).

$$Y = -0.129X + 0.965 \qquad r^2 = 0.936 \qquad (1)$$

According to the results, a significant time-dependent decrease in color attributes during storage time was observed in both packaging samples ($P < 0.05$) as absorbance of samples decreased markedly in 30, 60 and 90 days after production (Table 6).

Ochoa *et al.* (2001) declared that the color of syrup in sweet cherry, sour cherry and raspberry preserves during 5 months of storage progressively darkened during 90 days of storage, and after that color attributes remained approximately constant.

### Effects of Packaging Type on Sensory Properties

Mean scores of all sensory properties in both packages were acceptable (scored more than 3, which is considered the threshold point of acceptability product in 5-point hedonic scale) (Table 7). All sensory properties were affected and became less acceptable as the storage temperature was increased ($P < 0.05$) (Table 7).

## CONCLUSIONS

The findings of the present study demonstrated that:

(1) Selected FP packages could tolerate the pasteurization temperature well.

(2) Microbial quality of products filled in FP packages was highly maintained and no leakage or microbial contamination occurred during storage.

(3) PH and acidity changes in cherry preserves in both packages were similar, but Brix was higher in FPs.

(4) More stability of anthocyanins was observed in FP packages and better color quality was maintained in comparison to TP can samples, as the color of syrup in samples at FP packages remained as fresh cherry color. This attribute is so important in terms of economic and marketing point of view.

(5) The iron content of samples in TP can tend to increase during storage temperatures and storage time, but in FP, changes were not statistically significant at storage period.

(6) Iron content in TP cans ranged between 2.33 and 9.64 ppm after 3 months of storage. It can be claimed that all samples would probably contain more than 15 ppm iron after about 12 months of storage, the level which is considered as permissible level by Iranian National Standard and FAO/WHO International Committee. Therefore, metal residue will continue to be of concern because the shelf life of preserves in TP cans had been defined as 18–24 months, and it can be said that after 12 months of storage, iron content will have aggregated more than permissible level in most samples.

(7) Lead and tin content of cherry preserves in TP cans at different temperatures during 3 months of storage ranged between 13.96–82.43 ppb and 348.7–1,135 ppb, respectively. These values were less than the permissible level determined in standards.

(8) Overall, it can be claimed that preserves packed in FP have maintained their physicochemical, microbial and sensory properties similar to TP cans, and in some cases such as color quality and lower trace metal content were proven to be better than TP packages.

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