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THE QUALITY PARAMETERS OF TOMATO PASTE STORED IN CONTAINERS *ROBBY* IN COMPARISON WITH CONVENTIONAL WAYS OF COLD STORAGE

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Abstract. Food containers, especially those used for cooked and processed food, should comply with certain standards to increase the shelf life of food products. Tomato paste is the most popular processed food due to the presence of such functional compounds as lycopene, β-carotene, ascorbic acid, and phenolics. In this regard, the present study compares the quality of products stored for 56 days in the new container *Robby* (invented to keep tomato paste in) and in conventional containers (industrially manufactured or homemade). This study was a full factorial design experiment with 48 experimental treatments involving 3 different containers, 2 types of tomato paste (homemade and industrially manufactured), 2 different producers for each type of tomato paste, 2 refrigeration environments (an isolated laboratory refrigerator and a refrigerator used in a dormitory with normal household conditions), and 2 replicates. Chemical and microbial tests were performed using precise methods. The chemical tests included determining the acidity, measuring vitamin C and total soluble solids, salt content, concentrations of aflatoxins B1, B2, G1, and G2, and the findings were compared at the end of the storage period. All microbial tests were carried out by the pour plate method. The total viable cells were counted on Plate Count Agar (PCA) after incubation at 30°C for 24 h. Acid-resistant bacteria and mould/yeast were counted, respectively, on de Man, Rogosa and Sharpe agar (MRS) and DRBC after incubation at 30°C for 3–5 days. To analyse the data, three-way analysis of variance (ANOVA) and paired t-test were applied, using the $SPSS_{20}$ software. At the end of the study period, the least and the worst contaminated homemade samples were examined for aflatoxin. As to the industrial samples, the type of a container had a significant effect on the total microbial count, yeast and mould count, LAB and vitamin C concentration. The same results (except those concerning vitamin C) have been obtained for the homemade samples. Compared with conventional means of cold storage of tomato paste, using *Robby* containers results in the least change in the microbial and chemical quality of tomato paste, preserves more vitamin C in the product, hinders the secondary contamination and microbial growth. Also, proliferation of microorganisms in homemade tomato paste during refrigeration can be well controlled when this container is used.

Keywords: paste, microbial and chemical changes, aflatoxin, cold storage, *Robby* container.

Introduction. Formulation of the problem

Tomato is one of the most consumed agricultural products in Iran, with per capita consumption three times more than the world average in 2013. Iran is ranked seventh in terms of tomato production, after Egypt and Italy [1]. A major part of fresh tomatoes is converted into tomato juices, paste, sauce, and purée [2,3]. Of them, tomato paste is the main tomato-based product. It is preserved using homemade or industrial means [4]. However, when it is cold-stored, fungal or microbial growth usually takes place after the can is opened [5,6]. Fungal spores are mostly destroyed by canning processes. However, some species with heat-resistant ascospores, like *Byssochlamys fulva*, *Aspergillus*, and *Penicillium*, can survive the pasteurisation of tomato paste. Also, secondary contamination at the refrigeration stage is another cause of mould spoilage after opening the can [7].

Mould spoilage of tomatoes is associated with a decrease in vitamin C, increase in pH [8,9], and accumulation of mycotoxin, the latter greatly affecting human health [10]. In recent years, some studies have been carried out to extend the tomato paste shelf life during cold storage by applying natural preservatives or additives [11,12]. These approaches are not generally practical, because natural preservatives alter the organoleptic properties of tomato paste.

Currently, the most common recommendation for tomato paste storage at the refrigeration stage is to cover the original tin with a plastic lid or to place the tomato paste into a clean air-tight glass or plastic container. If tomato paste is homemade, in Iran, they traditionally apply a layer of vegetable oil over it. In 2016, a container named *Robby* was invented for storing semi-solid foods, and in particular, tomato paste. It was registered under the patent number 77317 at the Innovation Organisation of Iran, and became popular soon. Also, in 2016, it won the first prize at the IENA festival in Germany. According to the inventor, this container functions as a small pumping device by providing an isolated low pressure environment. It is claimed that *Robby* ensures longer shelf life of food and limits a consumer's exposure to mycotoxin. However, so far, these features have not been compared, using scientific methods, with the conventional ways of storing tomato paste. This study considers the change in the chemical and microbial properties of industrially canned and homemade tomato paste kept in different containers, including the *Robby* container, during the refrigeration period.

This section is an attempt to select related and topically close studies to compare with the research results at the end. Yalmeh *et al.* evaluated the effect of sodium salt on the growth of *Aspergillus niger* isolated from tomato paste. They found that sodium chloride did not have a complete inhibitory effect on *Aspergillus niger* [13]. Safdar *et al.* in their study of the effect of time and temperature on the quality characteristics of tomato paste, showed that the amount of soluble solids and the acidity gradually increased while the pH and vitamin C decreased [14]. Omidbeigi *et al.* in their study proved the inhibitory effect that thyme, summer savory, and clove essential oils had on *Aspergillus* in tomato paste [15]. Elhami Rad and Shahidi also showed that during production of paste, high Brix values (38–35), spraying salt on its surface, and storage at zero Celsius had but a limiting effect on the microbial changes and failed to stop them completely [16]. The study by Kabazakalis *et al.* showed that storing commercial juices at refrigerator temperature, compared to storing them at room temperature, and keeping them in closed containers, compared to open containers, reduced the loss of vitamin C [17]. Some studies, including Soloty's (2002), have established that plant extracts and natural additives can increase the shelf life of tomato paste [18].

Most studies considering tomato paste have focused on adding preservatives to it in order to increase its shelf life. However, none of them mentions the type of a container for tomato paste. The distinguishing feature of this research is studying the containers in which tomato paste is packaged.

The purpose and objectives of the study

1. Evaluation and comparison of chemical and microbial changes of tomato paste during storage in a refrigerator using different maintenance methods.
2. Comparison of keeping tomato paste in a *Robby* container with traditional ways of storage, such as cans, glass, and glass with oil coating.

Research materials and methods

Materials. The chemicals and culture media required for microbial tests were all provided by Merck Company, Germany.

A pilot study was conducted prior to the main experiment in order to obtain background information on the prevalence of microbial contamination of commercial tomato paste. For this purpose, 24 randomly collected samples of canned tomato paste from different brands were examined during July 2016.

Design of the experiments and preparation of the samples. This study was a full factorial design experiment with 48 experimental treatments involving 3 different containers, 2 types of tomato paste (homemade and industrially manufactured), 2 different producers for each type of tomato paste, 2 refrigeration environments (an isolated laboratory refrigerator and a refrigerator used in a dormitory with normal household conditions), and 2 replicates. All samples were examined for chemical and microbial changes, on a biweekly basis, for 6 weeks. 12 tomato paste cans (800g) of each of the two industrial brands under study were purchased from the same production lot to be used as samples. Of these, four cans were opened and covered with a plastic lid (Treatment 1), four were opened, placed into glass jars, and covered with metal lids (Treatment 2). The remaining four cans were placed into four *Robby* containers (Treatment 3). Twelve homemade tomato paste samples (1-1.2 Kg) were provided directly from each of the two local produces, all were put in glass jars. Four samples were kept in the original glass containers covered with metal lids (Treatment 4), four samples were kept the same way as the previous ones, but covered with a layer of vegetable oil by the produces (Treatment 5), and four samples were placed into four *Robby* containers (Treatment 6). The *Robby* containers were steamed and allowed to dry exposed to UV light before filling. All samples were equally distributed in two refrigeration environments. Specially chosen students in the dormitory were asked to use all 6 treatments on a frequent basis. The temperature in both refrigerators was 4°C.

Chemical tests. The acidity, which was expressed based on the citric acid percentage, was determined by the volumetric titration method using 0.1M NaOH [14]. Vitamin C was measured according to standard AOAC method 967.21 [19]. The total soluble solids were measured with an automatic digital refractometer (Atago RX-5000, Japan), and the pH was measured with a meter PP-50 [20]. The salt content was measured according to Iranian National Standard No. 761 [21].

Concentrations of aflatoxin B1, B_2, G_1, and G_2 in Treatments 5 and 6 were compared at the end of the storage period. In brief, fifty grams of tomato paste was shaken for 30 min, 5 g of sodium chloride being added with 120 ml of methanol: H2O (80:20 v/v). After filtration, 20ml of the filtrate was diluted with 130 ml of deionised water and filtered through a glass microfibre filter, and 70ml of the filtrate was used to be further purified on an AflaTest™ immunoaffinity column. Chromatographic analysis was carried out by using an Agilent 1260 Infinity system (Palo Alto, California, USA) coupled with a fluorescence detector set with the excitation and emission wave-lengths 362nm and 425nm respectively. The mobile phase was a mixture of water, methanol, and acetonitrile (50:30:20%; v/v) containing 350µl of 4 M nitric acid and 120mg of KBr/l. The flow rate was 1 ml/min, and the column temperature was 25°C [22].

Microbial tests. All microbial tests were carried out by the pour plate method. The total viable cells were counted on Plate Count Agar (PCA) after incubation at 30°C for 24 h. Acid-resistant bacteria and mould/yeast were counted, respectively, on deMan, Rogosa and Sharpe agar (MRS) and DRBC after incubation at 30°C for 3-5 days [23,24].

The statistical method: to analyse the data, three-way analysis of variance (ANOVA) and paired t-test were applied, using the $SPSS_{20}$ software.

Results of the research and their discussion

Microbial examination of the tomato paste cans collected from the market revealed that 12 out of 24 samples were positive in terms of both total microbial count and DRBC count. The total microbial count ranged from 0.95 to 2.84 ($\log_{10}$CFU/g), and yeast and mould count varied from 0.65 to 1.43 ($\log_{10}$CFU/g), with no acid-resistant bacteria detected. All the samples tested had been assigned to the Institute of Standards & Industrial Research of Iran (ISIRI) and complied with Document No. 2326 "Microbiological characteristics of acidic or acidified food materials." According to this standard, canned tomato paste must be free from any microbial contamination [25], thus the value 50% observed indicated noncompliance with the standard.

The results of the effect of different storage conditions on the microbial and chemical characteristics measured for industrially made and homemade tomato paste are tabulated in Table 1.

Table 1 – Chemical and microbial changes in industrially canned tomato paste during cold storage of the samples under study*

Container type	Time (day)	Total count ($lgCFUg^{-1}$)	Mould & yeast (lg CFU g^{-1}).	Lactobacilli (l_0 CFU g^{-1})	Vitamin C (mg/100g)	^{0}Brix	Acidity (mg/100g)	pH
Robby in the laboratory	0	0	0	0	12.75±3.66	29.41±1.81	1.73±0.15	4.08±0.03
	14	0	0	0	10.59±2.88	28.73±1.81	1.73±0.15	4.10±0.08
	28	0	0	0	9.03±2.84	29.16±1.67	1.86±0.31	3.98±0.03
	42	0.34±0.20	0	0	7.92±2.59	28.79±1.52	1.86±0.31	4±0.03
	56	1.09±0.23	0	0	6.02±3.48	29.21±1.28	1.93±0.25	3.98±0.04
Robby in the dormitory	0	0	0	0	13.37±2.96	29.11±1.57	1.46±0.16	4.07±0.04
	14	0.56±0.32	0	0	11.25±2.28	28.87±1.72	1.73±0.15	4.12±0.08
	28	0.56±0.32	0	0	8.87±2.88	28.92±1.47	1.86±0.31	3.98±0.04
	42	0.50±0.29	0	0	7.92±2.59	28.51±2.62	1.86±0.31	3.98±0.04
	56	0.50±0.29	0	0	6.02±3.48	29.19±1.85	2.13±0.31	3.98±0.04
Glass jar in the laboratory	0	0	0	0	13.55±3.03	29.08±1.50	1.73±0.15	4.06±0.03
	14	0	0	0	9.33±4.33	28.93±1.23	1.66±0.25	4.11±0.02
	28	0.31±0.31	0	0	5.49±3.33	29.06±1.98	1.66±0.25	3.99±0.04
	42	0.49±0.28	0	0	3.55±4.26	27.29±3.48	1.86±0.31	3.98±0.04
	56	1.11±0.46	1.18±0.68	1.03±0.60	0	29.17±1.83	2.06±0.26	3.99±0.06
Glass jar in the dormitory	0	0	0	0	12.75±3.66	29.16±1.37	1.79±0.13	4.05±0.04
	14	0.45±0.30	0	0	9.15±4.53	29.55±1.62	1.73±0.15	4.10±0.03
	28	1.27±0.23	0	0	4.10±1.71	29.08±1.32	1.73±0.15	3.99±0.04
	42	1.48±0.37	0	0	1.42±1.64	29.69±2.24	1.86±0.31	3.98±0.04
	56	1.39±0.30	0	0	0	29.62±1.51	1.99±0.16	3.97±0.05
Metal can in the laboratory	0	0	0	0	11.15±5.51	29.75±1.32	1.59±0.16	4.06±0.04
	14	0.61±0.35	0	0	6.80±1.81	28.83±1.50	1.46±0.15	4.09±0.04
	28	1.22±0.09	0	0	5.22±3.02	28.85±1.59	1.73±0.15	3.99±0.05
	42	1.77±0.39	0	0	2.13±2.72	29.13±1.74	1.86±0.31	3.98±0.04
	56	0	0	0	0	28.09±0.42	2.13±0	3.98±0.04
Metal can in the dormitory	0	0.50±0.29	0	0	14.34±5.50	29.46±1.42	1.73±0.15	4.06±0.03
	14	2.65±0.78	0	0	8.37±3.23	29.06±1.98	1.73±0.15	4.08±0.04
	28	4±1.30	0	0	4.78±2.54	29.04±1.41	1.73±0.15	3.98±0.04
	42	4.46±1	3.10±1.79	3.09±1.79	2.13±2.72	29.19±1.86	1.73±0.15	3.98±0.03
	56	4.61±0.35	3.14±1.82	3.10±1.79	0	29.88±1.50	2.20±0.13	3.98±0.04

*The data are presented as the mean value ± SE for 2 individual replicates of samples and 2 replicated tests

According to the information in Table 1, for the industrially canned tomato paste, the container type had a significant effect on the total microbial, yeast and mould count and acid-resistant bacteria ($p<0.001$). The microbial population was zero on the first day of the experiment, but increased during the storage period. The greatest delay in microbial growth was observed in the *Robby* container kept in the laboratory refrigerator: there, the growth only began after one month. The second longest delay was in the glass-jar kept in the same refrigerator. In the *Robby* container kept in the dormitory refrigerator, microbial growth began after 14 days of refrigeration and remained stable after that. In the rest of the samples, microbial growth began on the 14^{th}-28^{th} day of the experiment and increased rapidly. The highest microbial population at the end of the storage period reached 4.46±1 (lg CFU/g). It was observed in the tomato paste sample stored in the original can covered with a plastic lid and kept in the dormitory refrigerator. It appears that the high microbial load in the dormitory refrigerator environment interferes with the isolated conditions expected from a *Robby* container.

Yeast and mould and acid-resistant bacteria counts were rarely observed in the canned tomato paste samples. The glass jar stored in the laboratory refrigerator and the metal can stored in the dormitory refrigerator were mould-positive in the final checks. As shown in Table 1, the container type had a significant effect on the vitamin C concentration ($p<0.001$). Using a *Robby* container in both laboratory and dormitory environments allowed effectively maintaining the vitamin C concentration by retaining 50% of the original content at the end of the storage period, while in other treatments, vitamin C was fully destroyed.

The effect of the Robby container on the quality of homemade tomato paste. The chemical and microbial changes in homemade tomato paste cold-stored for 56 days are tabulated in Table 2.

Table 2 – Chemical and microbial changes in homemade tomato paste during cold storage of the samples under study*

Container type	Time (day)	Total count ($lgCFUg^{-1}$)	Mould & yeast ($lg\ CFU\ g^{-1}$).	Lactobacilli ($l_0\ CFU\ g^{-1}$)	^{0}Brix	Acidity (mg/100g)	pH
Robby in the laboratory	0	1.29±0.74	0.31±0.31	1.07±0.62	13.04±1.13	1.73±0.15	3.76±0.04
	14	1.32±0.77	0.34±0.20	1.29±0.75	12.59±1	1.59±0.31	3.73±0.009
	28	1.83±1.06	0.45±0.30	1.83±1.05	12.61±0.76	1.73±0.15	3.67±0.005
	42	2.18±1.30	0.52±0.36	2.23±1.29	12.72±0.70	1.86±0.31	3.66±0.008
	56	2.49±1.44	0.72±0.38	2.42±1.40	13.24±0.20	1.86±0.0	3.73±0.02
Robby in the dormitory	0	1.26±0.73	1.17±0.67	1.05±0.61	12.72±1.02	1.46±0.16	3.73±0.01
	14	1.05±0.61	1.27±0.74	0.89±0.52	12.10±0.87	1.59±0.31	3.73±0.005
	28	0.85±0.49	1.79±1.04	0.67±0.39	12.39±1	1.73±0.15	3.66±0.005
	42	0.65±0.38	2.22±1.28	1.19±0.69	12.67±1.06	2±0.46	3.67±0.009
	56	2.21±1.28	2.50±1.44	2.40±1.19	12.62±0.94	1.66±0.25	3.72±0.06
Glass in the laboratory	0	1.90±1.10	1.14±0.67	0.93±0.54	12.94±0.73	1.73±0.15	3.71±0.01
	14	3.03±1.75	0.99±0.58	3.07±1.77	12.65±1.06	1.73±0.15	3.76±0.04
	28	3.61±2.09	0.66±0.40	3.67±2.12	12.53±0.78	1.59±0.31	3.65±0.03
	42	3.83±2.21	1.21±0.70	3.82±2.20	12.08±0.94	1.26±0.40	3.83±0.23
	56	4.19±2.42	2.31±1.33	4.17±2.41	12.15±0.47	1.20±0.46	3.98±0.54
Glass in the dormitory	0	1.44±0.84	0.92±0.53	1.04±0.60	12.97±0.62	1.86±0.31	3.72±0.01
	14	2.39±1.38	3.05±1.76	2.39±1.38	12.38±0.76	1.59±0.31	3.71±0.008
	28	5.03±0.48	3.65±2.11	5.13±0.48	12.68±1.11	1.33±0	3.66±0
	42	4.75±1.01	3.80±2.19	4.29±1.32	12.80±0.82	1.73±0.15	3.67±0.02
	56	6.27±0.36	4.18±2.41	5.61±0.31	12.68±0.90	1.46±0.27	3.69±0.03
Glass in the laboratory, with an oil covering	0	5.54±0.46	0.88±0.51	5.53±0.34	12.89±1.37	1.73±0.15	3.72±0.01
	14	4.96±0.09	02.38±1.38	5.11±0.02	12.42±0.67	1.73±0.15	3.71±0
	28	5.12±0.58	5.08±0.52	5.17±0.58	12.23±0.69	1.59±0.31	3.64±0.01
	42	4.40±1.23	4.56±1.17	4.30±1.28	12.30±0.73	1.73±0.15	3.65±0.01
	56	5.11±1.22	6.43±0.28	5.61±0.93	12.85±0.84	1.59±0.31	3.70±0.04
Glass in the dormitory, with an oil covering	0	1.14±0.66	5.44±0.38	1.02±0.59	12.70±0.90	1.73±0.15	3.73±0.13
	14	1.66±0.96	5.02±0.07	1.68±0.67	12.41±0.77	1.59±0.31	3.71±0.01
	28	6.93±0.46	5.17±0.58	6.81±0.39	12.44±0.95	1.73±0.15	3.69±0.009
	42	7±0.38	4.23±1.26	6.69±0.18	12.74±0.69	1.73±0.15	3.65±0.008
	56	6.76±0.34	5.65±0.95	6.59±0.32	12.65±0.84	1.33±0.31	3.72±0.02

*The data are presented as the mean value ± SE for 2 individual replicates of samples and 2 replicated tests

Unlike the industrially canned tomato paste samples, a diverse population of the microbes under study was observed at the beginning of the storage period.

The samples stored in a *Robby* container in the dormitory refrigerator, with the total count 2.21±1.28 (lg CFU/g), and the samples covered with vegetable oil and kept in a glass jar in the same refrigerator, with the microbial population 6.76±0.34 (log CFU/g), had, respectively, the lowest and highest total microbial counts the last time they were checked. The homemade tomato paste samples expectedly showed a higher population of microorganisms than the factory-made samples. The *Robby* container functioned better in controlling microbial growth than commercial containers did to preserve the product in terms of total microbial, yeast and mould, and acid-resistant bacteria counts.

In the tomato paste samples kept in glass jars with an oil covering, high populations of mould, yeast, and acid-resistant bacteria developed during the whole experiment, which ended up in the highest total microbial, mould and yeast, and acid-resistant bacteria counts in these samples at the end of the storage period. This result has shown that, contrary to traditional beliefs, covering tomato paste with an oil layer does not extend the product's shelf life.

Despite the noticeable difference in the DRBC count (yeast and mould) between the samples kept in a *Robby* container and those kept in a glass jar and covered with oil, the results of aflatoxin measurement demonstrated no significant difference between them (0.2±0.1µg/g vs 0.4±0.2µg/g). So, both have been found safe in terms of aflatoxin, because these levels are well below the maximum residue level established for aflatoxin in similar products (5µg/g).

The first part of this study reveals that despite being regulated by the national standard, half of the tomato paste products examined did not comply with the microbial regulations: background microbial contamination has been shown in commercially canned products supposed to be free from it. This will affect the shelf life of tomato paste after it is opened upon refrigeration. Nonconformity with the national standard of Iran was more than once reported for foods other than tomato paste, which are subject to this standard [26-30]. As to canned tomato paste products, we have found no similar report, whether on the microbial population or on noncompliance with the national standard.

The main results of this study support the inventor of *Robby*'s claim that it extends the shelf life of tomato paste, regardless of the sanity level of the refrigeration environment and/or the background contamination of the paste. Nevertheless, our results have failed to show *Robby*'s restriction effect on aflatoxin production. Comparing the results of Table 1 and Table 2, it can be inferred that when tomato paste contains a low population of microorganisms, a *Robby* container is effective in controlling the secondary contamination as well as restraining the microbial proliferation. However, in homemade products highly populated with microorganisms, its performance is limited to slowing down the microbial multiplication rate.

As to vitamin C contained in tomato paste and its decrease over time, the results of this research are consistent with those obtained by Safdar *et al.* [14]. Vitamin C is one of the most oxidation-sensitive compounds, and examination of its presence shows how much the food components have been exposed to oxidation. Kabasakalis *et al.* reported that storage in a refrigerator and storage in a closed container allowed preserving vitamin C better than storage at room temperature in an open container [17]. In this research, neither the container type nor the storage duration had any significant effect on the Brix, acidity, and pH ($p > 0.05$).

However, contaminated tomatoes and tomato products were shown to be possible carriers of aflatoxin in the diet [31]. Some studies revealed that refrigeration prevents aflatoxin production by the growth of the species *Aspergillus* [32]. Possibly, the homemade tomato paste samples were dominated by moulds other than aflatoxin-producing genera and halophilic yeast, and this resulted in a reasonably low aflatoxin concentration in them.

Similarly to what was observed for the industrially produced samples, storage containers and time had no significant effect on the Brix, acidity, and pH of the homemade samples ($p>0.05$). The results obtained in this study are different from the results of Safdar *et al.* [14] in terms of changes in the pH, acidity, and Brix: studying the effect of time and temperature on the quality properties of tomato paste has shown a gradual increase in the soluble solids and acidity and a decrease in the pH [14].

Comparison of the quality of the industrially canned and the homemade tomato paste samples after being opened and during cold storage has shown that all the microbial factors tested greatly depended on the tomato paste type ($p<0.001$). each time the samples were checked, the total microbial, yeast and mould, and acid-resistant bacteria counts were significantly lower in the industrially manufactured tomato paste than in the homemade samples. As to the chemical properties, at the beginning of the experiment, the samples of industrially canned tomato paste contained 1-15 mg/100 g of ascorbic acid, while the homemade samples were completely free of it. Regarding the Brix, acidity, and pH level, the values of Brix (27.29-29.88) and pH (3.97 and 4.11) were higher in the commercial tomato pastes than in the homemade samples ($p<0.001$). However, the acidity range in both groups remained within the acceptable limits of tomato paste acidity. Also, homemade tomato pastes had a higher salt concentration (1.95±0.71%) ($p<0.05$) in comparison with the industrially produced samples (1.05±0.12). Contrary to the traditional beliefs that homemade tomato pastes are healthier than the industrially produced ones (for which reason they are usually offered at a higher price on the market), a higher salt content decreased the healthiness of these products, compared to the industrially canned ones, with no higher preserving effect.

Our results were consistent with the study by Yalmeh *et al.* regarding the inefficiency of salt as a mould inhibitor. They have shown that sodium chloride does not have a complete inhibitory effect on *Aspergillus niger* [13]. Elahami Rad and Shahidi (2004), who examined the physicochemical and microbial changes in bulk tomato paste, established that high total soluble solids (Brix=35-38), along with spraying the product's surface with salt and storage at 0°C, had but a slight effect on the microbial growth [16]. Some studies used plant extracts and natural additives to increase the shelf life of tomato paste. Soloty (2002) stated that fresh garlic and chloroform extract of garlic (allicin) inhibited the growth of *Bacillus coagulance* in tomato paste [18]. In the same context, Omidbeygi *et al.* examined the antifungal activity of extracts of thyme, savory, and clove in a culture medium and in tomato paste, and showed that thyme and savory extracts could restrict the microbial growth during tomato paste storage [15]. However, conversion of the natural taste and the unreasonable cost of these products hinder their commercial production.

Conclusion

Compared to the conventional means of tomato paste cold storage, using *Robby* containers affects the microbial and chemical quality of tomato paste but to a lesser extent, results in more vitamin C in the product, hinders the secondary contamination, and slows down the microbial growth. Also, the broad proliferation of microorganisms in homemade tomato paste during refrigeration can be well controlled using this container.

Current and future developments

Despite the marketing success of *Robby*, a new version of *Robby* container is now being developed. It has a nanoplastic structure, and is under investigation to improve its antibacterial effect. Also, similar containers are being developed by the same inventor to store other *pseudoplastic* foods in a refrigerator.

Conflict of interest

All authors declare that they have no conflict of interest regarding the information presented in this paper.

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