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A Study of the Quality of Canned Tomatoes Available in Misurata City Markets to Detect of Starch Fraud and Heavy Metal Contamination

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دراسة جودة الطماطم المعلبة المتاحة في أسواق مدينة مصراتة للكشف عن غش النشا وتلوث المعادن الثقيلة

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Abstract:

The present study sought to quantify certain quality indicators and identify instances of commercial fraud by incorporating starch and heavy metal contamination into a random sample (21 brands) of canned tomato varieties available in the markets of Misurata city. The results obtained were then compared with the Libyan standard specification. The samples were divided into three groups (Arab, European, Turkish) on the basis of origin and subjected to quality tests (total solids, pH measurement, net and filtered weights, percentage of added salt), in order to detect fraud by adding starch and artificial colors, and to measure levels of heavy metals. The analysis of total solids and pH value revealed no statistically significant differences between the three groups. The mean value for the three groups was found to be between 27 and 27.7, which is below the level specified by the Libyan standard. Significant discrepancies were observed in the actual weight of the samples, with those of Arab origin exhibiting the lowest levels of added salt. The analysis did not reveal the presence of artificial colors in any of the research samples. Upon the addition of starch, instances of fraud were identified in approximately 14% (3 samples) of the 21 samples. The largest proportion was observed in the samples of Arab origin, representing 33.3% (2 samples) out of 6 samples, followed by the samples of Turkish origin, which constituted 20% (1 sample) out of 5 samples. The addition of starch was not observed in the samples of European origin. The heavy metals detected in all samples were within the limits set by the Libyan standard specification 426/2020 for tomato paste, with the exception of zinc and tin, for which the results differed. No differences were observed for lead, copper, and tin.

Keywords: Canned tomatoes, Starch fraud, Heavy metal contamination, Libyan standard specification.

الملخص

سعت الدراسة الحالية إلى قياس بعض مؤشرات الجودة وتحديد حالات الغش التجاري من خلال الكشف عن وجود النشا وتلوث المعادن الثقيلة في عينة عشوائية (21 علامة تجارية) من أصناف الطماطم المعلبة المتاحة في أسواق مدينة مصراتة. تمت مقارنة النتائج المحصلة مع المواصفة القياسية الليبية. تم تقسيم العينات إلى ثلاث فئات (عربية، أوروبية، تركية) بناءً على الأصل، وتم إخضاعها لاختبارات الجودة (المواد الصلبة الكلية، قياس الرقم الهيدروجيني، الوزن الصافي والمصفى، نسبة الملح المضاف) للكشف عن الغش من خلال إضافة النشا والألوان الصناعية، ولقياس مستويات المعادن الثقيلة. أظهرت تحليل المواد الصلبة الكلية وقيمة الرقم الهيدروجيني عدم وجود فروق ذات دلالة إحصائية بين الفئات الثلاث. ووجد أن المتوسط للقيم للفئات الثلاث يتراوح بين 27 و27.7، وهو أقل من المستوى المحدد في المواصفة الليبية. لوحظت فروق كبيرة في الوزن الفعلي للعينات، حيث أظهرت العينات ذات الأصل العربي أدنى مستويات من الملح المضاف. ولم تكشف التحليلات عن وجود ألوان صناعية في أي من عينات البحث. عند إضافة النشا، تم تحديد حالات الغش في حوالي 14% (3 عينات) من 21 عينة. وكانت النسبة الأكبر في العينات ذات الأصل العربي، حيث تمثل 33.3% (2 عينة) من 6 عينات، تليها العينات ذات الأصل التركي بنسبة 20% (1 عينة) من 5 عينات. ولم يُلاحظ إضافة النشا في العينات ذات الأصل الأوروبي .كانت المعادن الثقيلة المكتشفة في جميع العينات ضمن الحدود المحددة في المواصفة القياسية الليبية 2020/426 لمعجون الطماطم، باستثناء الزنك والقصدير، حيث اختلفت النتائج. ولم تُلاحظ أي فروق بالنسبة للرصاص والنحاس والقصدير.

الكلمات المفتاحية: الطماطم المعلبة، غش النشا، تلوث المعادن الثقيلة، المواصفة القياسية الليبية.

Introduction

Lifestyle and other environmental factors, in addition to nutrition, affect human health. However, nutrition plays a significant role in disease prevention and treatment. Therefore, the study of human nutrition facilitates understanding the complexities and social and biological factors involved in maintaining the health of individuals and society as a whole (Geissler & Powers, 2017). The transformation of food production, processing, manufacturing, marketing, and promotion has had a significant impact on people's nutritional lifestyles. This has resulted in the provision of increasingly energy-dense foods that lack essential and important nutrients. This is occurring concurrently with a shift towards more sedentary and less active lifestyles (Wildman, 2018). Food provides the body with the energy it requires to function, facilitates the construction and regeneration of bodily tissues, and serves to protect and fortify the immune system against disease (Mazahra, 2008).

The consumption of tomatoes has been demonstrated to confer health benefits and reduce the risk of developing diseases such as cancer, osteoporosis and cardiovascular disease (Periago et al., 2008). Additionally, tomatoes are a rich source of nutrients and bioactive compounds (Paulino et al., 2020).
It remains unclear whether increasing the consumption of these particular vegetable species would result in greater benefits with regard to chronic disease risk. (Saini et al., 2020), tomatoes are the most widely consumed non-starchy vegetable and represent the primary source of dietary lycopene. This powerful antioxidant exhibits enhanced bioavailability following cooking and processing. (Sakemi et al., 2020). With regard to the question of canning, the optimal varieties for canning are Roma, heirloom, and vine tomatoes, as well as green tomatoes (Mary, 2022).

Chemical composition and nutritional value of tomatoes

Tomatoes are consumed worldwide as fresh vegetables due to their high content of essential nutrients and antioxidant-rich phytochemicals. Tomatoes contain a variety of nutrients, including minerals, vitamins, proteins, essential amino acids (lysine, threonine, valine, histidine, arginine), monounsaturated fatty acids (linoleic and linolenic acids), carotenoids (lycopene and β-carotenes), and phytosterols (β-sitosterol, campesterol and stigma sterol). Lycopene is the primary dietary carotenoid present in tomatoes (Salehet al., 2019). A 100-gram portion of fresh tomatoes contains 93.5 grams of water, 22 calories, 1.1 grams of protein, 4.7 grams of total carbohydrates, 13 milligrams of calcium, 27 milligrams of phosphorus, 0.5 milligrams of iron, 244 milligrams of potassium, 900 international units (IU) of vitamin A, 0.06 milligrams of thiamine, 0.04 milligrams of riboflavin, 0.7 milligrams of niacin, and 23 milligrams of ascorbic acid (vitamin C). The ascorbic acid content of the fruit is subject to fluctuations in weather conditions. In cloudy weather, the content decreases to 10 mg, whereas in clear weather, it increases to 26 mg (Merrill & Watt, 1963). Please refer to Table 1.

Table 1: Vitamin content of ripe tomatoes (Kader & Grierson, 1986).

Vitamins	Amount per 100 g of tomatoes
Vitamin A (Beta Carotene)	900-1271 IU(1)
Vitamin B1 (Thiamine)	50-60 µg(2)
Vitamin B2 (Riboflavin)	20-50 µg
Vitamin B3 (Pantothenic Acid)	50-750 µg
Vitamin B6 (Complex)	80-110 µg
Nicotinic Acid	500-700 µg
Folic Acid	6.4-20 µg
Biotin	1.2-4.0 µg
Vitamin C	15000-23000 µg
Vitamin E	30-1200 µg

(1) IU of vitamin A = 6 micrograms of beta-carotene.
(2) Microgram = 1/1000 milligram = 1/1000000 gram.

Tomatoes are a rich source of diverse fatty acids, with linoleic and polyunsaturated acids being the most prevalent. From this perspective, tomatoes can be considered a rich and highly nutritious food product (Freitas et al., 2018). The term "canned tomatoes" is used to describe a product that has undergone a filtration and concentration process, resulting in a juice that is free of seeds, peels, and rough tissues, and that retains its full colour and nutritional value (Nasr, 2009). The presence of variable levels of antibiotic-resistant bacteria was identified among tomatoes sold in different markets. Such contamination may be attributed to inadequate sanitation practices, improper handling, or inadequate transportation protocols from the farm to the market. The presence of antibiotic-resistant bacteria among tomatoes gives rise to concerns regarding the public health risks associated with the consumption of fresh tomatoes (Forson Akua Obeng et al., 2018). One strategy for the rapid sorting of tomatoes is the utilisation of hyperspectral/multispectral imaging. In their study, Wen-Hao Su and colleagues propose an enhancement to the conventional broadband infrared imaging techniques employed for the sorting of tomatoes, whereby the spectral resolution of the collected information is increased (Su, 2021).

It would be prudent to ascertain the potential for aflatoxin contamination in tomato products intended for sale. The presence of aflatoxins represents a potential health risk for humans. (Lilian et al., 2019). In recent years, gas chemical sensors have emerged as a promising tool for food safety control, including the early diagnosis of microbial contamination (Sberveglieri et al., 2014). The moisture content is monitored in order to ensure compliance with food legislation regarding the permitted moisture level in the product. Moisture is a fundamental component in the analysis of primary food substances, whether expressed on a wet or dry weight basis (Dalali & Al-Hakim, 1987). Study by (Eyeson, 1973) determined that the concentration of naturally soluble solids in tomatoes is within the range of 8% to 24%. This concentration is used to describe tomato paste that has been diluted, also known as tomato purée. Investigation by (Eckerle et al., 1984) observed that the increase in moisture is a consequence of the decomposition process in the product, indicating a decline in the evaluation degree of tomato paste during storage. This rate has been observed to increase with rising storage temperature. In 1977, the United States Department of Agriculture identified four standards for tomato paste based on concentration. These are the following concentrations: dilute (less than or equal to 24% natural total soluble solids, NTSS), medium (24% to 28% NTSS), high (28% to 32% NTSS) and very high (32% NTSS and above). (Goose and Binsted, 1973) found that the percentage of solids concentration in tomato paste after processing is 28-30% in the case of double concentration and 36-40% in the case of triple concentration. Some producers and users of tomato paste consider a concentration of 32% solids to be the standard.

In accordance with the stipulations set forth in the Libyan Standard Specifications 426 of 2020, the percentage of solids in tomato paste is to be a minimum of 28%. The measurement of pH is of significant importance in a multitude of applications within the realms of research and quality control operations (Dalali & Al-Hakim, 1987). Article by (Blanchard, 1967) indicated that the pH values in tomato concentrate samples were within the normal range for the tomato paste product, ranging from 3.8 to 4.2. (Villard et al. 1994) observed that the total acidity of 30% tomato paste samples stored at 4°C was identical to that observed at 25°C. However, there was a notable increase in acidity from 2.17 to 3.85 in the surface sample and from 2.17 to 3.51 in the bottom sample at the conclusion of the storage period. The cumulative nature of heavy elements and their potential to cause harm to living organisms represent a significant environmental concern. It is of great importance for the health of both humans and animals that a certain proportion of these elements are consumed, with some of these elements potentially being obtained through the food chain from plants. Since the Second World War, solder has been used in the fabrication of sheet metal and comprises 98% lead. The majority of lead contamination in canned foods can be attributed to solder, although some lead may also originate from the inner coating of the can, where it may exist as an impurity (Jorhem and Slorach, 1987). Moreover, study by (Ereifej, 1997) observed elevated levels of lead in tomato paste packaged in metal cans, which is presumably attributable to the migration of lead from the tin to the paste. The concentration of lead in the tin coating is minimal, with a range of 0.007 to 0.001%. The elevated concentration was observed in proximity to the coating surface, indicating that lead may be transported by the tin at ambient temperatures. The maximum permissible level of lead impurities in tin cans has been set at 0.02-0.08% in numerous countries (FAO, 1979).

Material and methods

Twenty-one samples of canned tomato paste were collected from various markets in Misurata city between 12-5-2022 and 14-5-2022. The samples exhibited a diverse range of country of origin, reflecting the global distribution of tomato paste production. The initial group, of European origin (Italy and Turkey), comprised 15 samples, while the second group of Arab region origin, included six samples from Oman, Tunisia, and Syria. All samples were sourced from tin cans with a weight of 400 grams.

2.3 A study of the standard characteristics of the samples was conducted.

Total solids test

There are three methods for detecting total solids Brix.

Pressure drying oven method

The reference tables method is conducted by taking 10 g of tomato sample and adding 20 ml of deionized water, then homogenizing and filtering. The initial drops are taken and their refractive index is recorded, after which the following drops are similarly analyzed. The resulting data is then compared with the data in the prescribed table.

The apparatus employed for this purpose was a microwave oven, which was used to facilitate the drying process. The total solids content was then determined by the aforementioned drying apparatus, with the requisite degree of drying set at 100%. This method entails the initial homogenisation of the components within the package, followed by the transfer of 3 g of tomatoes to the drying plate. The tomatoes are distributed evenly and placed within the device at the specified temperature of 100 degrees Celsius. The drying process is then monitored until the device indicates that it has reached the desired level of completion.

An iodine test is employed to detect starch. The presence of starch is indicated by the use of an iodine solution with a concentration of 0.02. A sample of tomato paste is taken and dissolved in a test tube containing distilled deionized water. The solution is then shaken well and drops of an iodine solution with a concentration of 0.02 are added. The appearance of a blue ring indicates the presence of starch in the solution. Conversely, the absence of a ring signifies the absence of starch, with the solution retaining its brown colouration.

The detection of artificial colours using the animal wool method

The treatment of animal wool to address this issue, pieces of wool are boiled in a dilute solution of ammonia (1+4) and subsequently washed with water. Subsequently, the samples are washed with a solution of acetic acid (1+4), followed by a further wash with water.

The following steps are to be carried out:

- In the event that the sample is in a liquid state, 50ml of it should be taken. In the case of solid samples, a volume of approximately 100 ml of water should be mixed with 25 ml of the sample.
- Should the sample be found to be non-acidic; it is recommended that it be acidified using acetic acid or a dilute solution of hydrochloric acid (1+9).
- A quantity of approximately five pieces of previously treated animal wool, with a length of approximately five centimetres, should be added to the sample.
- The sample and wool should be boiled for a period of 10 to 20 minutes, or until the desired colouration is achieved, should this be a factor.
- The wool is then removed and washed with water, after which it is transferred to a small cup and boiled in the presence of a dilute ammonia solution (1+50).
- Subsequently, the wool is removed from the cup and the contents of the cup are made acidic. Thereafter, additional pieces of animal wool are added to the cup and boiled for a period of 10 minutes. The appearance of colour in the pieces of wool serves as an indicator of the presence of coloured dyes.
- The pH level should be determined using the Jenway device (550 pH meter).

The following steps constitute the digestion process:

- Take 5 grams of canned tomato sample and place it in a 250 ml cup. Then, add a mixture of 6 ml of concentrated nitric acid (HNO_3 69%) and 2 ml of hydrogen peroxide (H_2O_2 30%). Heat the solution for an hour in a water bath at a temperature of 70°C inside the gas cabinet.

- The mixture should then be cooled slightly and the same volume of the previous mixture added. The solution should be heated on an electric heater to a temperature not exceeding 130°C and maintained for a period of 2-3 hours until the yellow vapours of nitrous oxide have dissipated.
- The mixture should then be cooled and 5 ml of deionized water added. The solution was filtered into a 25 ml standard flask with ashless filter paper (Wattman filter paper, Ash Less, No. 42), after which the volume was filled with deionized water to the mark. The blank sample (Horwitz, W., et al., 1982) was treated with the same previous steps as the sample (William, H., et al., 1980), which was not included.

A total of 21 samples of tomato pastes with a concentration of 28-30% were collected from local markets in Misurata city and divided into three groups. The first group was of Arab origin and comprised five samples (24%) from Arab countries, specifically Tunisia, Oman, and Syria. The second group was of Turkish origin and included six samples (28%). The third group was of European origin and consisted of 10 samples (48%) from Italy. All samples were in tin cans weighing 400 grams per package as shown in Figure 1.

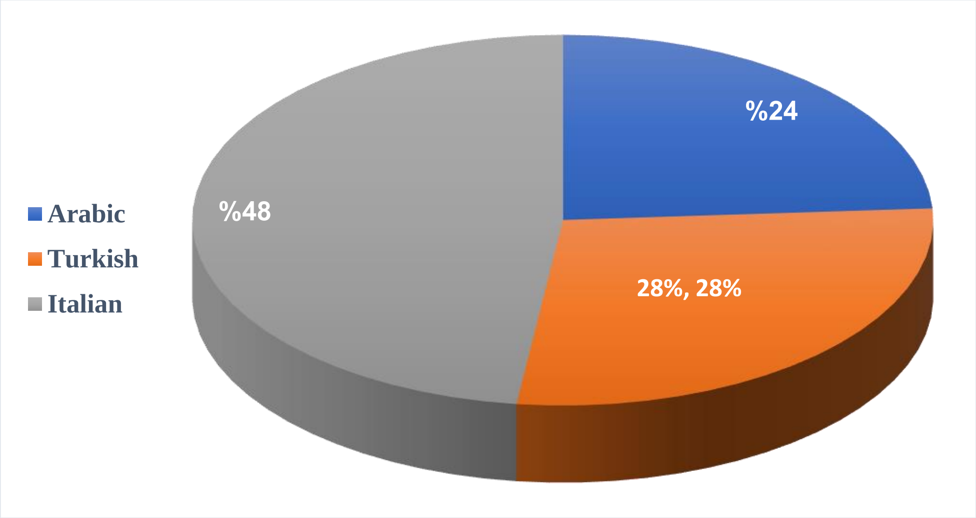

Figure 1: Distribution of samples by group according to country of origin.

Physical characteristics and standard specifications

One of the most crucial standard specifications that are evaluated for tomato paste is pH. The pH value should fall within the range of 4.0 to 4.4. A high or low pH value is regarded as a defect in the manufacturing process or indicative of product spoilage. The results are presented in Table 2.

Table 2: Average pH analysis results.

Group	NO	Mean	Std. Deviation	Std. Error Mean	P-value	Differences
Arabic	6	4.1750	0.06189	0.02527	0.424	No thing
Turkish	5	4.1460	0.03782	0.01691		
European	10	4.1680	0.01229	0.00389		

The one-way analysis of variance (ANOVA) revealed that the pH value data for the three groups exhibited no statistically significant differences (P-value < 0.05), as illustrated in Figure 2.

Conversely, an elevated total solids (TS) value is associated with a reduction in relative humidity, which in turn enhances the concentration and preservation of tomato paste. The mean value for the three groups was found to be between 27.0300 and 27.7420, which is below the level required by the Libyan standard specification as presented in Table 3.

The application of one-way analysis of variance (ANOVA) to the total solids data for the three groups revealed that the associated P-value exceeded 0.05, thereby indicating the absence of statistically significant differences between the groups in terms of total solids as presented in Figure 3.

The proportion of added salt must be within the recommended limits in order to enhance the product's preservation capabilities while maintaining its taste and preventing the migration of metals from the container to the tomato paste. The results presented in Table 4 demonstrate that the mean percentage of salt content falls within the recommended range for the three groups.

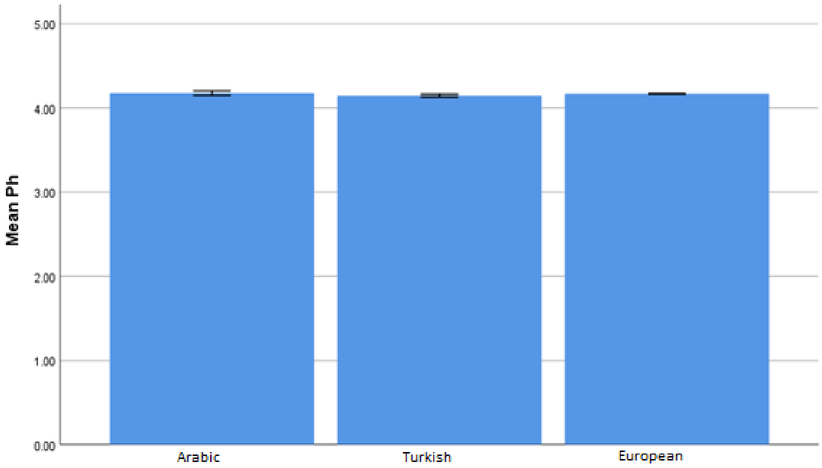

Figure 2: Results of pH analysis.

Table 3: Average results of total solids analysis.

Group	NO	Mean	Std. Deviation	Std. Error Mean	P-value	Differences
Arabic	6	27.0300	1.36357	0.55667	0.630	No thing
Turkish	5	27.7420	0.54788	0.24502		
European	10	27.5030	1.41291	0.44680		

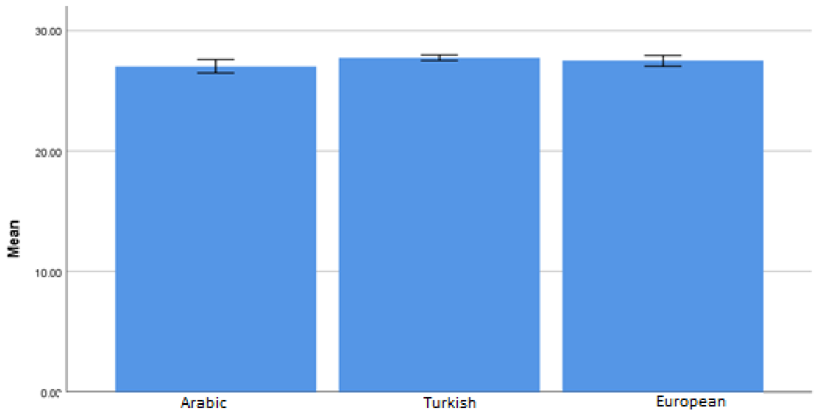

Figure 3. Results of Total Solids Analysis TS.

Table 4: Average results of total solids analysis.

Group	NO	Mean	Std. Deviation	Std. Error Mean	P-value	Differences
Arabic	6	0.4950	0.25929	0.10585	0.045	No thing
Turkish	5	0.6400	0.23770	0.10630		
European	10	0.7480	0.04894	0.01548		

The statistical analysis revealed that the percentage of the three groups exhibited a level of significance (P-value) less than 0.05, indicating a statistically significant discrepancy between the groups in terms of the percentage of added salt. Specifically, those of Arab origin demonstrated a lower percentage of table salt than those of European origin, while those of Turkish and European origin exhibited no notable distinction between them, as presented in Figure 4.

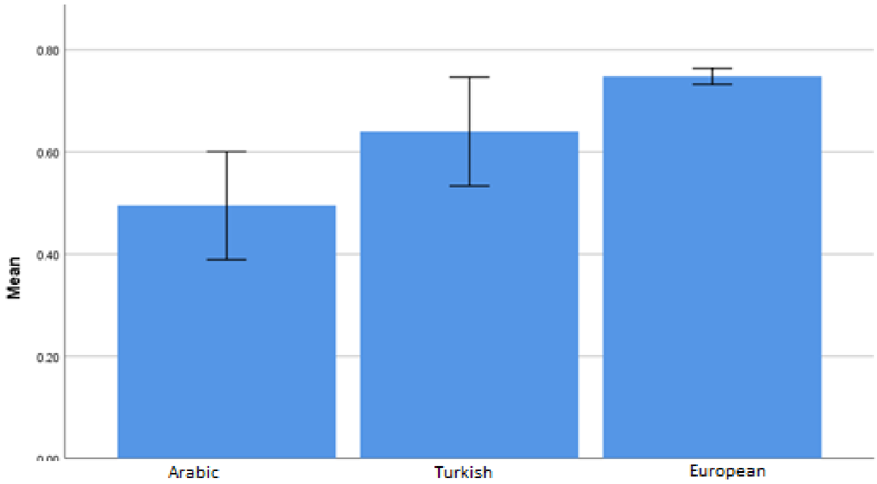

Figure 4: Results of the analysis of the percentage of salt added to tomato paste.

In regard to the weight, three significant calculations were employed: (1) the quantity of the product in the package divided by the water capacity, (2) the average net weight divided by the recorded weight, and (3) the actual weight in grams.

A study was conducted to compare the quantity of the product in the package from the water capacity between the groups. A comparison was conducted between the study groups of origin (Arab, Turkish, European) in terms of the quantity of the product in the package from the water capacity. This was achieved through the appropriate statistical test, which is the one-way analysis of variance (ANOVA), with the calculations performed using the SPSS statistical program. The average weight in grams from the water capacity was (108.9443, 109.2652, 109.7948), as presented in Table 5, respectively.

Table 5: Product quantity in the package of water capacity.

Group	NO	Mean	Std. Deviation	Std. Error Mean	P-value	Differences
Arabic	6	108.9443	1.18505	0.48379	0.920	No thing
Turkish	5	109.2652	5.02522	2.24735		
European	10	109.7948	4.72534	1.49428		

The preceding table's results indicate that the P-value is greater than 0.05, suggesting that there are no statistically significant differences between the groups in terms of the quantity of the product in the package relative to the water capacity as presented in Figure 5.

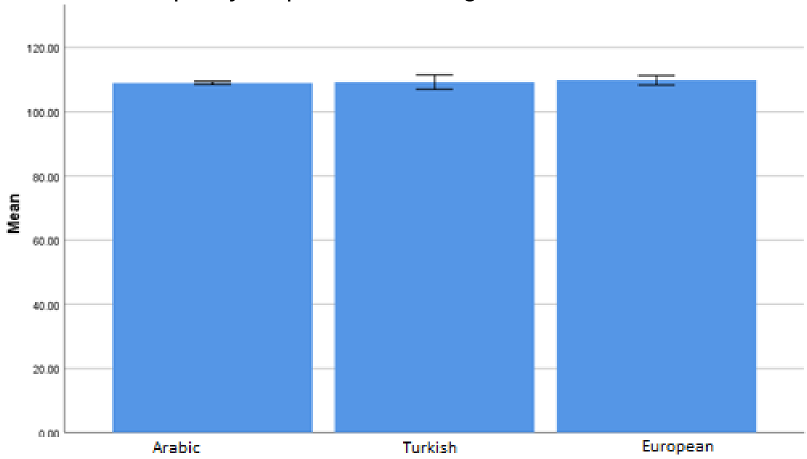

Figure 5: The quantity of the product in the package from the water capacity of the groups.

The objective of this study is to compare the average net weight of the recorded weight between the various groups. All research samples were recorded with a weight of 400 grams. The results of the statistical analysis indicated that there were statistically significant differences between the groups in terms of the actual weight of the samples, whereas no significant differences were observed in the actual weight of the samples in comparison to the weight recorded on the packaging as seen Table 6.

Table 6: Actual weight and actual weight as stated on the package.

	Group	NO	Mean	Std. Deviation	Std. Error Mean	P-value	Differences
Actual Weight	Arabic	6	402.1738	175.7575	71.75273	0.045	Yes, there are
	Turkish	5	392.1424	5.08162	2.27257		
	European	10	397.1301	2.71814	0.85955		
Actual Weight from Blogger	Arabic	6	101.1760	3.11818	1.27299	0.246	Nothing
	Turkish	5	99.9400	0.76854	0.34370		
	European	10	99.5015	1.16184	0.36741		

A comparison of the heavy metal content of different groups. Minerals are an essential component of the nutritional profile of tomato fruits. Consequently, tomato paste contains varying quantities of minerals, including those present in substantial proportions and beneficial for human nutrition. However, other minerals may originate from the packaging material or welding processes, which often involve the use of multiple metals simultaneously. The presence of high levels of metals in any substance or compound carries immediate risks associated with poisoning and chronic risks associated with the development of numerous diseases. Table 7 illustrates the concentrations of metals identified in samples of Arab origin, expressed in micrograms per kilogram. All detected metals fall within the permissible limits set by the Libyan Standard Specification 426/2020 for tomato paste.

Table 7: Number of heavy metals detected in tomato paste samples of Arab origin.

NO	Sample	Origin	Heavy Metals (ppm)				
			Lead	Tin	Copper	Zinc	Arsenic
Maximum limits of Libyan specification 426/2020			**1.50**	**10.00**	**10.00**	**19.00**	**1.00**
1	Obaida	Tunisian	<0.0006	0.1680	1.673	1.718	<0.0003
2	Lile	Tunisian	<0.0006	<0.0005	1.456	1.402	<0.0003
3	Bakna	Tunisian	<0.0006	0.0050	2.545	1.472	<0.0003
4	Algouta	Syrian	<0.0700	<0.0005	2.612	1.917	<0.0003
5	Aliya	Tunisian	<0.0006	<0.0005	2.008	2.250	<0.0003
6	Dna	Sultanate of Oman	<0.0006	0.3750	2.740	1.788	<0.0003
Average results			0.01448	0.09158	2.17233	1.75783	0.0003

The results presented in Tables 8 also indicate the quantities of metals detected in samples of Turkish origin in micrograms per kilogram, from different brands. These results were all within the limits set by Libyan Standard Specification 426/2020 for tomato paste, with the exception of lead, tin, copper, zinc, and arsenic, which exhibited average results of 0.00128, 0.0388, 2.9004, 1.6736, and 0.0003 micrograms per kilogram, respectively.

Table 8: Number of heavy metals detected in tomato paste samples of Turkish origin.

NO	Sample	Origin	Heavy Metals (ppm)				
			Lead	Tin	Copper	Zinc	Arsenic
Maximum limits of Libyan specification 426/2020			**1.50**	**10.00**	**10.00**	**19.00**	**1.00**
1	Altuns	Turkish	<0.0006	<0.0005	2.650	1.727	<0.0003
2	Burcu	Turkish	<0.004	0.046	4.001	2.165	<0.0003
3	SGN	Turkish	<0.0006	0.109	3.288	0.954	<0.0003
4	TAT	Turkish	<0.0006	<0.0005	1.595	1.402	<0.0003
5	Alfaker	Turkish	<0.0006	0.038	2.968	2.120	<0.0003
Average results			0.00128	0.0388	2.9004	1.6736	0.0003

The quantities of metals detected in ten different European brand samples of tomato paste, expressed in micrograms per kilogram, were all within the limits set by the Libyan Standard Specification 426/2020. The average results for lead, tin, copper, zinc, and arsenic were 0.00538, 0.41, 3.1798, 1.5113, and 0.00127 micrograms per kilogram, respectively.

A comparison was conducted between the study groups, classified according to their origin (Arab, Turkish, or European), in terms of heavy metal content. This comparison was made using the appropriate statistical test, namely the one-way analysis of variance (ANOVA). The calculations were performed using the SPSS statistical software. The results demonstrated statistically significant differences in the zinc and tin minerals, with a P-value less than 0.05. Conversely, no statistically significant differences were observed in the lead, copper, and tin minerals.

Table 9: Number of heavy metals detected in tomato paste samples of European origin.

NO	Sample	Origin	Heavy metals (ppm)				
			Lead	Tin	Copper	Zinc	Arsenic
Maximum limits of Libyan specification 426/2020			1.50	10.00	10.00	19.00	1.00
1	Alsafa	Italian	<0.0006	0.299	1.719	1.334	<0.0003
2	Aljied	Italian	<0.0006	1.248	4.047	0.832	<0.0003
3	Albostan	Italian	0.03900	<0.0005	4.208	1.276	<0.0003
4	Aya	Italian	<0.0006	<0.0005	4.374	1.679	<0.0003
5	Alryhan	Italian	<0.0006	0.823	3.288	1.706	<0.0003
6	Alborj	Italian	<0.0006	0.433	2.106	1.629	<0.0003
7	Nova	Italian	<0.0006	0.044	4.816	1.679	<0.0003
8	Alamera	Italian	<0.0006	0.566	2.185	1.415	<0.0003
9	Alzen	Italian	0.01000	0.552	2.620	2.102	<0.0003
10	Fotora	Italian	<0.0006	0.134	2.435	1.461	0.010
Average results			0.00538	0.41	3.1798	1.5113	0.00127

The addition of artificial colours and starch was not identified as a method of fraud detection in the course of the experiment. The detection of fraud through the addition of starch revealed that approximately 14% (3 samples) of the 21 samples analysed contained added starch. The largest proportion of samples was of Arab origin, accounting for 33.3% (2 samples) of the total number of samples (6 samples), followed by samples of Turkish origin, which constituted 20% (1 sample) of the total number of samples (5 samples). The addition of starch was not observed in samples of European origin as shown in Figures 6.

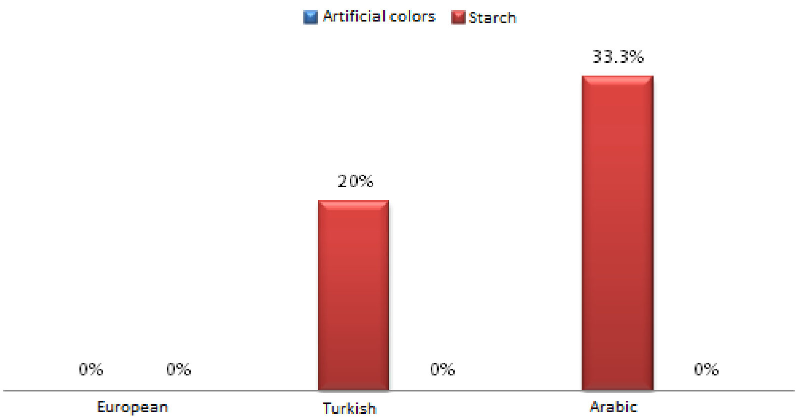

Figure 6: Percentage of use of artificial colors and starch.

Conclusion

Tomato paste is a principal component of the diet in Libya, with numerous varieties and brands imported from across the globe. The quality and safety of these varieties remain a significant concern for professionals in the fields of food and nutrition sciences. The findings of this research highlight the necessity for a classification system for imported products that is subject to rigorous regulatory and legal oversight. This system should focus on the health aspects of the product, including the quality of the raw material and its conformity with standard conditions, as well as the quality of the packaging and the safety of the metals used in welding. Furthermore, the protection of consumers from commercial fraud perpetrated by some manufacturing companies is of paramount importance. This includes the addition of artificial colours or fillers to compensate for certain product characteristics, as well as the continuous monitoring of transportation and storage processes. The latter is crucial due to the susceptibility of these materials to the migration of metals from packaging to food, which can result in a multitude of health issues.

Recommendations

- It is recommended that the role of government institutions concerned with food safety be activated by providing them with modern detection technologies.
- It is recommended that consumer protection organizations be established and supported in the field of food safety.
- It is recommended that imports be regulated and reduced, with products imported from countries known for the quality of their products being limited.

- It is essential to monitor the conditions of transportation and storage of these products.
- It is recommended that further studies be conducted on other types of canned and frozen foods, with a particular focus on those that are most commonly consumed or known to spoil quickly.
- Products of an elevated quality should be classified according to the quality marks that are recognized in this field.

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