J. Appl. Res Plant Sci. Vol. 4(2), 612-624, 2023, https://doi.org/10.38211/joarps.2023.04.02.152

Research Article

OPEN ACCESS

Available on https://www.joarps.org
Journal of Applied Research in Plant Sciences
(JOARPS)
ISSN: 2708-3004 (Online), 2708-2997 (Print)

Assessment of Selected Trace Metals in Commonly Consumed Canned and Raw Food Products in Sindh, Pakistan

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Article Received 18-12-2022, Article Revised 20-02-2023, Article Accepted 20-04-2023.

Abstract

The current study uses a flame atomic absorption spectrometer to quantify seven trace elements—Chromium (Cr), Cobalt (Co), Zinc (Zn), Manganese (Mn), Sodium (Na), Potassium (K), and Calcium (Ca) in canned and raw food products sold in Sukkur and Khairpur, Sindh, Pakistan. Current study results were compared to WHO/FAO maximum and minimum limits. Most samples were contaminated with trace elements (likely from anthropogenic activities, local industries, and brick kilns) and exceeded the allowable limits. Food products had varied metal content. In canned food products, Cr was max in peas (6.99 mg/kg) and min in pineapple (3.08 mg/kg), Co was max in pineapple (3.11 mg/kg) and min in honey (1.50 mg/kg), Zn was max in tamarind (5.77 mg/kg) and min in pineapple and mushroom (2.95 mg/kg), Mn was max in ginger (0.39 mg/kg) and min in pineapple and mangoes (0.24 mg/kg), Na was max in ginger (167 mg/kg) and min in honey (76.7 mg/kg), and K was max in tamarind (4942 mg/kg) and min in honey (76.7 mg In raw food products, Cr was highest in carrot (6.21 mg/kg) and lowest in pineapple (3.08 mg/kg), Co was highest in pineapple (3.24 mg/kg) and lowest in carrot (1.14 mg/kg), Zn was highest in carrot (6.33 mg/kg) and lowest in pineapple and honey (2.96 mg/kg), Mn was highest in ginger (0.41 mg/kg) and lowest in honey (0.24 mg/kg), Na was highest in garlic (202 mg/kg) and lowest in strawberries (65.1 mg/kg), and K was highest in tamarind (4963 mg/kg) and lowest in butter. In conclusion, to ensure public safety, these elements must be monitored in canned and raw food products.

Keywords: *Toxicity, Heavy metals, Food safety, canned food, essential elements, macro-nutrients, atomic absorption spectrometry*

Introduction

In the past few decades, food safety has become a major public concern as our food production systems have caused major global environmental impacts in terms of natural resource depletion and pollution (Marini *et al.* 2021). The demand for growing food safety has encouraged research on the risk encountered by food products contaminations instigated by pesticides, toxins, or heavy metals (Radwan and Salama 2006). The contaminations originated due to the presence of heavy metal atoms, which are identified as the foremost contaminants of the food products. Their accumulation in the food chain results in several health and environmental problems due to their toxic upshot to humans, plants, and animals (Pizzol *et al.* 2013). In general, heavy metals are well-known non-biodegradable and have extended biological half-live, it can be accumulated in several organs of body, resulting in undesirable side effect (Radwan and Salama 2006). Inhaling and ingestion both are the main routes through which heavy metals can reach the human body. The latter is the chief route for the overall population, whereas inhalation can also play a very important role in most contaminated places. Contamination can happen during food processing, packaging, and handling (Bordajandi *et al.* 2004). Canned food is a popular food source worldwide because it is affordable, low-priced, and easy to use (Korfali and Abou Hamdan 2013). Because of the hectic lifestyle and busy routine of the human population, the need for processed, convenient, packaged, or canned foods has considerably augmented during the last decade (Palisoc *et al.* 2019). In addition to the increased engross in the consumption of this canned food, it is found that there is increasing agony over the poisonous effect and safety of canned food products among peoples of Sindh. There has been increasing interests in estimating the contaminated level of the heavy metal atoms in canned foods also. Generally, when cans made up of metals are used for the packing of food, corrosion caused by acid present in food items in the metallic can surface may cause the absorption of metallic ions in food items, and thus canned food items are susceptible to contamination by heavy metals (Buculei *et al*. 2012). Solder is has also been identified as one of the sources of lead contamination during the canning process (Korfali and Abou Hamdan 2013). Several research studies have reported the existence of heavy metals in canned foods (Al Zabadi *et al*. 2018; Çelik and Oehlenschläger 2007; Granata *et al*. 2011; Hashemi-Moghaddam *et al*. 2011). Though several essential metal elements are necessary for enhancing productivity and growth, while other metal elements (non-essential) don't have any biological function. Trace metals can be hazardous for human health if consumed in excessive concentrations (Aigberua and Izah 2019). Such as increased level of Cr may be hazardous to respiratory organs, skin, kidneys, and liver causing various diseases, The toxicity of chromium within the cell may result from damage to cellular components during the hexavalent to trivalent chromium reduction process, by generation of free radicals, including DNA damage, cases of gastrointestinal effects after oral exposure to Cr (VI) compounds have also been reported. In one study, a 14-year-old boy who died after ingesting 7.5 mg Cr (VI)/kg as potassium dichromate experienced abdominal pain and vomiting before death. Oral exposure to Cr (VI) compounds may result in hematological toxicity. Excessive consumption of Co may result in severe health issues and is responsible for several diseases in humans such as in the heart, lungs and skin, inorganic forms of cobalt are toxic as they accumulate in various tissues and can evoke a chain of pathological cascade changes in cells. When consumed excessively, Zn can result in fever, nausea and vomiting, weakness, can also cause stomach pain and diarrhea, and can reduce concentration of good cholesterol. (Maitlo *et al*. 2020). Whereas, exposure to Mn causes several pathologies of central nervous system (CNS), neurological disorder, motor and psychiatric disorders, can increase violent acts, disturbance of libido and incoordination (Arain *et al*. 2015). While macronutrients such as sodium, potassium, and calcium play a vital biological role in diversity of plants as well as animals. Sodium can cause High Blood Pressure, Heart Disease, and Stroke. Storage and increased concentration of these macronutrients affected metabolic processes in the body (Aigberua and Izah 2019). Thus, information of the selected metal content in canned, as well as raw food products, is most important to assess their risk on human health in case of their excessive consumption.

Food available in canned packing is a popular food source around the world, it is also extensively consumed by a major population of peoples residing in Pakistan. The possible routs of transmittance of heavy metals into humans by the consuming canned food products have distraught scientific interests. Level of the heavy metal atoms in food products from different countries have been extensively conveyed in the available literature (Martorell *et al*. 2011; Rose *et al*. 2010; Song *et al*. 2017). However, a very little data is available on the safety of canned foods sold in developing countries like Pakistan. The widespread feasting of the canned food products and toxicity of heavy metal atoms on the health of public, the present study was carried to examine the concentration of selected seven trace metal atoms namely Chromium (Cr), Cobalt (Co), Zinc (Zn), Manganese (Mn), Sodium (Na), Potassium (K) and Calcium (Ca) in total thirty-four samples of food products comprising of seventeen canned and seventeen corresponding raw food vended in local shops, markets and supermarkets of Sukkur and Khairpur, Sindh, Pakistan. To determine the toxicity of both canned as well as raw food due to the consumption, the level of studied metal atoms were also compared and contrasted with WHO/FAO maximum and minimum allowable limits (Joint *et al*. 2009).

Materials and Methods

Sample Collection and Sample Pre-Treatment: Thirty-four different types of food were purchased at random from stores in local markets in Khairpur and Sukkur, two major urban cities in upper Sindh, Pakistan. These included garlic, ginger, mushrooms, pineapple, honey, carrots, strawberries, oranges, potatoes, apples, tomatoes, mangoes, pepper, butter, corn, tamarind, and peas.*Pre-treatment of raw foodstuff*: All the freshly collected samples were kept in dried and clean research grade storage plastic ice boxes and were soon brought to the laboratories of institute of chemistry for further analysis. The purchased raw samples of food were initially washed separately with the double deionized water, to get rid of the dust particles. The food samples were then cut by help of knife into small pieces and were allowed to get dry in an oven at 100ºC till the constant weight appeared. The dried samples then were grounded to powder form by using a commercially available blender and the samples were stored in research quality biodegradable plastic bags for acid digestion.

Pre-treatment of canned foodstuff: After opening of cans, the liquid contents immediately were drained off using a plastic sieve (2mm sieve size). Each sample was then homogenized for further analysis.

Reagents and Materials

A research grade chemical reagents were used to carry out current study. Hydrogen peroxide H_2O_2 (HPO) (30%), nitric acid HNO_3 (NA) (65%), perchloric acid $HClO_4$ (PCA) (65%), sulfuric acid H_2SO_4 (SA), phosphoric acid H_3PO_4 (PA) (85%) and other analytical reagents of world class chemical group Merck (Germany) were used. Stocked standard solution of metals i.e., Cr, Co, Zn, Mn, Na, K, and Ca with the concentration of 1000 ppm which were obtained from a famous company Fluka Kamica (Switzerland). The double deionized water was used to prepare standard solutions. Glassware was washed by sopping in NA (20%) for 24 hours and then was rinsed with help of double distilled water. After washing and cleaning, the glassware was dried at 60ºC in a research grade oven and was kept in a dirt-free environment.

Sample preparation: A total of thirty-four varieties of foodstuff (17 raw and 17 canned food) were collected and studied for heavy metal contamination. Following reported methods of acid digestion were carried out for the preparation of samples.

Raw food: 15 ml of a triacid mixture containing PCA, NA, and SA (1:5:1) was added into 1g of each desired sample and digestion was carried at 80ºC until the fumes were decolorized. Then the solution was cooled and filtered through Whatman-42 filter paper. The obtained filtrate was then diluted with the addition of double deionized water to 50 mL (Mukantwali *et al*. 2014). All necessary provisions were applied to evade the probable contamination of samples. *Canned food*: 50 mL of HPO and NA (1:1) was added into a beaker containing 1g of the desired sample. The beaker was shielded with a cleaned watch glass and was kept at the room temperature. After 48 hours, the samples were heated on an electric hot plate until the clean solution was obtained. The clear solution was cool and filtered through the Whatman-42 filter paper. The filtrate was then transferred to the sterilized tubes and diluted with the double deionized water. Tubes were kept in a water bath at 60ºC for about 30 minutes. PA (170 mL) was then finally added to tubes as a modifier and a tubes shaker was used to shake the tubes. The tubes were then stored at 4ºC for further analysis (Ali and Al-Qahtani 2012). The blank solutions were also made in the same solvents without samples and standard. Each sample was analyzed in triplicates and obtained result was calculated in a mean of three repetitively measurements ± standard deviation.

Analytical procedure: Analytical work was carried out on a research quality flame atomic absorption spectrometer (Perkin Elmer Analyst) to analyze concentration of Cr, Co, Zn, Mn, Na, K, and Ca in food samples. FAAS was equipped with an air-acetylene burner and hollow cathode lamps. All operational parameters of current study are shown in Table 1. The calibration was also done to get calibration curves for Cr, Co, Zn, Mn, Na, K, and Ca. The linear responses were found with a coefficient of determination (R^2) = 0.993 for Cr, Ca, and Na, 0.992 for K, 0.995 for Co and 0.997 for Mn and Zn. The analytical process was accomplished in the approach of peak height to calculate absorbance. During the overall process, a blank extraction (in absence of sample) was also carried. The concentration of metal elements was calculated from the calibration curves after wards the correcting the absorbance for the signals, by using a suitable reagent blank solution. Whole analysis procedures were carried out at the room temperature.

Table 1 Operational parameters for flame atomic absorption spectrometer

Elements	Wavelength (nm)	Slit Width (nm)	Fuel
Chromium	357.9	0.70	Acetylene/Air
Cobalt	240	0.20	Acetylene/Air
Zinc	212.9	0.70	Acetylene/Air
Manganese	279.5	0.2	Acetylene/Air
Sodium	590.2	0.4	Acetylene/Air
Potassium	266.8	2.6	Acetylene/Air
Calcium	423.0	2.6	Acetylene/Air

Results and discussion

The growing alarming situation about the safety of the food has encouraged the risk of research concern which are linked with the consumption of food contaminated by the heavy metal atoms. Thus, the knowledge regarding dietary intake having a vital importance to assess the risk towards human health. Food products contaminated with heavy metals creates a serious threat depending on the comparative levels. Food items packed in cans are most largely and frequently consumed in Pakistan. Owing to the lack of evidence about trace metal content in Pakistani canned and raw food, the main objective of the current study is to evaluate the contents of metals in various canned food types as well as the similar varieties of raw food available in the local shops, markets and supermarkets. In the present study, thirty-four varieties of canned and raw foodstuff were obtained from local shops, markets and supermarkets and quantitative analytical work was carried out to calculate concentration of Cr, Co, Zn, Mn, Na, K, and Ca by using FAAS. The results are placed in the Table 2.

Chromium: Chromium (Cr) appears to be the one of the most abundant metal elements found in the earth crust. It also occurs in the pancreas of humans, which help to synthesizes insulin, as its role is directly connected to the insulin, therefore it tends to play a vital role to cure diabetes mellitus (Behera and Bhattacharya 2016; Vincent 2010). It has been assumed to be its involvement in regulation of lipid and carbohydrate metabolism by increasing the efficiency of insulin (Maitlo *et al*. 2020). In current study, the amount of Cr was found in the range 3.08 to 6.99 mg/kg and 3.08 to 6.21 mg/kg in canned and raw food samples, respectively (Table 2). Figure 1 shows that the highest contents of Cr in raw foodstuff was found in carrot (6.21 mg/kg), while the lowest concentration was found in pineapple (3.08 mg/kg), followed by tamarind (3.12 mg/kg), and potatoes (3.14 mg/kg). Whilst in canned food, peas (6.99 mg/kg) followed by garlic (6.84 mg/kg) contained the highest amount of Cr, whereas its lowest amount was found in pineapple (3.08 mg/kg) followed by corn (3.11 mg/kg). The data presented in Table 2 shows that the concentration of Cr was higher as compared to the WHO/FAO allowable limit (3.8 mg/kg) in all examined canned food products except pineapple and corn. Whereas, nine out of seventeen samples of raw food products including carrot (6.21 mg/kg), mushrooms (4.23 mg/kg), tomatoes (4.25 mg/kg), apple jam (4.64 mg/kg), peppers (4.27 mg/kg), potatoes (5.04 mg/kg), garlic (4.65 mg/kg), corn (5.12 mg/kg), and peas (5.42 mg/kg) contained a higher amount of Cr as compared to the WHO/FAO allowable limit. Whereas the remaining investigated raw food samples were having contents within the permissible limits of WHO and FAO. Moreover, it can be seen in Figure 1 that the level of Cr in most of the canned food samples was greater as compared to their respective raw food samples. Increased consumption of Cr may cause hazardous effects including upset stomach, nose irritation, kidney and liver damage, lung cancer, and skin rash. While its deficiency can cause trouble in metabolism of glucose, protein and lipid (Behera and Bhattacharya 2016).

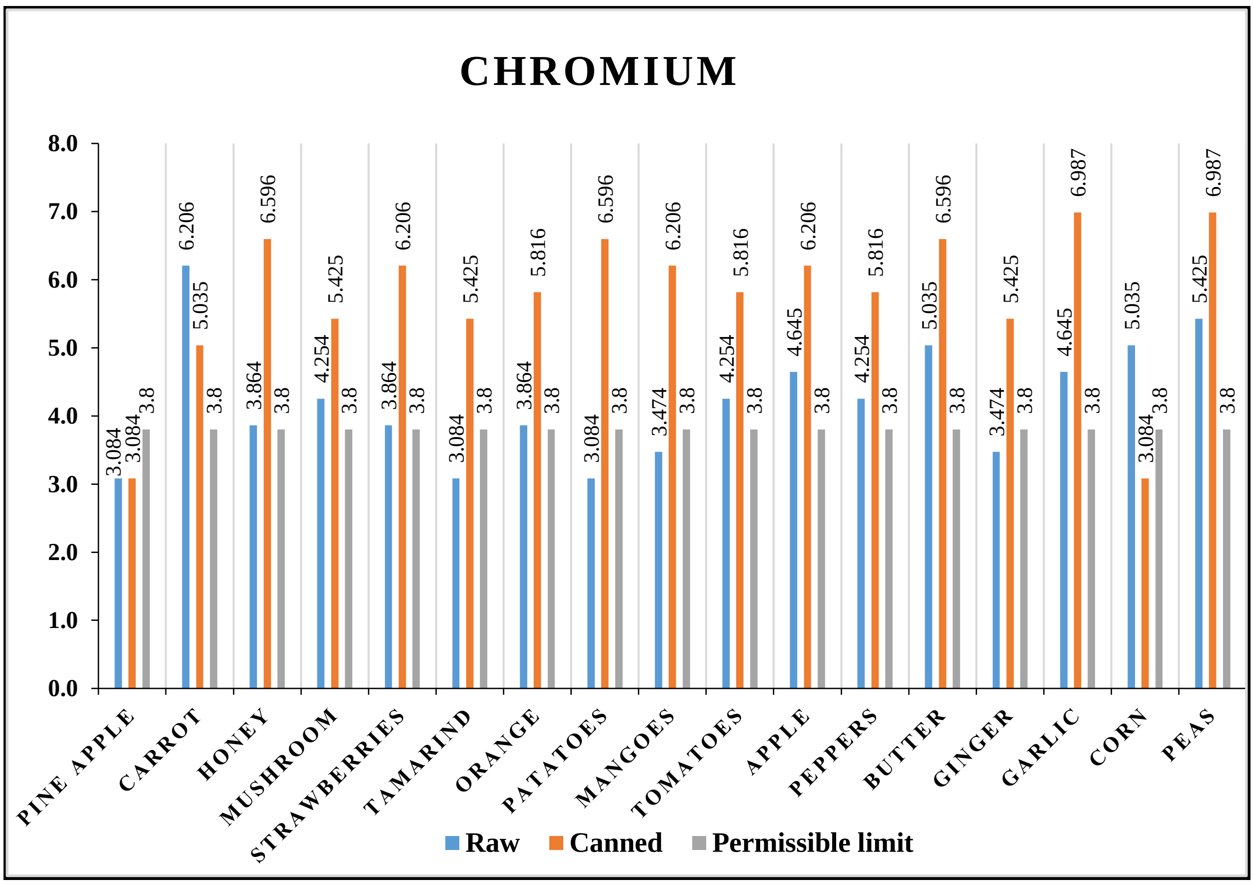

Fig. 1 Concentration of Cr in analyzed canned and raw food products.

Cobalt: Cobalt (Co) is one of an essential trace metal element. It is essential for humans, animals and animals for their metabolic processes. It occurs along with Vitamin B_{12}, which is useful in the preclusion of anemia and production of red blood cells (Ahmed and Uddin 2007). In current study, the amount of Co was found in the range 1.14 to 3.24 mg/kg and 1.50 to 3.11 mg/kg in raw and canned food samples, respectively (Table 2). Figure 2 shows that the highest concentration of Co in raw foodstuff was found in pineapple (3.24 mg/kg) followed by tomatoes (3.11 mg/kg), whereas the lowest concentration was found in carrot (1.14 mg/kg). Whilst in canned food, pineapple (3.11 mg/kg) contained the highest amount of Co, whereas its lowest amount was found in honey (1.50 mg/kg) followed by strawberries (1.56 mg/kg). The presented data in table 2 shows that the concentration of Co in ten samples of raw food including pineapple (3.24 mg/kg), orange jam (2.24 mg/kg), potatoes (2.41 mg/kg), mangoes (2.70 mg/kg), tomatoes (3.11 mg/kg), apple jam (2.11 mg/kg), butter (2.45 mg/kg), ginger (2.88 mg/kg), corn (2.84 mg/kg), and peas (2.28 mg/kg) were higher than the WHO/FAO maximum allowable limit (2.0 mg/kg). Ten samples of canned food products including pineapple (3.11 mg/kg), carrot (2.97 mg/kg), mushrooms (2.22 mg/kg), orange jam (2.40 mg/kg), tomatoes (2.58 mg/kg), peppers (2.30 mg/kg), butter (2.12 mg/kg), ginger (2.34 mg/kg), garlic (2.13 mg/kg), and corn (2.91 mg/kg) contained higher concentration of Co than WHO/FAO maximum allowable limit. Whereas the remaining investigated samples were within the maximum permissible limits set by WHO. Moreover, it can be seen in figure 2 that the level of Co in most of the raw food samples was greater as compared to their respective canned food samples. Though Co is an essential metal element it can be detrimental if taken in excessive quantities. Its increased intake can result in blood pressure, loss of weight, hyperglycemia, retarded growth, anemia, nausea, diarrhea, and slowed respiration (Ahmed and Uddin 2007).

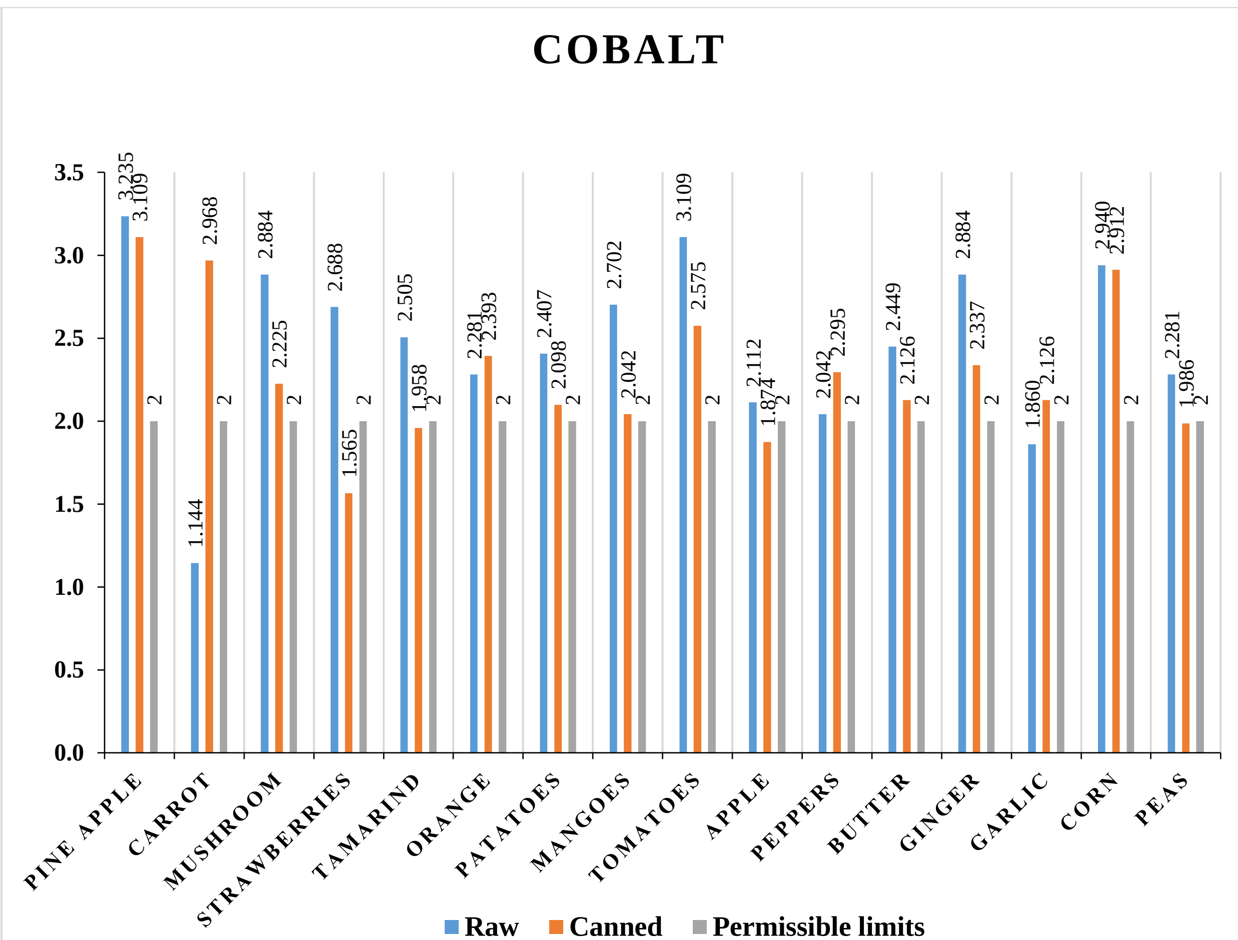

Fig.2 Concentration of Co in analyzed canned and raw food products.

Zinc: Zinc (Zn) is also an essential trace metal element mandatory for thyroid function, blood clotting, synthesis of DNA and protein, and proper growth. But its excessive consumption results in Zn toxicity and may produce hazardous effects on the level of blood lipoprotein, immune system and copper level (Dghaim *et al*. 2015). In addition, it may also cause vomiting, diarrhea, nausea, and abdominal pain (Maitlo *et al*. 2020). While its deficiency can cause growth retardation and hypogonadism (Nkansah *et al*. 2016).

In this study, the amount of Zn was found in the range of 2.96 to 6.33 mg/kg and 2.95 to 5.77 mg/kg in raw and canned food samples, respectively (Table 2). Figure 3 shows that the highest concentration of Zn in raw foodstuff was found in carrot (6.33 mg/kg), whereas the lowest concentration was found in pineapple and honey (2.96 mg/kg) followed by butter (2.97 mg/kg) and corn (2.98). Whilst in canned food, tamarind (5.77 mg/kg) followed by garlic (5.21 mg/kg) contained the highest amount of Zn, whereas its lowest amount was found in pineapple and mushroom (2.95 mg/kg) followed by butter (2.96 mg/kg). Moreover, it can be observed from figure 3 that except for tamarind (5.77 mg/kg), the amount of Zn in all studied canned food samples was within WHO/FAO maximum permissible limit (5.2 mg/kg). While in the case of raw food samples except for carrot (6.33 mg/kg) the amount of Zn in all studied samples was within WHO/FAO maximum permissible limit.

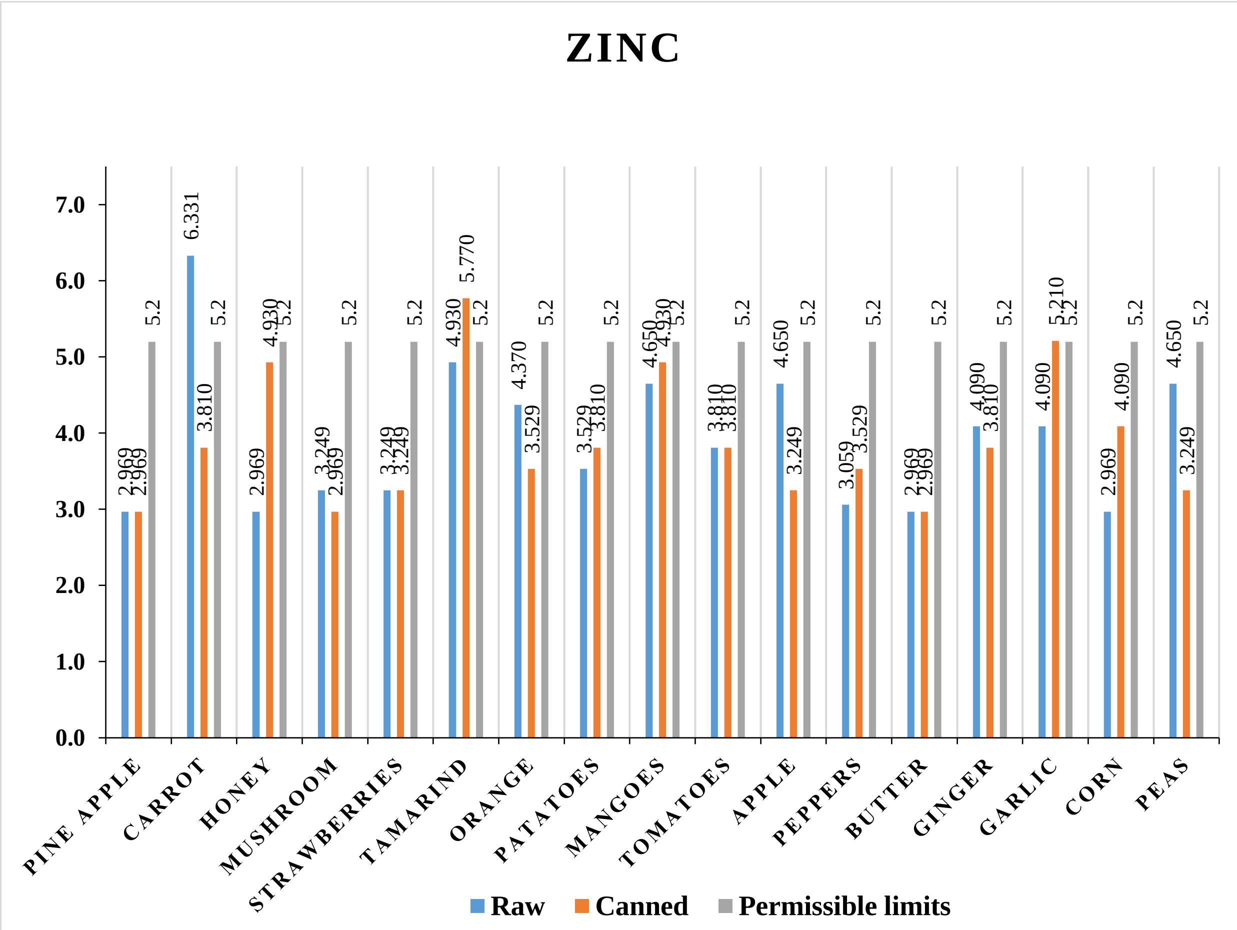

Fig .3 Concentration of Zn in analyzed canned and raw food products.

Manganese: Manganese (Mn) is an essential metal element that is required for the regular functioning of the immune system and physiological processes such as amino acid, protein, lipid, and carbohydrate metabolism. Deficiency of Mn rarely occurs in humans but its consumption in excessive amounts is linked with psychiatric disorders (Arain *et al.* 2015). In current study, the amount of Mn was found in the range of 0.24 to 0.41 mg/kg and 0.24 to 0.39 mg/kg in raw and canned food samples, respectively (Table 2). Figure 4 shows that the highest concentration of Mn in raw foodstuff was found in ginger (0.41 mg/kg), while the lowest concentration was found in honey (0.24 mg/kg). Whilst in canned food, ginger (0.39 mg/kg) measured the highest amount of Mn, whereas its lowest amount was found in pineapple and mangoes (0.24 mg/kg). The data in table 2 shows that the concentration of Mn in six samples of raw food including strawberries (0.37 mg/kg), tamarind (0.35 mg/kg), orange jam (0.37 mg/kg), butter (0.40 mg/kg), ginger (0.41 mg/kg), and peas (0.39 mg/kg), and six samples of canned food products including honey (0.37 mg/kg), strawberries (0.35 mg/kg), tamarind (0.35 mg/kg), tomatoes (0.36 mg/kg), ginger (0.39 mg/kg), and peas (0.37 mg/kg) were slightly higher than the WHO/FAO maximum allowable limit (0.3 mg/kg). Whereas the remaining investigated samples were within the WHO maximum permissible limits .

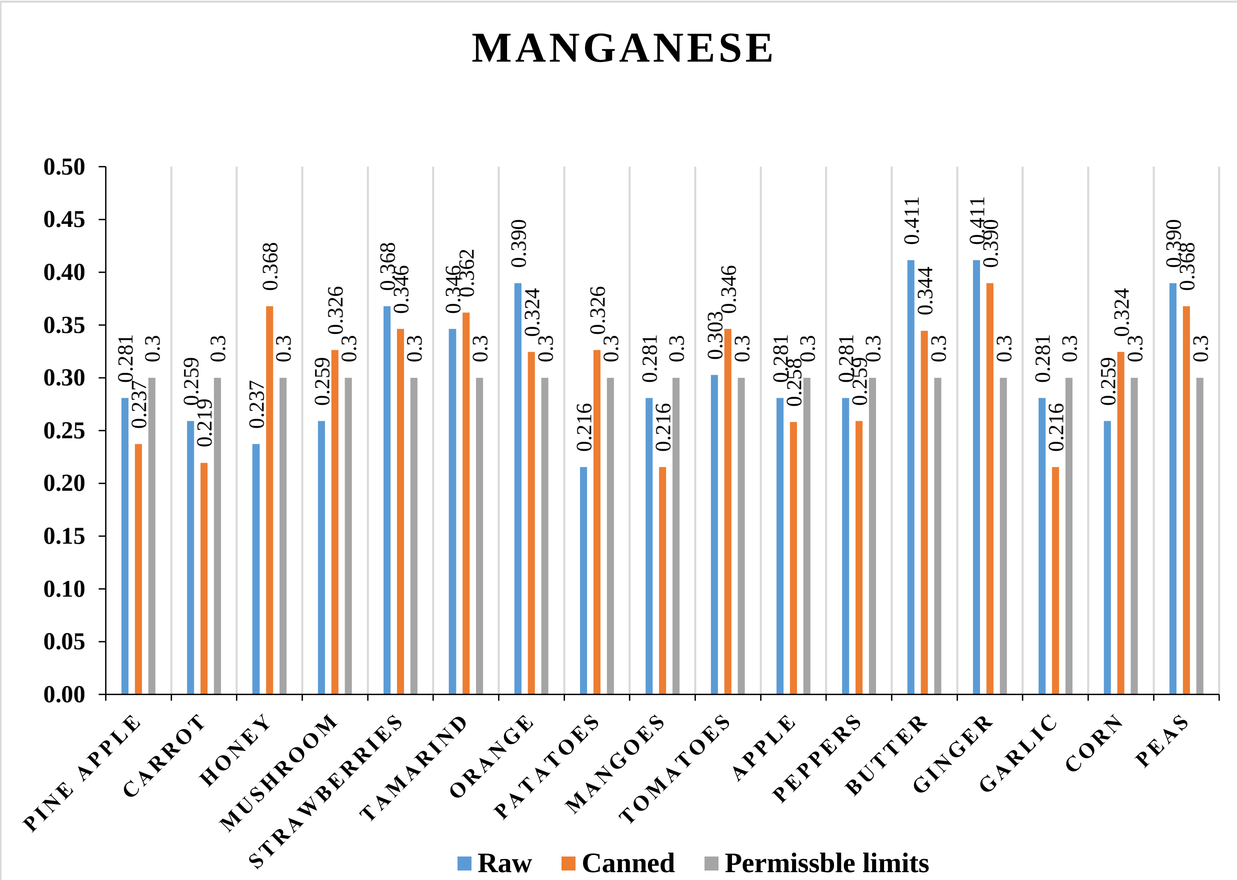

Fig.4 Concentration of Mn in analyzed canned and raw food products.

Sodium: Sodium (Na) is an essential trace metal element required for maintaining osmotic equilibrium, blood volume, pH, neurotransmission, and blood pressure. Though it is an essential element its intake at an excessive level may result in hypertension and high blood pressure (Chesters *et al*. 1997). In current study, the amount of Na was found to be in the range of 65.1 to 202 mg/kg and 76.7 to 167 mg/kg in raw and canned food samples, respectively (Table 2). Figure 5 shows that the highest concentration of Na in raw foodstuff was found in garlic (202 mg/kg), whereas the lowest concentration was found in strawberries (65.1 mg/kg) followed by pineapple (66.5 mg/kg). Whilst in canned food, ginger (167 mg/kg) followed by pepper (166 mg/kg) contained the highest amount of Na, whereas its lowest amount was found in honey (76.7 mg/kg) followed by pineapple (77.4 mg/kg). It can be seen in figure 4 that the concentration of Na in ten out of seventeen samples of canned food including carrot (117 mg/kg), mushroom (161 mg/kg), strawberries (113 mg/kg), tamarind (141 mg/kg), tomatoes (119 mg/kg), pepper (166 mg/kg), butter (115 mg/kg), ginger (167 mg/kg), corn (151 mg/kg), and peas (140 mg/kg) were higher than the WHO/FAO maximum allowable limit (103 mg/kg). Whereas four out of seventeen samples of raw food products including pepper (104 mg/kg), ginger (106 mg/kg), garlic (202 mg/kg), and corn (129 mg/kg) contained a higher concentration of Na than WHO/FAO maximum allowable limit. Whereas the remaining investigated samples were within the WHO maximum permissible limits. Moreover, it can be seen in figure 5 that the level of Na in most of the canned food samples was greater as compared to their respective raw food samples.

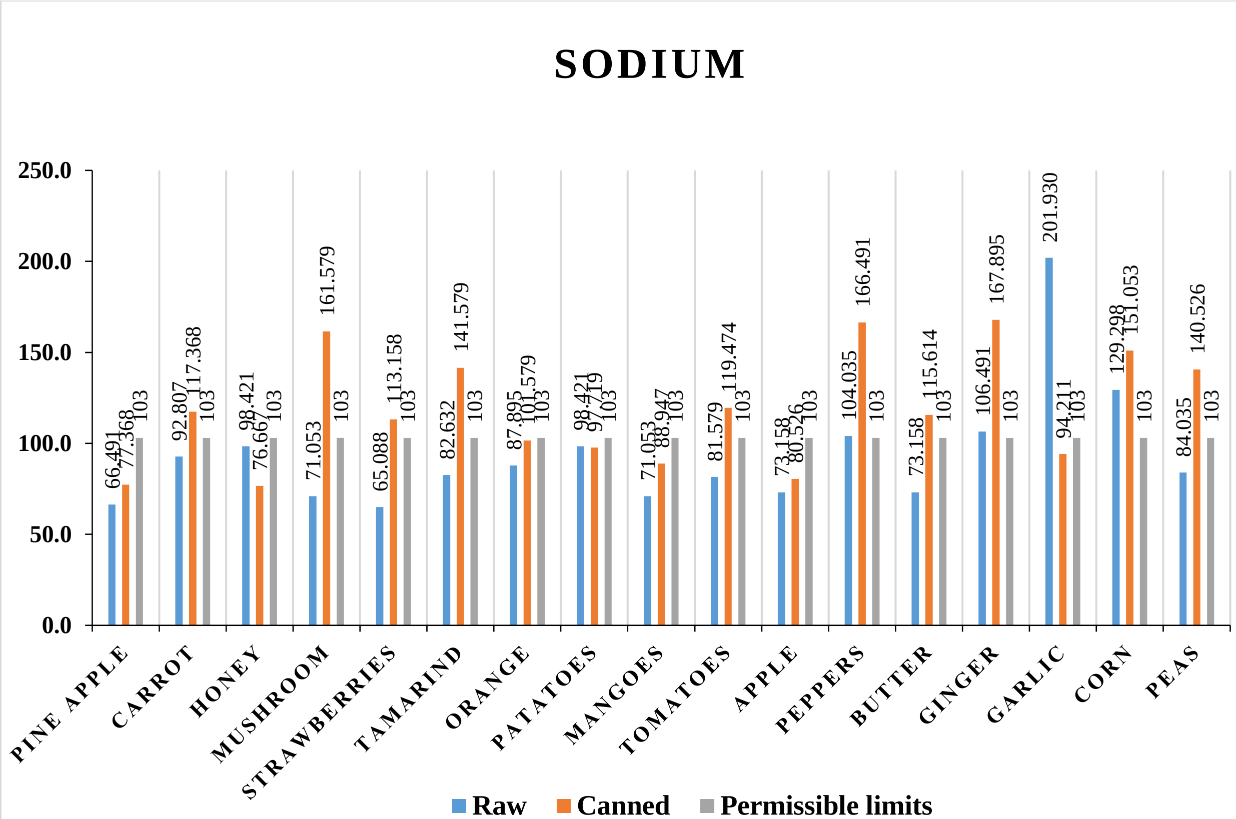

Fig. 5 Concentration of Na in analyzed canned and raw food products.

Potassium: Potassium is an essential element required to maintain bone health, neurotransmission, and osmotic pressure. Its deficiency can result in irregular heartbeat, weakness, hypokalemia, and cardiac arrhythmia (Chesters *et al*. 1997). In this study, the amount of K was found in the range of 976.5 – 4963 mg/kg and 888.7 – 4942 mg/kg in raw and canned food samples, respectively (Table 2). Figure 6 shows that the highest concentration of K in raw foodstuff was found in tamarind (4963 mg/kg) followed by ginger (4689 mg/kg) and mushroom (4497 mg/kg), whereas the lowest concentration was found in butter (976.5 mg/kg). Similarly, in canned food tamarind (4942 mg/kg) contained the highest amount of K, whereas its lowest amount was found in butter (888.7 mg/kg). It can be seen in figure 6 that the concentration of K in nine out of seventeen samples of raw food including carrot (2561 mg/kg), mushroom (4497 mg/kg), tamarind (4963 mg/kg), potatoes (3124 mg/kg), tomatoes (2589 mg/kg), ginger (4689 mg/kg), garlic (3193 mg/kg), corn (2335 mg/kg), and peas (2404 mg/kg) was higher than the WHO/FAO maximum allowable limit (2260 mg/kg). Whereas seven out of seventeen samples of canned food products including carrot (3462 mg/kg), mushrooms (3947 mg/kg), tamarind (4942 mg/kg), potatoes (3702 mg/kg), tomatoes (2476 mg/kg), ginger (3790 mg/kg), and garlic (3751 mg/kg) contained a higher concentration of K than WHO/FAO maximum allowable limit. Whereas the remaining investigated samples were within the WHO maximum permissible limits. Moreover, it can be seen in figure 6 that the level of K in most of the raw food samples was greater as compared to their respective canned food samples.

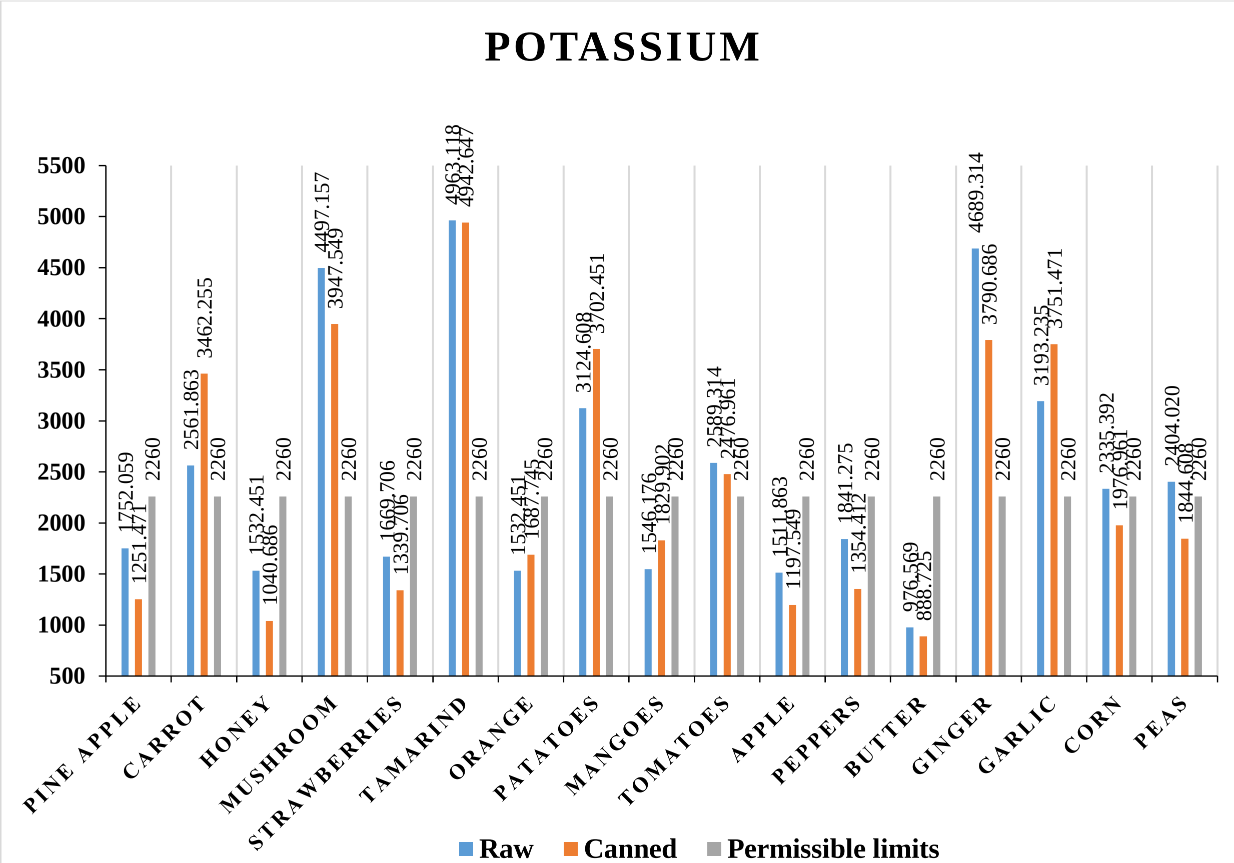

Fig. 6 Concentration of K in analyzed canned and raw food products.

Calcium: Calcium (Ca) is a very essential element necessary for the growth of bones, teeth, and skeleton. It is also a vital coenzyme in metabolism. Its deficiency however can result in poor blood clotting, rickets, and osteoporosis (Chesters *et al*. 1997). In this study, the amount of Ca was found in the range of 75.2 – 196 mg/kg and 71.4 – 186 mg/kg in raw and canned food samples, respectively (Table 2). Figure 7 shows that the highest concentration of Ca in raw food products was found in apple jam (196 mg/kg), whereas the lowest concentration was found in butter and mangoes (75.2 mg/kg). While, in canned food potatoes (186 mg/kg) followed by corn (182 mg/kg) contained the highest amount of Ca, whereas its lowest amount was found in honey (71.4 mg/kg) followed by peppers (75.2 mg/kg). It can be seen in figure 7 that except for the raw sample of apple jam the concentration of Ca in all studied canned and raw food samples was within the WHO/FAO maximum permissible limit (195 mg/kg).

This study was carried out to assess seven selected essential trace metals content including Cr, Co, Zn, Mn, Na, K, and Ca in different canned and corresponding raw food products sold in the local markets of Khairpur and Sukkur, Pakistan. The overall result of the current study showed that all examined samples contained different amounts of analyzed metals. The majority of examined raw and canned food products contained increased amounts of investigated elements as compared to their permissible limits. Whereas the levels of Zn and Ca in the investigated samples were within their permissible limits.

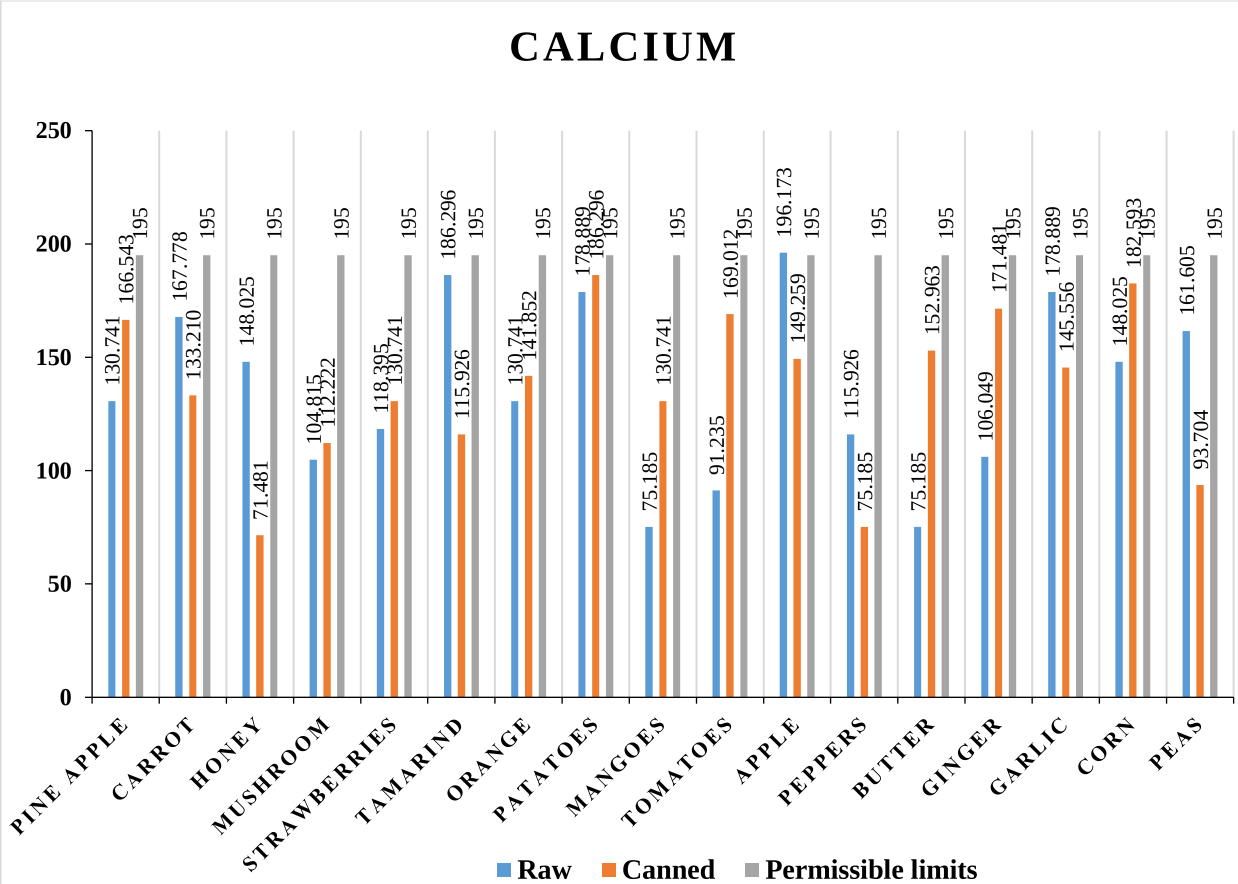

Fig. 7 Concentration of Ca in analyzed canned and raw food products.

1 **Table 2** Analytical results of trace metal contents in analyzed canned and raw food products.

Food Sample		**Chromium** (mean±S.D) **mg/kg (n=3)**	**Cobalt** (mean±S.D) **mg/kg (n=3)**	**Zinc** (mean±S.D) **mg/kg (n=3)**	**Manganese** (mean±S.D) **mg/kg (n=3)**	**Sodium** (mean±S.D) **mg/kg (n=3)**	**Potassium** (mean±S.D) **mg/kg (n=3)**	**Calcium** (mean±S.D) **mg/kg (n=3)**
Pineapple	**Canned**	3.08 ± 0.25	3.11 ± 0.02	2.95 ± 0.52	0.24 ± 0.03	77.4 ± 1.05	1251 ± 0.29	166 ± 1.13
	Raw	3.08 ± 0.68	3.24 ± 0.02	2.96 ± 0.48	0.28 ± 0.06	66.5 ± 0.61	1730 ± 0.31	130 ± 1.70
Carrot	**Canned**	5.04 ± 0.17	2.97 ± 0.04	3.81 ± 0.38	0.26 ± 0.04	117 ± 1.63	3462 ± 0.27	133 ± 1.49
	Raw	6.21 ± 1.17	1.14 ± 0.06	6.33 ± 0.48	0.26 ± 0.03	92.8 ± 0.73	2561 ± 0.17	167 ± 1.21
Honey	**Canned**	6.42 ± 0.35	1.50 ± 0.04	4.93 ± 0.72	0.37 ± 0.04	76.7 ± 0.61	1040 ± 0.15	71.4 ± 1.47
	Raw	3.84 ± 1.17	1.73 ± 0.02	2.96 ± 0.84	0.24 ± 0.04	98.5 ± 1.05	1511 ± 0.16	148 ± 1.62
Mushroom	**Canned**	5.23 ± 1.13	2.22 ± 0.06	2.95 ± 0.42	0.29 ± 0.07	161 ± 1.05	3947 ± 0.58	112 ± 1.70
	Raw	4.23 ± 0.68	1.88 ± 0.04	3.25 ± 0.16	0.27 ± 0.03	71.0 ± 1.03	4497 ± 0.13	104 ± 1.01
Strawberries	**Canned**	6.21 ± 0.72	1.56 ± 0.03	3.25 ± 0.23	0.35 ± 0.06	113 ± 1.05	1339 ± 0.29	130 ± 1.92
	Raw	3.86 ± 1.17	1.69 ± 0.02	3.26 ± 0.62	0.37 ± 0.06	65.1 ± 1.21	1669 ± 0.29	118 ± 1.26
Tamarind	**Canned**	5.42 ± 0.42	1.96 ± 0.02	5.77 ± 0.47	0.35 ± 0.02	141 ± 1.78	4942 ± 0.27	116 ± 1.37
	Raw	3.12 ± 0.53	2.01 ± 0.04	4.93 ± 0.97	0.35 ± 0.04	82.6 ± 1.06	4963 ± 0.49	186 ± 1.92
Orange Jam	**Canned**	5.77 ± 0.75	2.40 ± 0.02	3.57 ± 0.85	0.32 ± 0.04	101 ± 1.02	1687 ± 0.56	141 ± 1.82
	Raw	3.88 ± 0.13	2.24 ± 0.02	4.37 ± 0.84	0.37 ± 0.07	87.9 ± 1.04	1532 ± 0.17	130 ± 1.26
Potatoes	**Canned**	6.60 ± 0.30	2.09 ± 0.04	3.82 ± 0.52	0.30 ± 0.04	97.7 ± 0.61	3702 ± 0.28	186 ± 1.72
	Raw	3.14 ± 0.73	2.41 ± 0.03	3.53 ± 0.46	0.25 ± 0.03	98.6 ± 1.00	3124 ± 0.15	175 ± 1.53
Mangoes	**Canned**	6.22 ± 0.16	2.04 ± 0.06	4.95 ± 0.62	0.24 ± 0.02	88.9 ± 1.08	1829 ± 0.16	130 ± 1.05
	Raw	3.34 ± 0.42	2.70 ± 0.02	4.65 ± 0.27	0.29 ± 0.06	71.2 ± 1.06	1546 ± 0.29	75.2 ± 0.91
Tomatoes	**Canned**	5.82 ± 1.05	2.58 ± 0.03	3.83 ± 0.92	0.36 ± 0.09	119 ± 1.93	2476 ± 0.62	169 ± 1.16
	Raw	4.25 ± 0.95	3.11 ± 0.05	3.81 ± 0.59	0.30 ± 0.06	81.6 ± 1.09	2589 ± 0.52	91.2 ± 1.63
Apple Jam	**Canned**	6.26 ± 0.72	1.87 ± 0.07	3.25 ± 0.62	0.28 ± 0.08	80.5 ± 1.05	1197 ± 0.52	149 ± 1.82
	Raw	4.64 ± 0.77	2.11 ± 0.06	4.67 ± 0.48	0.29 ± 0.05	73.2 ± 1.07	1511 ± 0.38	196 ± 0.99
Peppers	**Canned**	5.88 ± 1.32	2.30 ± 0.06	3.58 ± 0.81	0.26 ± 0.03	166 ± 0.72	1354 ± 0.52	75.2 ± 1.92
	Raw	4.27 ± 0.62	2.04 ± 0.04	3.54 ± 0.38	0.29 ± 0.02	104 ± 0.61	1841 ± 1.11	115 ± 1.75
Butter	**Canned**	6.52 ± 0.15	2.12 ± 0.05	2.96 ± 0.41	0.31 ± 0.07	115 ± 0.52	888.7±0.34	153 ± 1.82
	Raw	5.04 ± 1.32	2.45 ± 0.04	2.97 ± 0.54	0.40 ± 0.05	73.2 ± 1.06	976.5± 0.94	75.2 ± 0.93
Ginger	**Canned**	5.46 ± 0.92	2.34 ± 0.15	3.84 ± 0.95	0.39 ± 0.04	167 ± 1.08	3790 ± 0.45	171 ± 1.92
	Raw	3.47 ± 0.27	2.88 ± 0.04	4.09 ± 0.82	0.41 ± 0.06	106 ± 1.21	4689 ± 0.14	106 ± 1.83
Garlic	**Canned**	6.84 ± 0.67	2.13 ± 0.03	5.21 ± 0.85	0.25 ± 0.06	94.2 ± 1.31	3751 ± 0.36	145 ± 1.52
	Raw	4.65 ± 0.72	1.86 ± 0.05	4.19 ± 0.48	0.30 ± 0.02	202 ± 1.63	3193 ± 0.29	178 ± 1.03
Corn	**Canned**	3.11 ± 0.37	2.91 ± 0.03	4.09 ± 0.48	0.33 ± 0.07	151 ± 1.26	1976 ± 0.22	182 ± 1.83
	Raw	5.12 ± 0.17	2.84 ± 0.05	2.98 ± 0.38	0.27 ± 0.03	129 ± 0.72	2335 ± 0.34	148 ± 1.62
Peas	**Canned**	6.99 ± 0.62	1.99 ± 0.08	3.26 ± 0.72	0.37 ± 0.08	140 ± 1.05	1844 ± 0.37	93.7 ± 0.99
	Raw	5.42 ± 0.67	2.28 ± 0.05	4.69 ± 0.85	0.39 ± 0.10	84.0 ± 1.21	2404 ± 0.17	161 ± 0.99

Conclusion

The current study proved that the investigated samples contained excessive concentrations of the selected trace metals. It may be concluded that the consumption of these food products vended in the local shops, markets and supermarkets of Sindh is not safe according to the health organizations. Therefore, strict procedures should be taken by food authority to reduce or eliminate the risk coming from the excessive intake of these elements. This can be done by performing routine analysis of the metal content in canned as well as raw food products sold in Pakistani markets and more cautious processing, handling, and advanced technologies in the packaging of raw materials can decrease the amounts of these trace metals, along with those further studies are required to determine possible route maps of toxic metals in food stuff and further work is required to reduce/remove toxic metals from human food chain.

Compliance with Ethical Standards

Conflict of Interest: Authors declare that they have no conflict of interest.

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