Nutritional Quality and Metallic Health Risk Assessment of Industrially Processed Tomato Ketchups Available in the Markets of Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. Author SM performed the sample collection and processing, performed analysis, data recording and wrote the first draft of the manuscript. Authors HMZ and HPS designed the study, managed the literatures and supervised the work. Author MA helped in manuscript preparation. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/EJNFS/2020/v12i330210

Editor(s): Dr. Manvesh Kumar Sihag, Mansinhbhai Institute of Dairy and Food Technology (MIDFT), India.

Reviewers: (1) Eduardo Ramirez Asquieri, Federal University of Goiás, Brazil. (2) Maria Nilfa Almeida Neta, Universidade Federal de Minas Gerais, Brasil.

Complete Peer review History: http://www.sdiarticle4.com/review-history/56233

Received 17 February 2020
Accepted 23 April 2020
Published 29 April 2020

ABSTRACT

An experiment was conducted to study the nutritional qualities of industrially processed tomato ketchups compared to homemade one and to assess metallic health risk due to consumption of those ketchups. Eight different types of industrially processed tomato ketchups available in the markets of Bangladesh from dissimilar producers and one homemade sauce were analysed in this study. Dry matter content in industrially processed tomato ketchups ranged between 32.52-38.41% while it was only 7.90% in case of homemade sauce. The average lycopene content of industrially processed tomato ketchups was 20.02 mg 100g⁻¹ sample while it was 29.10 mg 100g⁻¹ sample for homemade tomato sauce. Among the mineral nutrients - Ca, Mg, P and K contents in homemade tomato sauce were higher compared to industrially processed one. But Na content was higher in different industrially processed ketchups. Concentrations of Cu, Zn, Cr, Pb, Ni, Cd and Mn in industrially processed tomato ketchups ranged between 5.29-6.82, 2.14-34.08, 6.48-9.05, 7.56-11.51, 0.12-0.95, 0.36-0.46 and trace µg g⁻¹ (fresh wt. basis), respectively while in case of...
homemade tomato sauce the mean concentrations were 2.12, 3.33, 1.66, 2.08, 0.13, 0.09 and 1.73 µg g⁻¹ (fresh wt. basis), respectively. Thus, present study results inferred that higher amount of different heavy metals might be contributed by the addition of spices and other ingredients to industrially processed tomato ketchups. Target hazard quotients (THQ) values for Pb and Cr for industrially processed tomato ketchups approached or surpassed 1 for female. The cumulative target hazard quotients (CTHQ) values for the same tomato ketchups were also greater than one (>1) for both male and female, which indicate that the exposed populations are in a level of concern interval. On the other hand, individual THQ and CTHQ values for homemade sauce were less than 1 for both male and female, which indicate that dietary intake of this sauce is assumed to be safe.

**Keywords:** Mineral nutrient; heavy metal; target hazard quotients; tomato sauces/ketchups.

**1. INTRODUCTION**

Tomato fruits are commonly consumed fresh due to its perishable nature in normal condition. In order to make tomato fruits available during off season, it is processed to make tomato juice, puree, cocktail, paste, ketchup, sauce, jelly, soups, powder, tomato chutneys etc. Tomato sauces or ketchups are commonly consumed by all age groups in all over the world. Nowadays, it becomes a routine part of our daily diet. Furthermore, it is very attractive food item to the children. Tomato ketchups and sauces are high demanding condiment in the fast food industry and essential element in cuisines all over the world. It may be considered as one of the most important sources of carotenoids, different vitamins and phenolic [1].

Peoples are getting busier day by day in all over the world and hence the demand for ready to eat food items are increasing rapidly. To meet the increasing demand and huge opportunity to make money from this sector, a large number of new brands of sauces and ketchups have appeared in the market. In most cases they are not aware about the presence of heavy metals in their final product. Also, they are using different chemicals as preservatives to increase the shelf life of the product, to make their product tasty as well as lucrative. But the quality in context of heavy metal of the used materials/ingredients is questionable in respect of human health. Because it is well known that heavy metals can change their chemical form but they cannot be degraded or destroyed [2]. Thus, assessment of health risk due to intake of heavy metals through the food chain has been widely reported throughout the world including Bangladesh [3-7].

Food adulteration is dangerous issue for the development of a healthy nation and it can be a prime source to a number of diseases such as cancer, paralysis, mental retardation and hypertension etc. Therefore, it is essential to take necessary steps to check food adulteration as soon as possible. The existing food safety and regulatory management of Bangladesh is governed by many enactments and governmental bodies and more than dozen of laws deal with the food safety affairs excluding the common law provisions. It was found in a study that the food industries are usually ignoring the existing food regulations in Bangladesh [8]. The reasons like regulatory failures, choice of product, good price, lack of consumer awareness and educational and cultural influences are accountable for the existing food safety concerns in Bangladesh [8]. However, the government already took some noticeable initiative in this regard, such as campaigning against food adulteration, forcing the producers to change their methods of production and strengthen the monitoring system. But research study regarding the quality of industrially processed tomato ketchups available in the markets of Bangladesh is meagre. Thus, the present study was conducted to analyze different nutrient elements, moisture, dry matter and lycopene contents in ketchups available in the markets of Bangladesh. The study was also assessed the magnitude of heavy metals concentration in those ketchups, which will help the consumers to choose one that have possessed more nutritive value as well as safe in context of heavy metals content.

**2. MATERIALS AND METHODS**

**2.1 Collection of Tomato Ketchup Samples**

Eight (8) different types of tomato ketchups (sample IDs # 2-9) from dissimilar producers were analyzed in this study. The selected ketchups were collected from different markets and superstores in Mymensingh city,
Among the brands, eight different brands were selected randomly. There were 2 samples of foreign origin that are also available in the markets of Bangladesh. The rest 6 ketchup samples were manufactured by the different companies of Bangladesh and approved by the Bangladesh Standards and Testing Institution (BSTI). Collected samples were fresh, sealed and free from any kind of deterioration.

2.2 Preparation of Homemade Tomato Sauce

For the preparation of homemade tomato sauce, fresh tomatoes were collected from the experimental field of the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh. Then, tomatoes were washed properly with distilled water. After washing tomatoes were boiled for about ten minutes and peels of boiled tomatoes were removed. Then the boiled tomatoes were blended using an electric blender and finally kept about 500 g in a clean sterile glass jar by adding 5 mL of acetic acid to increase shelf life. Salt, sugar and spices were not added to this sauce. Finally, it was stored in a refrigerator for chemical analysis.

2.3 Processing of Tomato Ketchup Samples

The sample was homogenized and accurate amount was weighed as required for different analysis. The moisture content was estimated gravimetrically by measuring the mass of tomato ketchup/sauce before and after the water has removed by evaporation in an oven (AOAC Official Method 2001.12). The mass of residue is expressed as percentage of the original mass of ketchup/sauce, which was then ground for further chemical analysis.

2.4 Preparation of Extract of Tomato Ketchups

Finely ground samples were used to prepare extract for the determination of major mineral nutrient elements and heavy metals. Extract was prepared by wet oxidation method using di-acid mixture [9]. In this method, 1.0 g of finely ground sample was taken into a 250 mL conical flask and 10 mL of di-acid mixture (HNO₃:HClO₄ = 2:1) was added to it. Then the flask was placed on an electric hot plate for heating at 180-200°C temperature until the solid particles disappeared and white fumes were evolved from the flask. Then, it was cooled at room temperature, washed with distilled water and filtered into 100 mL volumetric flask through filter paper (Whatman No. 1). For quality control purpose, a blank extract was also prepared by taking same reagents without sample. Finally, the volume was made up to the mark with distilled water and preserved for the determination of different mineral nutrients and heavy metals in the samples.

2.5 Determination of Major Mineral Elements and Lycopene

Among the major mineral nutrient elements, Ca and Mg were determined by titrimetrically, P and S were measured spectrophotometrically (660 and 425 nm absorbance wavelength, respectively; T60 UV-Visible Spectrophotometer, PG Instrument, UK), and Na and K were estimated by flame photometrically (589 and 766 nm emission wavelength, respectively; 0.2 ppm limit of detection; Jenway PFP7, Flame Photometer, UK) [9]. The instrumental parameters were adjusted according to the manufacturer’s recommendations. Lycopene is responsible for the red colour of tomato. For the determination of lycopene content, about 10 g of each tomato ketchup/sauce was taken in beaker and the exact weight of the sample was recorded for calculation. This carotenoid in the ketchup/sauce samples was extracted in acetone and then taken up in petroleum ether following the method described by Sadasivam and Manickam [10].

2.6 Determination of Heavy Metals

Determination of different heavy metals (Cu, Pb, Cr, Cd, Zn, Ni and Mn) in aqueous ketchup/sauce extracts were done by an atomic absorption spectrophotometer (AAS) (SHIMADZU, AA-7000; Japan). At first the AAS was calibrated followed by the manufacturer’s recommendation. Then each extract was run directly in AAS for the determination of each heavy metal in the samples mentioned above. Hollow cathode lamp of Cu, Pb, Cr, Cd, Zn, Ni and Mn was employed as light source at wavelengths of 324.8, 283.3, 357.9, 228.8, 213.9, 232.0 and 279.5 nm, respectively for the determination of each metal.

2.7 Estimation of Daily Metal Intakes (DMI)

To assess the health risk associated with heavy metal contamination in tomato ketchups available
in the markets of Bangladesh, the daily intake of metal was calculated with the following formula:

\[
DMI = \frac{(IR \times C)}{BW}
\]

Where, IR is the ketchup/sauce ingestion rate (mg person\(^{-1}\) day\(^{-1}\)), C is the individual metal concentration in ketchup/sauce samples (mg kg\(^{-1}\), fresh weight), BW is the body weight assuming 70 kg for adult male and 50 kg for adult female [11].

2.8 Metal Pollution Index (MPI)

To examine the overall heavy metal concentrations in ketchups available in the markets of Bangladesh, the metal pollution index (MPI) was computed. This index was obtained by calculating the geometrical mean of concentrations of all the metals present in the ketchup samples [12].

\[
MPI (\text{mg kg}^{-1}) = (C_{f1} \times C_{f2} \times \ldots \times C_{fn})^{1/n}
\]

Where, \(C_{fn}\) = Concentration of metal n in the sample

2.9 Target Hazard Quotients (THQ)

THQ was calculated by the general formula established by the US EPA as follows-

\[
THQ = \frac{(E_F \times F_D \times DMI)}{(RfD \times W \times T)}
\]

Where, \(E_F\) is exposure frequency; \(F_D\) is the exposure duration; \(DMI\) is the daily metal ingestion (mg person\(^{-1}\) day\(^{-1}\)) and \(RfD\) is the oral reference dose (mg kg\(^{-1}\) day\(^{-1}\)); \(W\) is the average body weight (kg) and \(T\) is the average exposure time for non-carcinogens (365 days year\(^{-1}\) × number of exposure years).

3. RESULTS AND DISCUSSION

3.1 Physicochemical Characteristics of Tomato Ketchups

3.1.1 Moisture content

Moisture content is one of the important characters of tomato ketchups. Moisture and dry matter content in homemade and different industrially processed tomato sauces are presented in Fig. 1. On an average, the highest moisture content (92.10%) was observed in homemade sample (ID # 1). Among the industrially processed tomato ketchups, the maximum amount of moisture was observed in sample ID # 9 (67.48%) followed by sample ID # 8 (66.48%) and ID # 2 (66.27%). On the other hand, the lowest amount of moisture was found in sample ID # 5 (61.59%). So, it can be inferred from the present study that in case of industrially processed tomato ketchups, the manufacturer added salt, sugar, condiments and spices, and reduced more moisture from their product to increase its shelf-life/durability. According to Ayub et al. [13], the product having high moisture content has minimum shelf stability. Although the selected ketchup samples were high in moisture content, it also contained a high amount of sugar and a low pH, which reduces the water activity and inhibits the growth of diseases causing microorganisms in the ketchup/sauce samples [14]. They reported the maximum moisture content 59.60±0.32% and the minimum 28.14±0.19% in ten different types of sauces and ketchups available in Bangladesh.

3.1.2 Dry matter content

Dry matter is the solid component of fruits, essentially what is left when all the water is removed, and mainly consists of soluble carbohydrates and others. The highest dry weight (38.41%) was obtained from the sample ID # 5 and the lowest amount of dry matter was found from sample ID # 1 (7.9%). It is evident from the Fig. 1 that industrially produced ketchups have dry matter within the range of 32.52-38.41% while it was only 7.90% in case of homemade sauce. These variations in dry matter contents of the samples may be attributed to the formulations of each manufacturer. The higher dry matter content in industrially processed ketchups indicates huge reduction of moisture from the raw tomatoes as well as addition of salt, sugar, spices and other materials to the ketchups.

3.1.3 Lycopene content

Lycopene is one kind of carotenoids responsible for the red colour of tomato and the consumption of lycopene containing foods may reduce cancer or cardiovascular disease risk [15]. The amount of lycopene obtained from different ketchups and sauce are presented in Fig. 2. The average lycopene content of industrially processed tomato ketchups ranged from 7.09-37.76 mg 100g\(^{-1}\) sample with a mean value of 20.02 mg 100g\(^{-1}\) sample while it was 29.10 mg 100g\(^{-1}\) sample for homemade tomato sauce. The
average content of lycopene in tomato paste was 75.00 μg g⁻¹, 160.36 μg g⁻¹ in tomato sauce, 141.71 μg g⁻¹ in ketchup and 80.99 μg g⁻¹ in tomato extract [16], which is almost similar to the present study results. However, nutritional quality of different sauces/ketchups may vary due to other factors such as tomato variety, maturity, and storage time and condition [17]. Processing of tomatoes increased the bioavailability of lycopene and lycopene content of fresh tomato samples was approximately 12 mg 100g⁻¹ whereas in tomato products the lycopene content had the following values: in tomato paste approximately 16 mg 100g⁻¹, in tomato boiled sauce approximately 4 mg 100g⁻¹ and in tomato ketchup 17 mg 100g⁻¹ [18]. They also concluded that the lycopene content of tomatoes remained higher during the multistep processing operations for the production of juice or paste.

![Fig. 1. Moisture and dry matter content in homemade (sample ID # 1) and different industrially processed (sample IDs # 2-9) tomato sauce/ketchups. Each value is the mean of three replicates, and vertical bar indicates the standard deviation (SD)](image1.png)

![Fig. 2. Lycopene content in homemade (sample ID # 1) and different industrially processed (sample IDs # 2-9) tomato sauce/ketchups. Each value is the mean of three replicates, and vertical bar indicates the standard deviation (SD)](image2.png)
3.2 Mineral Nutrient Content in Tomato Ketchups

The results on mineral nutrient contents of different industrially processed and homemade tomato ketchups and sauce are presented in Table 1. Calcium is an essential macronutrient element, which is important for bone formation and prevention of osteoporosis along with beneficial effects on serum lipids [19]. The maximum amount of Ca (0.234%) was obtained from the homemade tomato sauce. On the other hand, Ca content in industrially processed tomato ketchups ranged from 0.074-0.157%. Similarly, the highest amount of Mg was also recorded from sample ID # 1 (i.e. homemade tomato sauce). Alternatively, Mg content in industrially processed tomato ketchups ranged from 0.042-0.094% (Table 1). Mg content in ten different types of sauces and ketchups available in Bangladesh markets ranged between 0.94-7.46 mg 100g\(^{-1}\) sample [14], which is almost similar to the present study results. On the contrary, the lowest amount (0.027%) of Na was recorded from homemade tomato sauce and its content ranged from 0.132-0.317% in industrially processed tomato ketchups. This study results revealed that industrially processed tomato ketchups contained 5-10 times higher amount of Na compared to homemade tomato sauce, which might be due to addition of Na based salts during processing of ketchups. Although Na is very much necessary for human to maintain the balance of the physical fluids system and is also required for nerve and muscle functioning, but too much Na can damage kidneys and increase the chances of high blood pressure [20].

Potassium has many biological functions and act as co-factor for many enzymes, which is required for insulin secretion, creatinine phosphorylation, carbohydrate metabolism and protein synthesis [21]. Tomato products are usually an excellent sources of K. Among the sauce and ketchups analysed, the highest and lowest quantities of K were found in sample ID # 1 (0.193%) and sample ID # 9 (0.024%), respectively. The highest amount of K was present in homemade tomato sauce while, K content ranged from 0.024-0.103% in industrially processed tomato ketchups. Similarly, the maximum concentration of P (0.146%) was also found in homemade tomato sauce and its content ranged from 0.025-0.062% in industrially processed tomato ketchups. So, it can be inferred from the present study that similar to Ca, Mg and K, homemade tomato sauce or paste is also a good source of P compared to industrially processed ketchups. However, it is evident from Table 1 that there was no remarkable variation observed among the products in context of S content. The highest and lowest concentration of S in different types of ketchups were 0.094 and 0.068%, respectively. Thus, it can be inferred from the present study that tomato sauces/ ketchups are a good source of different essential elements in the diet, particularly Ca, Mg, P and K.

3.3 Heavy Metal Content in Tomato Sauces

Food contamination by different toxic heavy metals constitute a significant health hazard. Heavy metals are harmful and become toxic to health if they are taken above the limit of daily dietary allowance recommended. The heavy metals content in different ketchups and sauce samples are presented in Table 2 and the sequence on the basis of mean concentration of different heavy metals in industrially processed ketchup samples was in the order of Pb > Zn > Cr > Cu > Cd = Ni > Mn.

Copper plays a vital role in human metabolism, largely because it allows many critical enzymes to function properly [22]. Industrially processed tomato ketchups contained Cu ranging from 5.29-6.82 μg g\(^{-1}\) fresh weight (Table 2). But according to WHO/FAO report daily acceptable intake of Cu is 3.0 μg g\(^{-1}\) [23]. The mean concentrations of Cu in homemade and industrially processed tomato sauce/ ketchups were 2.12 and 6.07 μg g\(^{-1}\) fresh weight, respectively. The minimum and maximum concentrations of Cr in different industrially processed tomato ketchups were 2.12 and 7.61 μg g\(^{-1}\) fresh weight, respectively. The average concentrations of Cr in homemade and industrially processed tomato sauce/ ketchups were 1.66 and 7.61 μg g\(^{-1}\) fresh weight, respectively (Table 2). But according to WHO/FAO report daily acceptable intake of Cr is only 0.05 μg g\(^{-1}\) [23], which was far below than the measured values. So, Cr content in different industrially processed tomato ketchups should be checked carefully by the manufacturing companies, as because high level of Cr in this food item may lead severe health issues such as respiratory problem, birth defects, infertility and tumor formation. However, trivalent Cr becomes essential and initiates insulin action and thus influences carbohydrate, lipid and protein metabolism at a reasonable level [24]. On the other hand, the minimum and maximum
concentration of Cd in different industrially processed tomato ketchups were 0.36 and 0.46 μg g⁻¹ fresh weight, respectively. The average concentrations of Cd in homemade and industrially processed tomato sauce/ ketchups were 0.09 and 0.41 μg g⁻¹ fresh weight, respectively (Table 2). According to WHO the total intake of Cd should not exceed 1.0 μg kg⁻¹ of body weight per day [25]. So, present study results revealed that industrially processed tomato ketchups may be a source of Cd exposure to human.

The lowest and highest concentrations of Pb in different industrially processed tomato ketchups were 7.56 and 11.51 μg g⁻¹ fresh weight, respectively. The mean concentrations of Pb in homemade and industrially processed tomato sauce/ ketchups were 2.08 and 9.83 μg g⁻¹ fresh weight, respectively (Table 2). In fact, there are no any known health benefits or biological role of Pb for the human body. On the contrary, Pb is a cumulative toxicant, which may affect multiple body systems and is particularly harmful to children. It can affect almost every organ and system in the human body. Although there is no safe level of exposure to Pb has been found, chronic toxicity of it is much more common and occurs at blood levels of about 40-60 μg dL⁻¹ [26]. But Zn is an essential trace element for all forms of life. Ensuring adequate level of Zn intake can reduce child illness, enhance physical growth and decrease mortality in developing countries [27]. The highest amount of Zn was found 34.08 μg g⁻¹ (fresh wt.) and the lowest concentration was 2.14 μg g⁻¹ (fresh wt.) with a mean value of 9.79 μg g⁻¹ (fresh wt.) among the industrially processed tomato ketchup samples (Table 2). The U.S. recommended dietary allowance (RDA) for Zn is listed by gender and age group. The RDA for Zn is 8 mg day⁻¹ for adult women and 11 mg day⁻¹ for adult men, appears sufficient to prevent deficiency in most individuals [28]. Hence, it can be inferred from the present study that a daily consumption pattern of tomato sauces/ ketchups may contribute to the recommended dietary intakes of Zn.

Manganese concentrations in all industrially processed tomato ketchups were trace, while its concentration in homemade tomato sauce was 1.73 μg g⁻¹ fresh weight (Table 2). According to WHO/FAO report daily acceptable intake of Mn is only 5.0 μg g⁻¹ [23]. So, it can be inferred that industrially processed tomato ketchups are free from both health benefit and toxicity of Mn. Both Fe and Mn are indispensable to human survival, excessive exposure to them can damage human health. The excessive intake of Mn can result in lung embolisms, bronchitis, impotency, and nerve damage, even to the point of Parkinsonism [29]. The minimum and maximum concentrations of Ni in different industrially processed tomato ketchups were 0.12 and 0.95 μg g⁻¹ fresh weight, respectively. The average concentration of Ni in homemade and industrially processed tomato sauce/ ketchups were 0.13 and 0.41 μg g⁻¹ fresh weight, respectively (Table 2). According to WHO/FAO report daily acceptable intake of Ni is only 0.20 μg g⁻¹ [23], and its exposure to human may cause toxic effects in the respiratory tract, kidneys, and reproductive and immune systems. So, it can be inferred that the levels of Ni concentrations in 75% industrially processed tomato ketchup samples were higher than the WHO/FAO guideline, which may create health hazard to human.

Table 1. Major mineral nutrient content in homemade (sample ID # 1) and different industrially processed (sample IDs # 2-9) tomato sauce/ ketchups

| Sample ID | Ca     | Mg     | Na     | K      | P      | S      |
|-----------|--------|--------|--------|--------|--------|--------|
| 1.        | 0.234  | 0.190  | 0.027  | 0.193  | 0.146  | 0.094  |
| 2.        | 0.131  | 0.043  | 0.165  | 0.100  | 0.051  | 0.076  |
| 3.        | 0.080  | 0.048  | 0.224  | 0.079  | 0.031  | 0.075  |
| 4.        | 0.157  | 0.047  | 0.231  | 0.067  | 0.027  | 0.068  |
| 5.        | 0.138  | 0.042  | 0.272  | 0.103  | 0.044  | 0.081  |
| 6.        | 0.078  | 0.094  | 0.132  | 0.077  | 0.025  | 0.079  |
| 7.        | 0.160  | 0.049  | 0.189  | 0.072  | 0.025  | 0.089  |
| 8.        | 0.155  | 0.047  | 0.261  | 0.097  | 0.045  | 0.074  |
| 9.        | 0.074  | 0.080  | 0.317  | 0.024  | 0.062  | 0.088  |
| Mean (# 2-9) | 0.122  | 0.056  | 0.224  | 0.077  | 0.039  | 0.079  |
| Min.      | 0.074  | 0.042  | 0.027  | 0.024  | 0.025  | 0.068  |
| Max.      | 0.234  | 0.190  | 0.317  | 0.193  | 0.146  | 0.094  |
| SD (# 2-9) | 0.038  | 0.019  | 0.060  | 0.025  | 0.014  | 0.007  |
3.4 Estimation of Daily Metal Intake (DMI)

To evaluate the health risk associated with heavy metals through consumption of available tomato ketchups, the daily intake of metals were calculated. There are several possible pathways of exposure of metals to humans, but the food chain is the most important. The daily intake of metals was calculated according to the average tomato sauce/ketchups consumption for both adult males and females. Average per capita per day desirable intake of sauce/ketchups was 20 g [30]. The daily metal intakes estimate of Ni, Mn, Zn, Cu, Cr, Cd and Pb from different ketchup samples were calculated by multiplying the daily intake and the metal concentrations determined in this study. The DMI values were compared with the upper tolerable daily intakes for metals. It is evident from Table 3 that daily metal intake of Pb for both male and female, was higher than that of upper tolerable intake level, which indicates serious adverse effects have been associated with intake of tomato ketchups. However, it is very much clear from the same table that daily metal intakes for both male and female for all metals except Mn were higher for industrially processed tomato ketchups in comparison with homemade tomato sauce.

3.5 Assessment of Metal Pollution Index (MPI)

The metal pollution index (MPI) was used to compare the total metals accumulation level in different tomato ketchups. It has indisputable importance of established chemical, biochemical and biological methods. The MPI is a reliable and precise method for monitoring metal pollution in food samples. The MPIs of individual tomato ketchup samples collected from the different markets of Bangladesh along with the homemade tomato sauce are presented in Fig. 3. Among the ketchups samples used in the present study, sample ID # 6 showed the highest MPI (7.12) while the lowest MPI was obtained from the homemade sauce (sample ID # 1). It is also apparent from the Fig. 3 that all industrially processed tomato ketchups showed comparatively higher MPI values (ranged from 3.18 to 7.12) than homemade tomato sauce (MPI=2.12), indicate higher metal pollution in industrially processed tomato ketchups.

3.6 Target Hazard Quotients (THQ)

Target hazard quotients (THQ) is a complex parameter used for the estimation of potential health risks associated with long term exposure to chemical pollutants [35-37]. The THQ < 1 means that the exposed population is assumed to be safe; 1 < THQ < 5 means that the exposed population is in a level of concern interval, and THQ > 5 means exposed population is unsafe. Target hazard quotients was measured considering DMI of people, average body weight (male: 70 kg and female: 50 kg) and average life expectancy (male: 70.8 and female: 73.1 years) [11]. Values of this parameter (THQ) due to intake of tomato ketchups for investigated metals are presented in Table 4. There were some heavy metal like Pb and Cr whose individual THQ values for industrially processed tomato ketchups approached or surpassed 1 for female. So, it can be inferred from the present study that

Table 2. Heavy metal content in homemade (sample ID # 1) and different industrially processed (sample IDs # 2-9) tomato sauce/ketchups

| Sample ID | Heavy metal contents (in µg g\(^{-1}\) fresh wt.) |
|-----------|--------------------------------------------------|
|           | Cu      | Cr      | Cd      | Pb      | Mn      | Zn      | Ni      |
| 1.        | 2.12    | 1.66    | 0.09    | 2.08    | 1.73    | 3.33    | 0.13    |
| 2.        | 5.40    | 6.48    | 0.38    | 7.56    | Trace   | 6.22    | 0.12    |
| 3.        | 6.00    | 7.48    | 0.41    | 9.36    | Trace   | 11.71   | 0.18    |
| 4.        | 6.82    | 8.17    | 0.45    | 10.56   | Trace   | 7.70    | 0.23    |
| 5.        | 5.95    | 7.29    | 0.42    | 10.17   | Trace   | 6.37    | 0.28    |
| 6.        | 6.46    | 9.05    | 0.46    | 9.65    | Trace   | 34.08   | 0.95    |
| 7.        | 6.64    | 8.06    | 0.43    | 11.51   | Trace   | 4.74    | 0.63    |
| 8.        | 5.97    | 7.34    | 0.40    | 10.27   | Trace   | 5.36    | 0.46    |
| 9.        | 5.29    | 7.00    | 0.36    | 9.59    | Trace   | 2.14    | 0.43    |
| Mean (# 2-9) | 6.07    | 7.61    | 0.41    | 9.83    | -       | 9.79    | 0.41    |
| Min.      | 2.12    | 1.66    | 0.09    | 2.08    | Trace   | 2.14    | 0.12    |
| Max.      | 6.82    | 9.05    | 0.46    | 11.51   | 1.73    | 34.08   | 0.95    |
| SD (# 2-9) | 0.55    | 0.80    | 0.04    | 1.14    | -       | 10.18   | 0.28    |
Table 3. Calculated daily metal intakes (DMI) for tomato sauce/ ketchup samples with the upper tolerable intake level (UTIL) and oral reference doses (RfD)

| SAMPLE ID | Cu (mg day⁻¹ · person⁻¹) | Zn (mg day⁻¹ · person⁻¹) | Cr (mg day⁻¹ · person⁻¹) | Pb (mg day⁻¹ · person⁻¹) | Ni (mg day⁻¹ · person⁻¹) | Cd (mg day⁻¹ · person⁻¹) | Mn (mg day⁻¹ · person⁻¹) |
|-----------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| UTIL (mg day⁻¹ · person⁻¹) | 10.0* | 40.0* | - | 0.24* | 1.0* | 0.064* | 11.0* |
| RfD (mg kg⁻¹ · day⁻¹) | 0.04<sup>a</sup> | 0.30<sup>a</sup> | 0.003<sup>b</sup> | 0.0035<sup>a</sup> | 0.02<sup>a</sup> | 0.001<sup>a</sup> | 0.014<sup>c</sup> |
| Daily Metal Intake (mg day⁻¹ · person⁻¹) | Homemade tomato sauce Male | 0.61 | 0.59 | 0.48 | 0.59 | 0.036 | 0.026 | 0.495 |
| | Homemade tomato sauce Female | 0.85 | 0.83 | 0.67 | 0.83 | 0.051 | 0.036 | 0.693 |
| | Industrially processed tomato ketchups Male | 1.73 | 2.80 | 2.17 | 2.81 | 0.117 | 0.118 | 0.00 |
| | Industrially processed tomato ketchups Female | 2.43 | 3.92 | 3.04 | 3.93 | 0.164 | 0.166 | 0.00 |

<sup>a</sup> = FDA [31]; <sup>b</sup> = Garcia-Rico et al. [32]; <sup>c</sup> = US EPA [33]; <sup>d</sup> = IRIS [34] and <sup>e</sup> = Khan et al. [35]

Fig. 3. Metal pollution index (fresh wt. basis) of homemade (ID # 1) and different industrially processed (IDs # 2-9) tomato sauce/ ketchups

Table 4. Target Hazard Quotients (THQ) and Cumulative Target Hazard Quotient (CTHQ) of heavy metals for homemade and different industrially processed tomato sauce/ ketchups

| SAMPLE ID | GENDER | THQ values of heavy metals |
|-----------|--------|---------------------------|
| 1         | Male   | Zn 0.003 0.26 1.70 0.035 0.002 0.015 0.158 0.410 |
| 1         | Female | Zn 0.004 0.036 0.238 0.050 0.003 0.021 0.222 0.573 |
| 2         | Male   | Mn 0.006 0.109 0.617 0.000 0.002 0.039 0.617 1.389 |
| 2         | Female | Mn 0.008 0.153 0.864 0.000 0.002 0.054 0.864 1.945 |
| 3         | Male   | Cr 0.011 0.117 0.764 0.000 0.003 0.043 0.713 1.650 |
| 3         | Female | Cr 0.016 0.164 1.069 0.000 0.004 0.060 0.998 2.310 |
| 4         | Male   | Pb 0.007 0.130 0.862 0.000 0.003 0.049 0.778 1.828 |
| 4         | Female | Pb 0.010 0.181 1.207 0.000 0.005 0.068 1.089 2.560 |
| 5         | Male   | Ni 0.006 0.121 0.830 0.000 0.004 0.043 0.694 1.698 |
| 5         | Female | Ni 0.008 0.169 1.162 0.000 0.006 0.060 0.972 2.377 |
| 6         | Male   | Cu 0.032 0.132 0.788 0.000 0.014 0.046 0.862 1.874 |
| 6         | Female | Cu 0.045 0.185 1.103 0.000 0.019 0.065 1.207 2.624 |
| 7         | Male   | Cr 0.005 0.122 0.940 0.000 0.009 0.047 0.768 1.891 |
| 7         | Female | Cr 0.006 0.171 1.316 0.000 0.013 0.066 1.075 2.647 |
| 8         | Male   | Ni 0.005 0.114 0.838 0.000 0.007 0.043 0.699 1.705 |
| 8         | Female | Ni 0.007 0.159 1.174 0.000 0.009 0.060 0.979 2.387 |
| 9         | Male   | Cd 0.002 0.102 0.783 0.000 0.006 0.038 0.667 1.597 |
| 9         | Female | Cd 0.003 0.143 1.096 0.000 0.009 0.053 0.933 2.236 |

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an individual heavy metal health risk through the food chain via consumption of industrially processed tomato ketchups was in the category of level of concern interval. The contributions from all metals bring the cumulative target hazard quotients (CTHQ) values for industrially processed tomato ketchups were also greater than one (＞1) for both male and female (Table 4), which indicate that the exposed populations are in a level of concern interval. So, It can be inferred from the present study that heavy metals health risk through food chain via consumption of tomato ketchup were in a level of concern interval and female are more vulnerable than man. On the other hand, in case of all metals, individual THQ values for homemade sauce were less than 1 for both male and female. Furthermore, CTHQ values for homemade sauce were also less than 1 for both male and female, which indicate that the exposed population is assumed to be safe.

Therefore, the present study suggests that the consumers should encourage to prefer homemade tomato sauces/ ketchups rather than the industrially processed one, which provides more nutrition along with important minerals for sound human health.

4. CONCLUSION

Tomato sauces/ ketchups are a good source of essential elements in the diet, mainly Ca, Mg, P and K. Furthermore, a daily consumption pattern contributes to the recommended dietary intakes of trace element such as Zn. However, present study inferred that the locally available different brands of tomato ketchups contain less amount of different mineral nutrient elements (Ca, Mg, K, P and S) but higher amount of different heavy metals (Cu, Cr, Cd and Pb) compare to homemade one. Among the heavy metals studied, individual THQ values for Pb and Cr of industrially processed tomato ketchups approached or surpassed 1 for female. The CTHQ values for the industrially processed tomato ketchups were also surpassed 1 for both male and female, which indicate that the exposed populations are in a level of concern interval. On the other hand, CTHQ values for homemade sauce was less than 1 for both male and female, which indicate that dietary intake of this sauce is assumed to be safe. Thus, producers/ manufacturer should consider about it and accordingly they should take necessary initiative to reduce heavy metal contents in their products to a minimum level. On the other hand, consumers should also consider about the metallic contamination level of the processed tomato sauces/ ketchups.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest among the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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