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Nutritional and microbiological evaluation on sauces and ketchups available in Bangladesh

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Abstract

The study was performed to compare the macro and micro nutrient elements, heavy metal contents and microbiological quality of ten different types of sauces and ketchups available in Bangladesh. Physicochemical properties, vitamin, minerals, preservatives and heavy metals concentration and microbiological quality were determined for all the samples. The results of this study suggest that the selected sauces and ketchups are good source of nutrient, antioxidant like vitamin C and energy. Heavy metals as well as concentration of preservatives were analyzed to assess the safety in terms of physical and chemical hazards associated with sauces and ketchups. Among heavy metals, only aluminum was detected in studying sauces and ketchups, but their concentration were lower than the permitted level. The results of this study were compared with existing results and recommendations which will be helpful for consumers to consider the nutritional quality and safety of sauces and ketchups.

Introduction

World-wide, tomatoes *(Lycopersicon esculentum)* constitute an important agricultural crop and an integral part of the human diet. Tomatoes are regarded as the most important source of the carotenoid, lycopene and a tomato-rich diet is reported to provide protection against some types of cancer and cardiovascular diseases (Willcox *et al*., 2003; Sesso *et al.*, 2004; Walfisch *et al*., 2007). Tomatoes are commonly consumed fresh but due to its perishable nature it rapidly deteriorates after ripening. In order to make tomato fruit available during off season, it is processed to make tomato juice, puree, cocktail, paste, ketchup, sauce, jelly, soups, powder and tomato chutneys etc.

Tomato ketchup and sauces are high demanding condiment in the fast food industry and essential element in cuisines all over the world. Tomato sauce and ketchup are produced from fresh and wholesome tomatoes of intensive red color by washing, crushing into pulp, concentrating and seasoning with different ingredients and bottling or canning. Food staffs that are usually served hot, including chips/fries, sandwiches, dogs, eggs and grilled or fried meat whereas tomato sauce is used for food coloring, seasoning and soup preparation. Tomato is also a primary ingredient in chilli sauce but the main flavor of the sauce comes from the presence of hot peppers. Tomato is a major ingredient for any ketchup or sauce because of its various health benefits. In the UK and in most Commonwealth countries, tomato sauce is more or less a synonym for tomato ketchup. There is no basic difference between sauces and ketchups. However sauces are generally thinner and contain more total solids minimum 30% than ketchups minimum 28%.

The basic ingredients in modern ketchup and sauces are tomatoes, sugar, salt, spices and vinegar. Natural colours such as caramel colors are used. Acid is an essential universal constituent of sauces and ketchups . The most commonly used acid is citric acid and acetic acid. Sauces and ketchups are pasteurized to give the required shelf life but the basic principle of preservation is the use of vinegar, which inhibits the growth of spoilage and food poisoning micro-organisms. Other ingredients such as salt and sugar contribute to the preservative effect and the correct Preservation Index ensures that the product does not spoil after opening and can be used a little at a time. Some may contain a preservative such as sodium benzoate but this is not necessary if an adequate Preservation Index is achieved. It should also be noted that pH is also an important factor and changes in pH could transform a food into one which can support the growth of pathogens (FDA, 2001).

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People are getting busier day by day and hence the demand for ready to eat food/drink is 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 presence of heavy metals in the final product. Also, they are using preservatives to delay their decomposition and to increase the shelf life of the product. Sodium benzoate, Ascorbic acid, Citric acid, Sulphites (or sulphites) - sometimes also labeled as sulfur dioxide, sodium sulphite, sodium and potassium bisulphate, sodium or potassium metabisulphite etc. are being used as preservatives in these types of products. 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 ignoring the existing food regulations in Bangladesh. 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 (Ali, 2013). Food adulteration can prove very dangerous for the development of a healthy society and this can lead 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 before it is too late. Adulteration and contamination in edibles especially beverages, bottled water, cooking oil/ ghee, spices, tea, sweeteners like sugar, sweetmeats, bakery products, milk and milk products, fruit and vegetable products are a constant threat to the health of the common people. One of the significant measures in this regard is to create awareness amongst the public regarding the safety and hygienic conditions. The kinds of impurities found in food items that are sold in the markets should be highlighted. This can only be done by more research work like this to test the deviation from the standard and by media coverage. The government should start campaigning against food adulteration, forcing the producers to change their methods of production (Akter *et al.*, 2012). By considering all these facts, the present study was conducted to prepare new and updated information about the nutritional composition of sauces and ketchups available in Bangladesh and also to magnitude the concentration of heavy metals and preservatives in these condiments. The authors believe that this study will help consumers purchase sauces and ketchups which have more nutritive properties and also this will give them an idea about the status of preservatives, heavy metals and microbiological quality in these condiments.

Materials and Methods

This study was conducted to evaluate the quality of sauces and ketchups by studying their physico-chemical, microbiological properties, vitamin, trace-elements, minerals, preservatives and heavy metals content. Five samples of each type of sauces and ketchups were collected for this experiment. Each value represents the average from five replications and the outcomes expressed as mean values ± standard deviations (SD). All the results were expressed as gram (g), percentage (%), kilocalorie (Kcal), milligram (mg) and microgram (µg) per 100 g of sauces and ketchups.

Sample collection

This experiment was carried out at Institute of Food Science and Technology, BCSIR, Dhaka. Ten different types of sauces and ketchups from dissimilar producers were analyzed in this study. The selected sauces and ketchups were collected from different markets and superstores in Dhaka city. Collected samples were fresh, sealed and free from any kind of deterioration.

Sample preparation

The sample was homogenized and accurate amount was weighed as required for different analysis. Five samples of each type of sauces and ketchups were selected for measurement.

Determination of physico-chemical properties

The pH was determined with a digital pH meter and titratable acidity was estimated with the visual acid-base method (Ranganna, 1986). The moisture content was determined by the digital moisture analyzer. The total soluble solid (TSS) was determined with a hand refractometer (Jahan *et al.*, 2011). Crude fiber, total fat was determined by the standard AOAC method (AOAC. 2005) and the estimation of total protein was made by the method (Kirk and Sawyer 1991). The content of total carbohydrate and energy was determined by the method (Osborn and Voogt, 1978).

Determination of vitamin-C and minerals

Vitamin C was determined by the method of Bessey and King (Jahan *et al*., 2011). Ash was determined by the process (Ranganna, 1986). Sodium and potassium contents were determined by flame photometric method mentioned by Ward and Johnston (Jahan *et al*., 2011). Calcium, Magnesium,

Copper, Iron, Manganese, Zinc and Chromium were determined by Flame Atomic Absorption Spectrometric method (Kirl and Sawyer, 1991).

Determination of preservatives

Sulpher di-oxide was determined by titration process (Ranganna, 1986) and Sodium Benzoate was determined by the method (krik and Sawyer, 1991).

Determination of heavy metals

Aluminum, Arsenic, Mercury, Lead, Tin and Cadmium were determined by Flame Atomic Absorption Spectrometric method (Kirk and Sawyer, 1991).

Bacterial analysis of collected samples

For the quantitative determination of total count of mesophilic bacteria, total coliform, the standard procedure was followed (FDA, 2001). Aerobic plate count (APC) was performed by pour plate method using plate count agar (PCA), which was incubated at 35±10^{0}C for 48±2h. Lauryl tryptose broth was used for isolation of *Escherichia coli*. Gassing tube was selected for *E.coli* enumeration using most probable number (MPN) method. Enumeration of fungi was performed on rose Bengal agar medium.

Statistical analysis

Statistical analyses were carried out by using Statistical Package for Social Science (SPSS) for Windows version 15.0. The results obtained in the present study are reported as mean values (obtained from the five replications) ± standard deviation (SD). Mean values were analyzed using student T test. The significant differences between mean values were analyzed by the Duncan multiple range test at a significance level of $p<0.05$.

Results and Discussion

Physico-chemical and nutritional properties

The results of the physico-chemical analysis are given in Table 1 and Table 2. It is evident that moisture content was found maximum in sample III (59.60±0.32%) and minimum in sample IV (28.14±0.19%). Product having high moisture content has minimum shelf stability (Ayub *et al*., 2005). Although the selected samples were high in moisture content, it also contained a high amount of sugar and a low pH. This reduces the water activity (a_w) and inhibits the growth of diseases causing microorganisms in the selected samples.

Ash contents reveal cumulative pictures of different minerals present in the food. The ash content of given samples was ranged from 0.10±0.05% to 1.43±0.01%. Maximum ash contents were found in sample I (1.43±0.01%) and minimum in sample VI (0.10±0.05%). The variations in ash contents of the samples may be attributed to the formulations of each manufacturer. The lower ash content indicates low fruit contents in the product.

Most of the common fruits are low in protein. Like that tomato and chili contains very little amount of protein as fresh fruits, 0.85% and 0.9% respectively (USDA nutrient database, 2010), this clarifies the very low amount of protein content in the selected sauces and ketchups. High level of protein content was investigated in sample I (0.17±0.02%) and low level for sample VI, IX and X (0.11±0.42%). Rest of the samples did not contain any protein.

Sugars are one of the most important quality parameters, because of its contribution to the flavour, quality, palatability and discoloration of tomato ketchup and sauces. The highest quantity of total sugar (TS) (49.77±2.62%) and reducing sugar (RS) (35.32±0.78%) was recorded in sample IV, while these were lowest in sample V and sample III (25.88±1.33% and 8.01±0.24%, respectively) .The obtained data were in agreement with those observed by (Vitacel, 2002; Sharoba *et al*., 2005) they found mean values ranged as: sucrose 9.3 and 4.2-12.7% glucose 6.1 and 3.7-10.8% fructose 5.7 and 3.6-11.0%, respectively.

Usually fat content of different fruits is not greater than 1% (Sajib *et al*., 2014; Ara *et al*., 2014). In this study, fat content among the samples varied from 0.03±0.755% to 0.75±0.04% .The lowest value of fat 0.03±0.75% and the highest 0.75±0.04% was exhibited by sample VI and II, respectively. Due to removal of tomato skin, there is a small lipid content decrease in selected samples. Furthermore there were no new source of fat in the selected sauces and ketchups.

Two important quality attributes of processing tomatoes are pH and titratable acidity (TA). These and other quality attributes can be affected by tomato fruit maturity and over-maturity. The acidity of the fruit is also important as a contributor to the flavor of the tomato products. In this study, total titrable acidity varied significantly in different types of samples. Maximum content of total titrable acidity (1.315±0.01%) was recorded in sample V while it was minimum (0.39±0.13%) in sample III. The results are in agreement with those obtained by (Porretta and Birzi, 1995).

Total solids content is an important factor in the production of tomato sauce and ketchups. It is well known that the higher of the total solids the better

Table 1. Physico-chemical properties of studied sauces and ketchups.

Sample	n	Moisture content (%)	pH	Titratable acidity (%)	TSS (%)	RS (%)	TS (%)	Colour (ppm#)	Viscosity (cP at 750rpm, 31°C)
Sample I	5	57.44±0.22^{c}	3.65±0.04^{d}	0.74±0.05^{bc}	37±0.32^{d}	21.73±1.23^{c}	26.90±0.87^{fg}	4.12±0.05^{c}	256±0.34^{d}
Sample II	5	57.02±0.21^{c}	3.55±0.10^{e}	0.78±0.05^{b}	33±0.10^{g}	12.84±0.45^{g}	32.21±1.42^{d}	3.75±0.09^{e}	266±0.20^{g}
Sample III	5	59.60±0.32^{a}	4.14±0.12^{a}	0.39±0.13^{f}	31±0.42^{h}	8.01±0.2.43^{j}	28.61±0.83^{ef}	4.14±0.12^{a}	244±0.43^{h}
Sample IV	5	28.14±0.19^{j}	3.15±0.04^{f}	0.69±0.08^{cd}	55±0.50^{a}	35.32±0.78^{a}	49.77±2.62^{a}	3.55±0.03^{f}	252±0.51^{a}
Sample V	5	43.21±0.25^{h}	3.8±0.09^{c}	1.31±0.01^{a}	35±0.40^{f}	11.30±0.98^{h}	25.88±1.33^{g}	3.85±0.08^{c}	239±0.48^{f}
Sample VI	5	58.60±0.10^{b}	4.06±0.04^{b}	0.48±0.06^{e}	36±0.10^{e}	28.58±0.83^{b}	32.14±2.44^{d}	4.06±0.05^{b}	202±0.10^{e}
Sample VII	5	44.05±0.59^{g}	3.84±0.04^{c}	0.46±0.10^{ef}	39±0.10^{c}	25.78±3.76^{c}	27.94±0.86^{ef}	4.35±0.04^{c}	210±0.10^{c}
Sample VIII	5	34.32±0.11^{i}	3.20±0.02^{f}	0.67±0.08^{cd}	31±0.10^{h}	24.36±0.72^{d}	38.57±1.84^{b}	3.70±0.03^{f}	208±0.13^{h}
Sample IX	5	49.38±0.15^{f}	3.20±0.05^{f}	0.49±0.07^{e}	41±0.05^{b}	26.69±0.20^{c}	35.20±1.92^{c}	3.50±0.06^{f}	214±0.15^{b}
Sample X	5	50.91±0.05^{e}	3.8±0.05^{c}	0.63±0.09^{b}	35±0.12^{f}	18.94±0.10^{f}	29.56±3.69^{e}	4.02±0.05^{c}	204±0.22^{f}

Note: Results were expressed as mean values ± standard deviation and values followed by different letters are significantly ($p<0.05$) different from each other. Preference has given aphetically from highest to lowest. # ppm=mg/Kg

Table 2. Nutritional properties of studied sauces and ketchups

Sample	n	Crude Fiber (%)	Total Carbohydrate (%)	Total Energy (Kcal/100g)	Total Protein (%)	Total Fat (%)	Ash (%)
Sample I	5	0.36±0.02^{f}	39.82±0.81^{i}	166±1.90^{h}	0.17±0.02^{ab}	0.17±0.02^{d}	1.43±0.01^{a}
Sample II	5	0.71±0.03^{d}	41.06±0.05^{g}	170.99±0.58^{g}	0±0.0^{c}	0.75±0.04^{a}	0.45±0.01^{d}
Sample III	5	2.62±0.39^{a}	37.16±0.20^{j}	150.59±0.43^{j}	0.15±0.43^{a}	0.15±0.03^{d}	0.31±0.16^{e}
Sample IV	5	1.15±0.08^{c}	69.38±0.55^{a}	283.37±2.71^{a}	0±0.0^{c}	0.65±0.01^{b}	0.68±0.06^{bc}
Sample V	5	0.51±0.03^{e}	55.39±0.42^{c}	223.09±3.57^{c}	0±0.0^{c}	0.17±0.12^{d}	0.72±0.08^{b}
Sample VI	5	0.54±0.02^{e}	40.62±0.55^{h}	163.24±2.54^{i}	0.11±0.42^{a}	0.03±0.03^{e}	0.10±0.05^{f}
Sample VII	5	0.73±0.01^{d}	54.57±0.24^{d}	219.54±1.88^{d}	0±0.0^{c}	0.14±0.06^{d}	0.50±0.07^{d}
Sample VIII	5	2.19±0.02^{b}	63.23±0.31^{b}	254±0.53^{b}	0±0.0^{c}	0.12±0.08^{d}	0.13±0.09^{f}
Sample IX	5	2.71±0.03^{a}	46.88±0.07^{f}	190.75±0.48^{f}	0.11±0.03^{bc}	0.31±0.03^{c}	0.61±0.10^{c}
Sample X	5	0.77±0.01^{d}	49.97±0.44^{e}	200.94±0.56^{e}	0.094±0.01^{bc}	0.07±0.19^{d}	0.71±0.01^{b}

Note: Results were expressed as mean values ± standard deviation and values followed by different letters are significantly ($p<0.05$) different from each other. Preference has given aphetically from highest to lowest.

will be the quality of the end product. Results showed that, the TSS content of sauces were comparatively higher than that of ketchups. Sample IV was found higher for TSS (55±0.50%) whereas sample III was found lower for TSS (31±0.42%). The above results are similar to those obtained by (Sharoba *et al*.,2005).

Among the parameters analyzed for the assessment of tomato quality, pH is very important because acidity influences the thermal processing conditions required for producing safe products. Among the sauces and ketchups analyzed sample III contains the highest amount of pH (4.14±0.12%) and the lowest amount of pH was in sample IV (3.15±0.04%). The obtained values were in accordance more or less with (Rani and Banins,1987), who found that the pH value for tomato ketchup ranged between 3.55 to 3.87. The variation of results with the reference may be due to the variation of the formulation of the manufacturers.

The selected samples were tested for sodium benzoate and sulfur dioxide, which acts as preservatives. Benzoic acid and its salts are used as a food preservative represented by the E-numbers E210, E211, E212, and E213. Benzoic acid inhibits the growth of mold, yeast and some bacteria. The efficacy of benzoic acid and benzoate is thus dependent on the pH of the food. Sodium benzoate is most suitable for use as an antimicrobial agent in foods and beverages which naturally are in the pH range below 4.5%; it is not recommended as a preservative at pH ranges higher than 4.5. Sodium benzoate content of selected

Table 3. Vitamin-C and trace-element content of the studied sauces and ketchups

Sample	n	Vitamin-C (mg/100g)	Copper (mg/100g)	Iron (mg/100g)	Zinc (mg/100g)	Manganese (mg/100g)
Sample I	5	34.00 ± 0.30^{d}	0.005 ± 0.001^{de}	0.172 ± 0.002^{e}	0.250 ± 0.002^{a}	N.D.
Sample II	5	31.4 ± 0.20^{e}	0.006 ± 0.004^{de}	0.760 ± 0.001^{a}	0.082 ± 0.001^{e}	N.D.
Sample III	5	24.3 ± 0.10^{fg}	0.005 ± 0.07^{bc}	0.235 ± 0.003^{c}	0.060 ± 0.01^{ef}	N.D.
Sample IV	5	13.2 ± 0.10^{j}	0.004 ± 0.00^{de}	0.035 ± 0.001^{j}	0.20 ± 0.02^{b}	N.D.
Sample V	5	53.4 ± 0.30^{a}	0.062 ± 0.01^{a}	0.350 ± 0.002^{b}	0.216 ± 0.04^{b}	N.D.
Sample VI	5	38.7 ± 0.10^{c}	0.034 ± 0.001^{b}	0.085 ± 0.004^{f}	0.032 ± 0.004^{g}	N.D.
Sample VII	5	45.7 ± 0.20^{b}	0.012 ± 0.002^{cde}	0.080 ± 0.001^{g}	0.124 ± 0.08^{d}	N.D.
Sample VIII	5	23.7 ± 0.10^{g}	N.D.	0.175 ± 0.002^{d}	0.045 ± 0.003^{fg}	N.D.
Sample IX	5	14.6 ± 0.10^{h}	0.030 ± 0.06^{b}	0.062 ± 0.005^{h}	0.028 ± 0.0001^{g}	N.D.
Sample X	5	25.4 ± 0.20^{f}	0.025 ± 0.002^{bcd}	0.045 ± 0.001^{i}	0.173 ± 0.004^{c}	N.D.

Note: Results were expressed as mean values ± standard deviation and values followed by different letters are significantly ($p<0.05$) different from each other. Preference has given aphetically from highest to lowest. N.D. = Not Detected

sauces and ketchups were varied from 0.02 ± 0.001 mg to 0.10 ± 0.01 mg. Sulfur preservatives, such as sulphites and Sulfur di-oxide inhibit the growth of microorganisms and prevent discoloration of sauces and ketchups. Sulfur di-oxide content of selected sauces and ketchups were varied from 0.07 ± 0.001 mg to 0.16 ± 0.02 mg. Checking food labels for sulphites, sulfur dioxide and E-numbers in the range of 220-228 is helpful; however, companies are only required to list sulphites as an ingredient when the amount is above 10 mg/liter or 10 ppm. The problems include stomach-ache, hives, bronchospasm and even anaphylactic shock.

Vitamin-C and trace-element content of the studied sauces and ketchups were revealed in Table 3. Tomato and tomato products are considered as a good source of vitamin C . The vitamin C contents of studied sauces and ketchups were ranged between 13.20±0.10 to 53.40±0.30 mg/100g.These findings comply with that reported by (Sharoba *et al*., 2005) who found the vitamin C content ranged 8.11 and 60.04 mg/100g and by (Yastrebov *et al*.,1979) who found the vitamin C content 10mg/100 g. It is well known that vitamin C is relatively unstable to heat, oxygen and light (Lin *et al*., 1998). However, the vitamin C content was highest in sample V (53.40±0.30 mg/100g) due to the fact that it was packaged in plastic mini pack, so contact with light reduces. While other sauces and ketchups are packaged in glass bottles.

Trace elements, minerals and heavy metals

The trace elements that were found in selected samples are copper, iron, manganese and zinc. The highest amount of copper was found in sample V, 0.07 ± 0.01 mg. The highest amount of zinc and iron was found in sample I and II, 0.27 ± 0.002 mg and 0.79 ± 0.001 mg respectively. Manganese was not detected in the selected samples. These minerals are also called micro-minerals which also work as antioxidants and are required in amounts less than 100 mg/day. Recommended Dietary Allowance (RDA) for copper is 900 µg/day for both adult male and female (Sajib *et al.*, 2014). Most fruits and fruit products contain a small amount of copper ranging from 0.005 ± 0.004 mg to 0.072 ± 0.01 mg. The U.S. recommended dietary allowance (RDA) for zinc is listed by gender and age group, the RDA for zinc (8 mg/day for adult women and 11 mg/day for adult men) appears sufficient to prevent deficiency in most individuals (Institute of Medicine, 2001). The highest amount of zinc was found 0.27 ± 0.002 mg in the sample I and lowest level found 0.02 ± 0.0001 mg in sample IX. The iron content of selected samples was varied from 0.03 ± 0.0001 mg to 0.79 ± 0.001 mg. According to USDA, the daily recommended intake of iron is 8 mg for adult male and 18 mg for adult female. Thus, consumption of these fruit products can be suggested as a food based strategy to alleviate or improve the unsatisfactory dietary iron intake of adolescents.

Minerals play an important role in maintaining proper function and good health in the human body. According to Hendricks, approximately 98% of the calcium (Ca) and 80% of the phosphorus (P) in the human body are found in the skeleton (Hendricks, 1998). Inadequate intake of minerals in the diet is often associated with an increased susceptibility

Table 4. Mineral and Preservatives content of selected sauces and ketchups

Sample	n	Sodium (mg/100g)	Potassium (mg/100g)	Calcium (mg/100g)	Magnesium (mg/100g)	Chromium (mg/100g)	Sodium Benzoate (%)	Sulfur dioxide (%)
Sample I	5	6.75 ± 0.001^{h}	7.92 ± 0.002^{d}	7.39 ± 0.001^{f}	2.16 ± 0.12^{e}	N.D.	0.04 ± 0.03^{c}	0.12 ± 0.002^{b}
Sample II	5	36.89 ± 0.002^{a}	11.45 ± 0.001^{b}	13.67 ± 0.002^{a}	5.79 ± 0.20^{b}	N.D.	0.06 ± 0.001^{b}	0.16 ± 0.02^{a}
Sample III	5	10.18 ± 0.004^{d}	4.11 ± 0.02^{g}	3.42 ± 0.003^{h}	1.36 ± 0.04^{g}	N.D.	0.06 ± 0.001^{b}	0.01 ± 0.003^{d}
Sample IV	5	8.59 ± 0.002^{f}	0.25 ± 0.003^{j}	2.38 ± 0.01^{j}	0.94 ± 0.002^{h}	N.D.	0.10 ± 0.01^{a}	0.16 ± 0.02^{a}
Sample V	5	8.67 ± 0.003^{e}	5.88 ± 0.001^{f}	6.14 ± 0.33^{g}	2.82 ± 0.21^{d}	N.D.	0.06 ± 0.002^{b}	0.08 ± 0.01^{c}
Sample VI	5	7.32 ± 0.006^{g}	5.90 ± 0.02^{e}	7.88 ± 0.003^{d}	1.96 ± 0.11^{f}	N.D.	0.04 ± 0.01^{c}	0.09 ± 0.04^{c}
Sample VII	5	14.17 ± 0.005^{c}	12.39 ± 0.002^{a}	12.68 ± 0.03^{b}	7.46 ± 0.42^{a}	N.D.	0.06 ± 0.001^{b}	0.07 ± 0.001^{c}
Sample VIII	5	8.59 ± 0.005^{f}	3.66 ± 0.04^{h}	3.11 ± 0.001^{i}	1.39 ± 0.003^{g}	N.D.	0.02 ± 0.001^{d}	0.08 ± 0.02^{c}
Sample IX	5	5.53 ± 0.007^{i}	2.43 ± 0.003^{i}	8.03 ± 0.02^{c}	3.42 ± 0.03^{c}	N.D.	0.04 ± 0.01^{c}	0.09 ± 0.02^{c}
Sample X	5	21.71 ± 0.002^{b}	7.94 ± 0.001^{c}	7.61 ± 0.002^{e}	1.86 ± 0.001^{f}	N.D.	0.03 ± 0.02^{cd}	0.12 ± 0.002^{b}

Note: Results were expressed as mean values ± standard deviation and values followed by different letters are significantly ($p<0.05$) different from each other. Preference has given aphetically from highest to lowest. N.D. = Not Detected

to infectious diseases due to the weakening of the immune system. Plants, animal foods and drinking water are an important source of essential elements (Chaturvedi *et al*.,2004). Table 4 shows the mineral content of studied sauces and ketchups.

These sauces and ketchups were also enriched with minerals like sodium, potassium, calcium, magnesium and chromium. Sodium content of selected sauces and ketchups were ranged between 5.53 ± 0.007 mg and 36.89 ± 0.002 mg per 100g of edible portion. Sodium variability of fruits sometimes relies on soil sodium, black soil contains a fair amount of sodium (Sajib *et al*., 2014; Ara *et al.*, 2014). Among the sauces and ketchups analyzed, the highest quantity of potassium was found in sample VII, 12.39 ± 0.002 mg. For the healthy adult, the RDA for sodium and potassium intake is not more than 2,400 mg and 4700 mg respectively per day (USDA, 2005). The highest amount of calcium was found in sample II, 13.67 ± 0.002 mg. Calcium with the name of "super nutrient" has been proven clinically associated with reduced risk of various non-communicable diseases such as osteoporosis, cardiovascular diseases and it also helps to reduce colorectal cancer risk by promoting the apoptosis in human colorectal epithelium that reduce colorectal neoplasm (Sajib *et al*., 2014). The highest amount (7.46 ± 0.42 mg/100 g) of magnesium was found in sample VII. The amount of chromium was not detected in studied samples.

Micronutrient deficiency is a common occurrence not only in developing countries but also in developed countries. According to WHO (World Health Organization), iodine, iron and vitamin A deficiency are the most widespread micronutrient deficiencies which in together affects about one third of the world's population (Allen *et al*., 2006). The best way to deal with this is to take foods rich in micronutrients. But this is not possible for all and hence comes the option of food fortification which is a nice way to fight against micronutrient deficiency diseases. The main motive of food fortification is to provide nutrients so that it will help to trim down nutritional deficiency diseases. None of the sauces and ketchups studied in this experiment was fortified.

Nowadays some growers as well as traders in Bangladesh are commercially using some chemicals, namely Ripen, Gold-Plus, Profit etc. for the ripening of fruits which ultimately come into the products made of those fruits. Young generation's are the foremost consumers of fast food and they are at particular risk of the harmful side effects of food adulteration, which may lead to serious liver and kidney diseases including various forms of cancer and hepatitis (Per *et al*., 2007). 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 of the studied samples is given in Table 5.

Among the samples analyzed, the highest amount of aluminum was found in sample II; 21.56 ± 0.02 mg and the lowest amount of aluminum were found in sample VII, 0.03 ± 0.001 mg. The European Food Safety Authority (EFSA) has established for the lifelong intake of aluminum a tolerable weekly intake (TWI) of 1 milligram (mg) per kilogram body weight

Table 5. Heavy metals content and microbiological analysis of the studied sauces and ketchups

Sample	n	Aluminum (mg)	Arsenic (mg)	Mercury (mg)	Lead (mg)	Tin (mg)	Cadmium (mg)	Standard plate Count CFU/g	Total coliform MPN/g	Total fungus CFU/g
Sample I		17.96 ± 0.01^{e}	N.D.	N.D.	N.D.	N.D.	N.D.	100	<3	50
Sample II	5	19 ± 0.02^{a}	N.D.	N.D.	N.D.	N.D.	N.D.	120	<3	300
Sample III	5	10.96 ± 0.002^{c}	N.D.	N.D.	N.D.	N.D.	N.D.	300	<3	500
Sample IV	5	6.07 ± 0.001^{g}	N.D.	N.D.	N.D.	N.D.	N.D.	100	<3	210
Sample V	5	0.57 ± 0.003^{i}	N.D.	N.D.	N.D.	N.D.	N.D.	100	<3	60
Sample VI	5	8.58 ± 0.002^{e}	N.D.	N.D.	N.D.	N.D.	N.D.	100	<3	200
Sample VII	5	0.04 ± 0.0003^{j}	N.D.	N.D.	N.D.	N.D.	N.D.	150	<3	350
Sample VIII	5	6.98 ± 0.01^{f}	N.D.	N.D.	N.D.	N.D.	N.D.	230	<3	250
Sample IX	5	7.95 ± 0.04^{d}	N.D.	N.D.	N.D.	N.D.	N.D.	100	<3	50
Sample X	5	0.72 ± 0.003^{h}	N.D.	N.D.	N.D.	N.D.	N.D.	120	<3	300

Note: Results were expressed as mean values ± standard deviation and values followed by different letters are significantly ($p<0.05$) different from each other. Preference has given aphetically from highest to lowest. N.D. = Not Detected

(BfR Health Assessment no. 034, 2008). Elevated aluminum level in fruit products may caused by the incorrect storage of product in aluminum containers that were not coated with varnish. As aluminum is dissolved by acid-containing and Salt-containing food, the metal was able to migrate to the food product. Bringing a change in packaging material, processing method and storage system may be helpful to reduce the aluminum level in these condiments. Arsenic, mercury, lead, tin and cadmium were not found in selected samples.

Heavy metals are used as food contact materials, mainly in processing equipment, containers and household utensils but also in foils for wrapping foodstuffs. They play a role as a safety barrier between the food and the exterior. They are often covered by a surface coating which reduces the migration in foodstuffs. When they are not covered by these food contact materials can give rise to migration of metal ions into the foodstuffs and therefore could either endanger human health if the total content of the metals exceeds the sanitary recommended exposure limits, if any, or bring about an unacceptable change in the composition of the foodstuffs or a deterioration in their organoleptic characteristics. Despite the fact that aluminum was found in selected samples but their concentration was lower than the safe level.

Microbiological analysis

Standard plate count of different types of sauce and ketchup varied from 100 - 300 CFU/g (Table 5). Yeast and mould count among the samples vary between 50-500 CFU/g. Sample iii contains the highest number of Total Viable Count and Yeast and mould count 300 CFU/g and 500 CFU/g respectively. But no Coliform was detected in the selected sauces and ketchups. Literatures indicates that the acceptable limit of Total Viable Count, Coliform , Yeast and Mould count for sauces and ketchups are $<10^4$ CFU/g, <10 MPN/g and $<10^4$ CFU/g (Ayele Alemu, 2009). Thus the microbiological qualities of all the products were within the acceptable limits.

The people of Bangladesh have a traditional attachment to high intake of energy contained foods and low intake of nutrients in their daily diet. Selected sauces and ketchups seem to be quite promising of the sources for vitamins and minerals in our habitual diet. If we enhance the regular intake of fruits and vegetables, then it is possible to alleviate prevailing nutrient deficiency problem from Bangladesh. The Government-authorized institute such as Bangladesh Council of Scientific and Industrial Research (BCSIR) and Bangladesh Standard Testing Institute (BSTI) should undertake pre-emptive investigations to check the microbial and nutritional quality of the sauces and ketchups as well as initiate increased public awareness programmes on contaminated and adulterated sauce and ketchups.

Conclusion

Present study has shown that the locally available ketchup and sauces contain safe levels of nutritional and microbial elements for human consumption and free from heavy metals contamination. The study also indicates that the sauces and ketchups are rich source

of vitamin C, important minerals, fibre and TSS, TS, RS but poor source of protein and fat. Preservatives quantities added in sauces and ketchups are within the acceptable limit. Therefore, the present study suggests that the different varieties of the ketchup and sauces provide nutritional contents and important minerals which are supportive for health benefit of the consumers.

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