Research Article

Elemental Analysis of Condiments, Food Additives and Edible Salts Using X-Ray Fluorescence Technique

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ABSTRACT

The present study was undertaken to measure elemental composition of food additives, condiments and edible salts commonly used in savory dishes and cuisines. Himalayan pink salt, Sajji salt, Sajji kachwa salt, Black salt, Rock salt, Table salt, Iodised salts, Lahori salt, Aji-no-motto (Chinese salt) *etc*., were analysed. X-ray fluorescence technique (XRF) has been utilized for quantification due to its multielement analytical capability, lower detection limit, capability to analyze metals and non-metals alike and easy sample preparation. The analysis was performed by using sequential wavelength-dispersive (WD) XRF spectrometer based on end-window Rh-anode tube using 4 kW generator (60 kV, 170 mA) and energy-dispersive (ED) XRF set up involving the ^{241}Am radioactive source as an exciter. The iodine element in the iodised salts was calculated using the calibration curve plotted by spiking the control sample with $NaIO_3$ following sequential dilution methodology. Recently an excessive quantity of Aji-no-motto was reported in fast food products. Its elemental composition was also recorded. Since the reports on mineral composition of the edible salts consumed in India are scarce so such studies are important to ascertain the safe quantity of their intake and associated health effects.

Keywords: Savory dishes, Detection limit, End-window Rh-anode tube, Calibration curve, Sequential dilution.

INTRODUCTION

Many edible salts, food additives and condiments have marine origin, although the salinity of sea water varies worldwide, yet the relative proportions of its constituent ions remain constant[1]. The evaporation of saline water leads to common table salt after it undergoes numerous purification steps. Since pre-historic times, salt has been used as an essential condiment for flavoring the food, preserving eatables, curing fish and other meat products, and tanning. It has attained immense importance in daily livelihood. The mineral form of table salt is Halite, which is an ionic compound of the sodium chloride (NaCl). It forms isometric crystals. The commercially available salts have variable minerals composition. Various edible salts used for culinary purposes are Himalayan pink salt, *Sajji* salt, *Sajji* kachwa salt, Black salt, Rock salt, Table salt, *Lahori* salt, Aji-no-motto (Chinese salt), Celtic salt, Coarse salt, Iodinated salt, Flake salt, and Kosher salt. The human body cannot manufacture salts by itself so they have to be supplied externally. A principal function of sodium chloride is to regulate pH and osmotic pressure of the fluid and its movement to and from the cell and maintain the electrolyte balance. It also aids in the transmission of messages by the nerve cells and in the peristaltic movement of the digestive tract. Sodium helps to regulate the movement of muscles in the human body including that of the heart. The chloride ion produces hydrochloric acid, which helps in digestion and is present in salivary amylase also[2]. It produces gastric acid which is another component of hydrochloric acid. It helps the blood to carry carbon dioxide, potassium absorption, and conserves acid-base balance. Thus, it must be included essentially in everyday diet to make its level balanced. For normal healthy person, the salt concentration can vary only within narrow limits. The human body depletes salt by sweat, excreted through urine, increased bowel mobility and diarrhea *etc*. The daily intake of the salts replenishes the essential minerals in humans. Our body primarily consists of fluids having minerals which act as electrolytes on cell membranes allowing transmission of impulses in muscle and nerve fibers and in this way cellular metabolism is controlled. The homeostasis requires balanced diet made up of carbohydrates, proteins and salts. The kidneys maintain bodily concentration of salts at the appropriate level. The intestines reabsorb salts from the digested foods and gastric juices. Chronic salt deprivation in humans lead to serious health problems like nausea, muscular cramps, loss of appetite, weight loss. Excessive depletion of body salt leads to possible vascular collapse and finally death may occur. If excessive sodium exists in salts and other foods products then problems of hypertension, diseases of heart, liver and kidney may occur[3]. The deficiency of chloride may results in erthyrocyturia, metabolic alkalosis and hypokalemic[4] *etc*. Such nutrients elements are indispensible for animals too. Since fodder and plant have little salt content, so insufficient salt levels stunts the growth, lowers production of milk, produces lassitude, loss of weight *etc.*, of young animals. In modern farms, livestock are fed with vitamin and mineral supplements along with *Sajji* Kachwa salt. Thus salt is an ideal vehicle to deliver physiological amounts of essential minerals as Mg, Mn, Fe, Co, Zn and Cu *etc*., in the diet.

Worldwide there are many salt mines formed by transformations of sea in geological events, *viz.*, deep mines from Khewra region of Pakistan, or high altitude mines in the Himalayan Mountains or salt flats in Bolivia. The physical and chemical composition of salt varies depending upon the location sites, climatic conditions and processes adopted[5]. The commercial harvesting technique for deep salt deposits is solution mining which involves the deep injection of fresh water at high pressure through pipes and the saturated brines are brought to the surface and are used to produce highly pure salt[6]. The refined edible table salt constitutes the compound NaCl ~ 99.5% by weight. Many anti-caking agents like potassium or sodium ferrocyanide are added, in the range of 5-15 ppm (mg/kg or μg/g), to prevent adjacent grains of crystalline salt cementing together forming a hard solid mass. Thus free flowing table salt is obtained by providing a mechanical coating on crystals which acts as a lubricant and absorbs any water vapour in the post packaging stage. Commonly used free flowing salt additives are magnesium carbonate, calcium silicate, sodium silico-aluminate and tricalcium phosphate (at a level of 1-2%). The sulphates of magnesium, calcium and potassium are additional major elements found along with sodium chloride in the salt crystals[7]. Low sodium salts are sold as "propriety salts" due to the absence of regulations laid down by concerned authorities in India. The sale of non-iodised salt was banned in India, since then iodized salt became popular household commodity. Healthy human beings require iodine which is an essential component of the thyroid hormones, thyroxine and triiodothyronine. The inadequate iodine leads to insufficient production of these hormones, adversely affecting many body parts like muscle, heart, liver, kidney, and the development of brain. The iodine deficiency disorder (IDD) is the major cause of mental retardation amongst the world's population. Iodine deficiency leads to physical sluggishness (inertia), goiter (enlarged thyroid), hypothyroidism, delayed neurological development, slow physical growth, reproductive failure and defective nervous system. To overcome the iodine deficiency, the table salts are fortified by iodine to supplement this essential nutrient by adding sodium iodide, sodium iodate and potassium iodide. In most of the developed and developing countries, iodised salt is mandatory as edible salt. On average a human being needs less than 225 μg of iodine in a day[8]. The recommended concentration of iodate in the iodised salts is 40-60 ppm. The maximum tolerable limit of daily iodine intake is 150 μg. The iodine content should not be less than 15 ppm on dry weight basis.

Black Salt is a special type of volcanic rock salt which is mined from different geographic locations. In *Ayurveda*, the Black salt (*Kala namak*, Himalayan rock salt or *Sanchal*) is believed to possess amazing therapeutic benefits. Its rich iron content is assumed to be a cure of heartburn, bloating and flatulence. Since ancient times, it is being used in sub-continent cuisines as a flavoring condiment. This rock salt is believed to be very beneficial for patients with high blood pressure because of its low sodium content. It is assumed to be a rejuvenator, improves eyesight, helps in digestion, softens the bowel *i.e.,* laxative. It is claimed that this salt consists of 84 major and minor traces elements including iron[9]. It is obtained from the rock deposits and is used as a raw material without any processing. It has a many colors like purple, pinkish, grey and black. It is believed that dark colored salts are more mineral rich. It has a distinctive sulfurous odour[10]. The presence of sodium chloride in it provides salty taste, and iron sulphide provides peculiar bitter taste and dark violet coloration due to all the sulphur compounds, mainly hydrogen sulphide. The increased intake of dietary sulfur may helps psoriasis and rheumatic conditions of patients.

Sajji kachwa salt is made by adding herb called *Sajji*, to the molten form of Himalayan pink salt. On being cold it acquires foamy, crunchy texture which is brittle and then it is grounded to form salt. In Japan, this mineral rich salt is popularly used as condiment and it aids digestion and stomach healing. A popular taste enhancer is China salt (*Aji-no-Moto*) or Ac'cent or Vetsin. It is a sodium salt of the amino acid *i.e.,* glutamic acid called as monosodium glutamate (MSG), having chemical formula as $NaC_5H_8O_4$. It has a unique taste different from the four basic tastes of sweet, salty, sour and bitter. MSG is regarded as a flavor enhancer as it blends, rounds and balances the total perception of taste-active compounds in the food products. It is believed to enhance the flavour of proteins by stimulating the taste buds and increasing the saliva produced in the mouth. It appears as a white and odorless crystalline powder which in solution dissociates into glutamate and sodium. It crystallizes easily and is palatable and the most soluble food additive. It improves the overall taste of food products only in the right concentration. It is a common condiment in Chinese and Japanese fast foods. An excess of MSG has an unpleasant taste and may have physical effects like an allergic reaction commonly called "Chinese restaurant syndrome" but no statistical association has been found between natural level of glutamic acid in foods and toxicological concern in humans. Now days, an excessive quantity of *Aji-no-motto* was reported in fast food relished by growing children. The Food Safety and Standards Authority of India (FSSAI) has advised through investigations on *Aji-no-motto* due to its health concerns.

The present study was undertaken to study mineral composition of various gourmet condiments, food additives and salts samples. The XRF technique has been utilized for quantification due to its multielement analytical capability, lower detection limit, high resolution, greater reliability, capable of analyzing metals and non-metals alike and easy sample preparation. Since the reports on the mineral composition of edible condiment salts consumed in India are scarce, so such studies are important to investigate health effects associated with their excessive intake. The goal of this study is to provide the necessary data of their chemical constituent to set sub-continental guidelines.

MATERIALS AND METHODS

Various samples were randomly bought from local market in May 2012, including branded iodinated salts and raw salts (in the form of crystal lumps), which are commonly used as additives in cooked food in India. Samples included Sajji salt, Sajji kachwa salt, Black salt (Nagina, Catch brand and non-branded), lahori salt (khewra and branded), Table salt (Tata and Gagan brand), Himalayan rock salt, Kala sanchal salt (MDH brand). The labeling of the samples was done prior to investigation. The physical examination of black salt crystals revealed that they were irregular in shape, embedded with non-crystalline impurities with few specs of black substances and of different colors like pink, red, grey *etc.*

In the present work, the trace elemental analysis of salt samples has been performed using energy-dispersive (ED) and wavelength-dispersive (WD) x-ray fluorescence set ups. The WDXRF spectrometer used in the present work is S8 TIGER of Bruker AXS, Germany, installed at Sophisticated Analytical Instrumentation Facility (SAIF), Panjab University, Chandigarh. This spectrometer is based on end-window Rh-anode tube equipped with 4 kW high intensity x-ray generator at a maximum voltage of 60 kV and a maximum tube current of 170 mA. The photons from the x-ray tube after passing through primary filters excited the sample. Filters of Al, Cu, Pb and Be foils having different thickness were used in front of X-ray tube window. The characteristic *K/L* x-rays emitted from various elements present in the sample are diffracted from the analyzer crystals, *viz.*, LiF200, LiF220, PET, XS-55, XS-N and XS-C. The available sets of crystals covered the entire elemental range from $_6C$ to $_{92}U$. The diffracted x-rays were detected by the flow gas proportional counter (90% Ar + 10% CH_4) and the NaI(Tl) scintillation detector. The signals from the detector were further processed and arranged in ascending order of energy. The soller slits have been used in the path of incident and diffracted X-rays which make the geometry precise. The diffracted low-energy X-rays are detected using gas proportional counter and for high energy X-rays using a scintillation counter. The heart of the instrument, high-precision goniometer having two independent stepper motors for separate θ /2θ drive. The standard GEOQUANT and STANDARDLESS analysis software were available for the quantitative analysis. The spectra were acquired in the best detection mode[11]. Nearly 10 g of the dry salt sample was finely grounded and pressed with a pressure of 20 tons to form a stable pellet. A vibratory cup milling machine (make INSMART, India) using 2HP motor grinded salt samples upto size of 5 micron. The hydraulic press (make INSMART, India) capable of producing maximum pressure upto 40 tonne was used for the pallet formation. The physical examination of glossy pallets for any structural anomaly in formation was important step during every analysis. This method of sample preparation for elemental characterization is simple, fast and cost effective.

The fundamental parameter approach was adopted for EDXRF analysis to arrive at the elemental concentration[12]. The geometrical arrangement involves an annular source of ^{241}Am (10 GBq, Dupont, USA) radioisotope target, and the detector[13]. The geometric arrangement contains W-alloy shield to protect the detector from the unwanted photons. The photons emitted from the target reach the detector through the collimator. An LEGe (Low energy germanium) detector (100 mm^2 x 5 mm, 8-μm Be window, FWHM = 180 eV at the Mn Kα X ray energy of 5.89 keV and 200 eV at the 14.4 keV γ-ray energy, Canberra, US) in the horizontal configuration coupled with a PC based multichannel analyzer was used to collect the fluorescent X-ray spectra. The concentration of iodine in the popular iodised salts has been precisely measured using an EDXRF set up. A calibration curve was plotted by spiking the salt with $NaIO_3$ using sequential dilution from 300, 250, 200, 150, 100, 50, 25 ppm in the control sample. The linearity of the graph was used to find unknown quantity of iodine in the samples.

RESULTS AND DISCUSSION

Our bodies require essential minerals, but if they are taken in large amounts they can produce adverse affect on the health. Human beings from different strata's of society have different dietary intakes. They can have deficient, adequate, or toxic intakes of the essential nutrient. A deficiency of element occurs on very low intake as per person's specific need, Adequacy occur when a person gets enough, but not too much intake, and toxicity occurs when a person gets an overdose of a nutrient. Upper Safe Levels of Intake have been established by The National Academy of Sciences, Institute of Medicine, US which can be effectively used when assessing and planning the dietary intakes of the general but healthy population[6]. Tolerable Upper Intake Level (UL) is a parameter defined for almost all individuals in the general population, which quantifies the highest average daily intake level of an element posing no risk of adverse health effects. As intake of an element increases above the UL, the potential risk of adverse effects may also increase. These are calculated from dose-response data and hazard evidence identification on humans. The limits of UL's for commonly observed elements calcium (Ca), phosphorus (P), magnesium (Mg), fluoride (F), selenium (Se), iron (Fe), zinc (Zn), iodine (I), manganese (Mn), molybdenum (Mo), sodium (Na) and chloride (Cl) are 2.5 g, 3-4 g, 350 mg, 10 mg, 400 mcg, 45 mg, 40 mg, 1-100 mcg, 11mg, 2mg, 2.3 g and 3.6 g respectively. The excess of calcium *i.e.*, hypercalcemia can lead to renal insufficiency, kidney stone formation or milk-alkali syndrome and can badly affect the absorption of other vital elements like iron, zinc, magnesium, and phosphorus. The critical effects of phosphorus are hyperphosphatemia and hypocalcemia which leads to calcification of non-skeletal tissues and adjustments in calcium-regulating hormones. The adverse effects related to magnesium are osmotic diarrhea, abdominal cramping, nausea, serious neurological and cardiac symptoms, and even death. The skeletal fluorosis effect is due to excess intake of fluoride. Many food supplements meant for growing kids are containing selenium. The excessive intake of selenium can lead to hair loss, nail brittleness fatigue, skin rash, garlic breath odor, irritability, gastrointestinal disturbances, and nervous system disorders. The gastrointestinal side effects are also associated with ingestion foods having high iron content; other adverse effects are impaired zinc absorption and increased risk for vascular disease. The overload of copper may lead to abdominal pain, vomiting, cramps, nausea, diarrhea, and liver damage. No adverse effects have been reported from consumption from foods containing excess zinc. Iodine is a very important element for humans. Its critical adverse effect is elevated serum thyroid stimulating hormone concentrations and acute responses include burning sensation in stomach, abdominal pain, cardiac irritability with weak pulse, produce goiter, coma, cyanosis, iodermia and an increased risk of thyroid papillary cancer. The deficiency of iodine in diet is mitigated by using iodized table salts. The critical adverse effects of magnesium are neurotoxicity and its elevated concentration in blood. Molybdenum compounds appear to have low toxicity in humans, but available data are inadequate. No adverse effects have been convincingly associated with excess intake of chromium from food or dietary supplements. Patients with impaired urinary potassium secretion may have adverse effects due to excess of potassium. The high sodium in diet severely effects of blood pressure of hypertensive persons, its other adverse effects include cardiovascular abnormalities, increased urinary calcium excretion, osteoporosis, gastric cancer, and asthma. Also, sodium and chloride are assumed to be in equimolar quantities in foods so the UL limit for chloride was set based on that of sodium. The elemental analysis of various samples was performed by WDXRF technique and results are given in the Tables 3 (a-b).

A calibration curve for iodine was drawn by following the spiking technique by sodium iodate to the branded salt (S12), to access iodine content in popular iodized salts. With the help of plotted calibration curve of iodine spiking, it was observed that all other iodized table salts had iodine content in the range 9-63 ppm. These values are close to the prescribed limit ≥ 15 ppm range of iodine, except for sample 14 whose iodine content which falls short of recommended value.

It is safe to use branded iodized free flowing table salts, rather they should be preferred for cooking in place of non-iodized salts, especially pregnant women have higher requirement of iodine keeping in view optimal development of foetus[14].

In the present study, iodine content of *churan* samples was observed upto 706 ppm as given in Table 1. The iodine content was ascertained with the help of linearity calibration curve of iodine spiked salt. The *K* x-ray peaks of various elements presents in Sample19 are shown in Fig. 1, the strong peak of iodine gave its concentration to be 706 ppm. Fig. 2 shows spectrum of sample18, where in the concentration of iodine was observed to be 241ppm. Exceptionally high iodine content was found in two sample is a matter of concern, but these *churans* are taken in very small quantities in the time of indigestion. It appears to be fairly safe for the people because of its rare intake. Apart from the major elements Na and Cl, the Mg (0.06-1.07 %), S (0.05-2.06 %), K (0.02-21.86 %), Ca (0.01-1.26 %), Mn (up to 0.02 %), Fe (up to 0.29 %), Br (0.0053-0.04 %) and Si (0.01-0.92 %) trace elements were detected. The average composition of NaCl in commercial iodized salt was 99.78 % and the *Lahori* black salt (*Khewra*) was about 80-84 %. Since the patients of hypertension are recommended to take with low sodium salts, it was observed that branded *Lahori* black salts can be one such option. They should avoid MSG due to very high Na content ~90%. The uranium content of iodinated commercial salts is below detection limit which is expected from salts of marine origin. The average concentration of uranium in sea ore salts is $6.3x10^{-3}$ ppm[15]. Fig. 3 shows the main *K* x-ray peaks observed in WDXRF spectrum of Chinese salt in the energy range 1-5 keV. The inset shows the complete spectrum taken using X-ray tube source. The major elements present in Chinese salt observed by WDXRF technique are given in Table 2. In Fig.4, WDXRF spectrum of three branded samples S9, S10 and S11 in the energy range 1-6.5 keV is shown. The inset shows their complete spectrum. It is observed that sample Sajji Kachwa salt (S2), Lahori salt Branded (S5) and Lahori salt Non-branded (S6) had lower concentration of Na and Cl. The sample S2 contained very high mineral content. Further an attempt was made to establish a statistical correlation among quantified elements in these salts and the results are given in Table 4. The statistical parameters, *viz.*, population variance, standard deviation and coefficient of variation (CV %) has been performed on the composition of all major and trace elements along with that of sodium and potassium.

The Analysis of variance and coefficient of variation revealed that in all the samples under study, sodium and chloride had the less variation in composition whereas the remaining elements exhibited large variation.

It is known fact that higher the CV %, higher is the variability amongst the population thereby lesser consistency and *vice versa*.

Since the CV % of K is 315.3 (highest) so it may be concluded that in the given samples, it had maximum variability where as Cl with CV % of 7.2 (lowest) has maximum consistency as shown in Table 4. The large values of variance may be due to different collection sites of salts, different harvesting techniques, contamination during extraction and the variation in sea environment producing these salts.

Table 1: Iodine content in various edible salts

Sample label and name	Concentration (in ppm)
S13 Table Salt (Brand-Saffola)	9
S14 Namak (Brand- Saffola plus)	63
S15 Salt (Brand-Tata lite)	32
S16 Pakistani rock salt (Non-branded)	11
S17 Kala namak (Non-branded)	-
S18 Namak Sulemani (Brand-Hamdard)	241
S19 Lavan Bhaskar (Brand-Dabur)	706
S20 Table Salt (Brand-Gagan)	27

Table 2: Elemental composition of Aji-no-motto (Chinese salt)

Element	Mean concentration (in % or ppm)
Sodium ($_{11}Na$) (as $NaNC_5H_8O_4$)	90.29 %
Silicon ($_{14}Si$)	300
Aluminum ($_{13}Al$)	200
Iron ($_{26}Fe$)	83
Calcium ($_{20}Ca$)	80
Chlorine ($_{17}Cl$)	67
Sulfur ($_{16}S$)	36
Potassium ($_{19}K$)	34
Ruthenium ($_{44}Ru$)	27
Copper ($_{29}Cu$)	9
Cobalt ($_{27}Co$)	6

Table 3(a): Elemental composition of various food additives /condiments /salts

Sample	Concentration (in %)								
	Cl	Na	K	Ca	Mg	Si	S	Fe	Al
S1	56.68	38.78	0.1	0.99	0.5	0.61	2.06	0.05	0.2
S2	49.96	23.77	21.86	1.26	1.07	0.92	0.48	0.2	0.24
S3	58.31	41.09	0.1	-	-	0.05	0.38	0.05	-
S4	58.73	40.9	0.02	0.02	0.05	0.06	0.17	0.01	0.01
S5	51.4	30.55	0.12	0.08	0.06	0.02	0.13	0.0047	-
S6	48.11	33.47	0.07	0.06	0.05	0.01	0.1	0.0053	-
S7	58.95	40.75	0.04	0.01	0.14	-	0.05	0.0023	-
S8	58.9	40.38	0.51	0.15	0.41	0.02	0.47	0.0082	0.01
S9	58.77	40.44	0.05	0.0015	0.26	0.13	0.16	0.0068	0.0052
S10	58.41	40.71	0.1	0.05	-	0.18	0.39	0.06	0.06
S11	58.64	40.71	0.11	0.02	0.06	0.09	0.29	0.04	0.02
S12	59.20	40.30	0.08	0.03	0.24	0.0090	0.10	-	0.0046

Table 3(b): Elemental analysis of various food additives /condiments /salts

Sample	Concentration (in ppm)								
	Ti	Br	Mn	P	Ag	Sr	Cu	Ni	Zn
S1	64	68	28	-	-	58	19	25	-
S2	800	400	200	82	47	32	29	23	22
S3	-	100	-	78	-	-	18	17	-
S4	-	97	-	-	-	-	22	15	-
S5	-	53	-	-	-	-	27	15	16
S6	-	81	-	48	-	-	26	16	16
S7	-	400	-	13	28	6	20	-	-
S8	-	100	-	-	-	13	24	19	16
S9	-	200	-	-	27	24	24	17	11
S10	49	100	-	65	-	8	24	21	12
S11	-	100	-	55	-	7	18	17	-
S12	-	400	-	-	-	-	25	21	-

- Below detection limit

Table 4: Statistical analysis of elemental concentrations

	Cl	Na	K	Ca	Mg	Si	S	Fe	Al	Ti	Br	Mn
Arithmetic mean	56.08	37.41	2.08	0.29	0.29	0.21	0.43	0.04	0.08	0.03	0.015	0.011
Geometric mean	55.93	36.94	0.08	0.06	0.16	0.08	0.26	0.017	0.031	0.014	0.012	0.0075
Median	58.41	40.44	0.07	0.06	0.14	0.08	0.29	0.01	0.02	0.0064	0.01	0.011
Population Variance	15.51	29.74	39.14	0.2	0.1	0.08	0.288	0.003	0.0085	0.0012	1.4635	7.4E-05
Standard Deviation	4.13	5.72	6.56	0.48	0.34	0.307	0.563	0.0575	0.0921	0.0429	0.0127	0.0122
Coeff. of Variation %	7.4	15.3	315.3	164.6	116.8	147	132.3	144.7	127.7	141.1	82.15	106.7

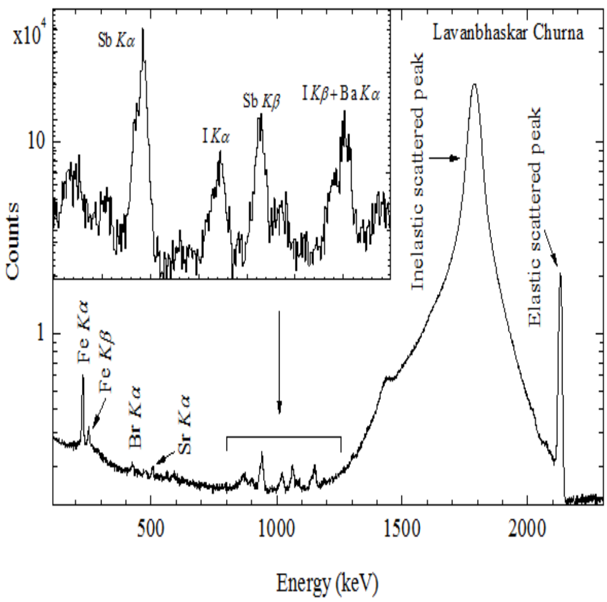

Figure 1: Typical complete EDXRF spectrum of Lawanbhaskar Churna taken using ^{241}Am source.

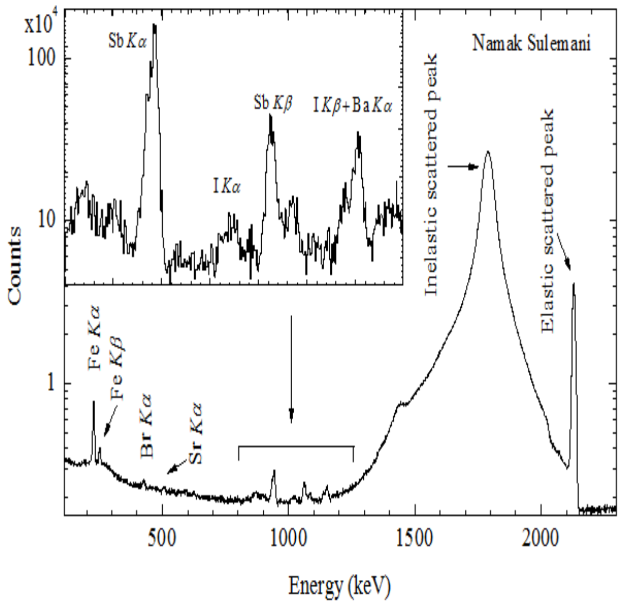

Figure 2: Typical complete EDXRF spectrum of Namak Sulemani using ^{241}Am source.

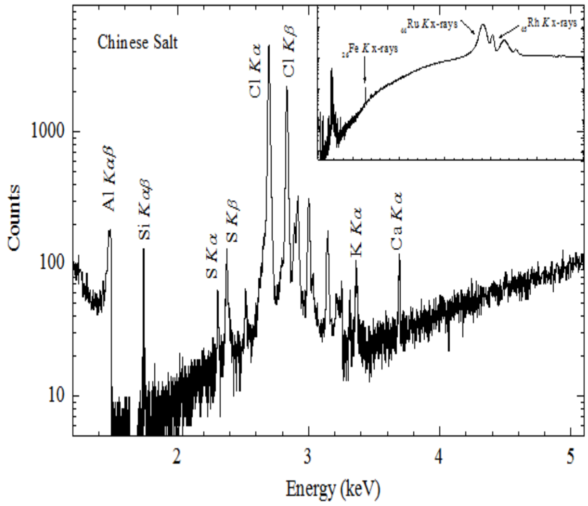

Figure 3: Typical WDXRF spectrum of Chinese salt in the energy ranges 1-5 keV and inset shows complete spectrum.

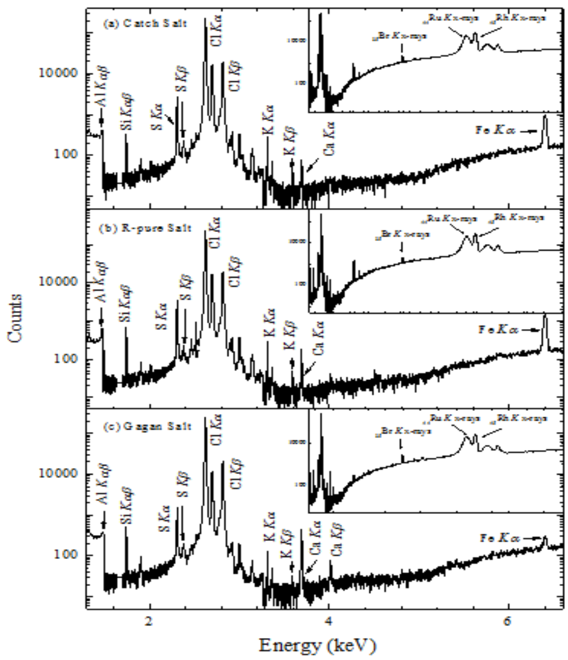

Figure 4: Typical WDXRF spectrum of (a) Catch brand salt, (b) R-pure brand salt and (c) Gagan brand salt in the energy range 1-6.5 keV and inset shows complete spectrum.

CONCLUSION

It is observed that with the help of X-ray fluorescence technique even minor trace elements having concentration of few ppm can be recorded. The various condiment salts exhibited heterogeneity in composition of major and trace elements. The high values of coefficient of variance (%) of K, Ca, Mg, Si, S, Fe, Al, Ti and Br may be due to different location of harvesting, improper handling of raw salts, faulty refining technique and contaminated storage. With the help of calibration curve, it was observed that the salts were having iodine content in 9-706 ppm. Two samples of branded digestive *churans* contained very high iodine content, which is not that harmful as it is taken very small quantities in the distress time. It is recommended that people should be encouraged to buy iodized table salt only, even though it is slightly costly but its benefits are priceless. Further, the analysis of china salt revealed high content of Na.

The patients of hypertension, *i.e.*, high blood pressure should resist from taking foods having condiment China salt and opt branded black salt in place of ordinary table salt having high Na content. X-ray fluorescence technique can be effectively used to arrive at elemental analysis of condiments, food additives and edible salts.

This simple technique can be very helpful in arriving at the results of mineral composition of the food stuff easily, precisely, accurately and promptly. In India, scientific reports and studies related to mineral composition of various gourmet condiment salts is scarce so our results can be very helpful in guiding the people about health effects associated with inadequate intake these salts. This will help Government in establishing the guidelines for vendors selling street foods like *dahi chaats*, *golgappes*, *tikkis*, noodles, mommos, *channa bhaturas etc.*, using these salts in right proportions. We suggest that food and health dept should regularly monitor the products sold and establish the quantity of salts used. Thus more intensive studies are required keeping in view the tropical variations, different tastes, and different food habits of people of the sub-continent.

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