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A study on heavy metal content in rolled oats available in domestic market in India

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ABSTRACT

Oat is an important cereal crop in developing worlds and the one of most commonly cultivated species is *Avena sativa* L. Oats possess beneficial effects against gastrointestinal problems, has anticancerous effects. **Rolled oats** are a type of lightly processed whole-grain food. Traditionally, they are made from oat groats that have been dehusked and steamed, before being *rolled* into flat flakes under heavy rollers and then stabilized by being lightly toasted. Rolled oats that are sold for porridge usually have had the tough outer bran removed. They have often, but not always, been lightly baked, pressure-cooked, or otherwise processed in some fashion. **Thick-rolled oats** are large whole flakes, and **thin-rolled oats** are smaller, fragmented flakes. Rolled whole oats, without further processing, can be cooked into a porridge and eaten as **old-fashioned oats**, but more highly fragmented and processed rolled oats absorb water much more easily and therefore cook faster into a porridge, so they are sometimes called "**quick**" or "**instant**" oats. Oats have high nutritional value. Oat based food products like breads, biscuits, cookies, probiotic drinks, rolled oats (instant oatmeal) are gaining increasing consideration.

Exposure of heavy metals to human beings has risen dramatically in the last 50 years. Humans are more likely to be exposed to heavy metal contamination from the dust that adheres to edible plants than from bioaccumulation. There are no reports regarding the level of heavy metal content in rolled oats. The objectives of this study was to determine the concentrations of Lead (Pb) and Copper (Cu) in Rolled oats collected from different part of India and also to assess whether the Rolled oats available in domestic market of India were safe for human consumption.

Out of 59 samples of rolled oats analysed, Lead (Pb) content ranges from Not detected i.e 0.00 ppm in 8 samples and 51 samples contain Lead (Pb) ranges from 0.005ppm to maximum of 0.120 ppm. As per FSSAI, the maximum permissible limit in "food not specified category" is 2 ppm (max.). It clearly indicates that all the samples were found to contain Lead (Pb) within the permissible limit as specified by FSSAI.

Out of 59 samples of rolled oats analysed, 58 samples were found to contain low level of Copper (Cu) content ranges from 0.028 ppm to 1.095 ppm. The Copper (Cu) content was "Not detected" in one sample of Rolled oat. As per FSSAI, the maximum permissible limit in "foods not specified category" for Copper (Cu) is 30 ppm. It

clearly indicates that all the samples were found to contain Copper (Cu) within the permissible limit as specified by FSSAI.

The Rolled oat samples are safe for human consumption. The concentration of Lead (Pb) and Copper (Cu) in all the Rolled oats samples collected from different parts of India is within the safe limits as prescribed by FSSAI.

Keywords: Rolled oats; India; heavy metal; Atomic absorption spectrometry; Lead (Pb), Copper (Cu).

INTRODUCTION

Oats are whole-grain cereal, known scientifically as *Avena sativa*. Origin of Oats is North America and Europe, now producing in different states of India. They are very good source of fiber, especially beta-glucan, and are high in vitamins, minerals and antioxidants [1]. Whole oats are the only source of a unique group of antioxidants called avenanthramides, believed to have protective effects against heart disease [2]. Due to their beneficial health effects, such as lowering blood sugar and cholesterol levels, Oats have gained considerable interest as a health food. Oats are most commonly rolled or crushed, and can be consumed as oatmeal (porridge), in baked goods, bread, muesli and granola. Whole grain oats are called Oat groats. The Oat groats are most commonly rolled or crushed into flat flakes and lightly toasted to produce oatmeal. Quick or instant oatmeal is made up of more thinly rolled or cut Oats that absorb water much more easily and therefore cook faster. The Oat bran (the fiber-rich outer layer of the grain) is often consumed separately as a cereal, with muesli or in breads. To produce infant Oatmeal, Oats are often further processed into powder that becomes a thick porridge when mixed with water. Oats have a well-balanced nutritional composition, and one serving (30 grams) of oats contains 117 calories. Oats have high content of dietary fibres, phytochemicals and nutritional value. It possesses various health benefits such as hypocholesterolaemic and anticancerous properties [3]. The creamy texture of oatmeal comes from the water binding properties of its soluble fibres. An added advantage of oats as a food ingredient is that they do not contain gluten, they have avenins as their storage proteins. Thus they can be used in gluten free foods targeted at people with celiac disease because avenins are less likely to cause allergies even among celiac

sufferers [4, 5]. However, oats cannot be used in bread making due to lack of gluten which prevent oat flour from being used as the sole flour in raised bread. Hence most oat breads still contain wheat flour. Rolled oats are a type of lightly processed whole-grain food. Traditionally, they are made from oat groats that have been dehusked and steamed, before being *rolled* into flat flakes under heavy rollers and then stabilized by being lightly toasted. Rolled oats that are sold for porridge usually have had the tough outer bran removed. They have often, but not always, been lightly baked, pressure-cooked, or otherwise processed in some fashion. Thick-rolled oats are large whole flakes, and thin-rolled oats are smaller, fragmented flakes. Rolled whole oats, without further processing, can be cooked into a porridge and eaten as old-fashioned oats, but more highly fragmented and processed rolled oats absorb water much more easily and therefore cook faster into a porridge, so they are sometimes called "quick" or "instant" oats.

The main sources of heavy metals in plants are their growth media, nutrients, agro inputs, soil and others factor such as pesticides and fertilizers. Heavy metals along with other pollutants are discharged to the environment through industrial activity, automobile exhaust, heavy duty electric power generators and pesticides used in agriculture etc and enter into the food chain. Heavy metals have great significance due to their tendency to accumulate in the vital human organs over prolonged period of time. Heavy metals especially Lead (Pb) is a physiological and neurological toxin that can affect several organs in the human body. Lead can also damage kidneys and reproductive systems. Heavy metal such as Copper is essential for human body as it is an integral part of numerous enzymes including ferro-oxidase (ceruloplasmin), cytochrome-c-oxidase, superoxide dismutase etc. It also plays a role in iron metabolism melanin

synthesis and central nervous system function. However, chronic (long term) effects of copper exposure can damage the liver and kidneys. Acute symptoms of copper poisoning by ingestion include vomiting, hematemesis (vomiting of blood), hypotension (low blood pressure), melena (black "tarry" feces), coma, jaundice (yellowish pigmentation of skin) and gastrointestinal distress. Presence of these pollutants (Pb and Cu) in Rolled Oats above the permissible limit may lead to severe health hazards to the people consuming it So, estimation of their levels in contaminated food is very important for the safety of human health [6-8].

There are no reports available in the literature about any study on the level of Heavy metals in the Rolled Oats available in India as well as abroad. Therefore, it is important to study the presence of heavy metal contamination in the Rolled oats. In the present study, the concentration of these two heavy metals including Lead (Pb) and Copper (Cu) was determined in Rolled Oats samples collected from all parts of India.

MATERIALS AND METHODS

Sample Collection

A total of 59 samples of Rolled oats were Purchased/collected from market from different Geographical areas such as Amritsar (2), Chennai(1), Bhopal(6) and Nagpur (50)

APPARATUS AND REAGENTS

Atomic Absorption Spectrophotometer AAS 7000SP with air-acetylene base for flame; Microwave Digestion System (Model 3000, Anton Paar), Contaminated free digestion vessels are used for digestion, Mixer – For grinding the sample, Volumetric Flask (100 ml), Pipettes, Funnels (Glass or plastic), filter paper Whatman No 4 or equivalent and Glass rods Concentrated HCl (AR Grade), Concentrated HNO₃ (AR Grade), Distilled water, Lead standard (99.99%) and Copper Standard (99.99%).

Sample preparation and digestion

One portion of a well homogenized sample was grinded in a mixer. From this, 0.1g of ground sample (dried) was weighed into digestion Teflon vessel. 6 ml concentrated HNO₃ and 1 ml

concentrated HCl was added in the sample in fume hood. Vessels were left aside for 5 minutes to initial vigorous reaction. Teflon vessels were closed in position in Microwave Digestion System (Model 3000, Anton Paar). Door was closed properly. After 50 minutes, digestion was over. System was cooled to room temperature. The digestion vessels were unscrewed. Cap and sides of Teflon vessel were rinsed with distilled water. Solution was filtered into 100 ml volumetric flask. Filter paper and funnel was washed properly then solution was made up to mark with distilled water. A reagent blank, sample blank, spike samples were prepared in the same manner with the same quantity of acid as for samples..

PREPARATION OF STANDARDS

Stock standard solution (1000 ppm)

0.10 g Pb (99.99%) / Cu (99.99%) powder was dissolved into 2 ml HNO₃: H₂O (1:1) solution. Then it was made up to 100 ml volumetric flask with distilled water.

Intermediate standard (100 ppm)

10 ml of 1000 ppm solution was pipetted out into 100 ml volumetric flask and made up to mark with distilled water.

Working Standards

The range of working/calibration standards were prepared such as blank (0), 0.5ppm, 1 ppm, 2 ppm, 4 ppm and 6 ppm in 100 ml volumetric flask.

ANALYSIS OF LEAD (PB) AND COPPER (CU) BY AAS

Analysis of Lead and Copper in White pepper samples was carried out using Flame and air-acetylene AAS 7000 SP workstation as Per AOAC Official method 999.10.

RESULTS

A total of 59 samples of Rolled oats were analysed for the presence of Lead (Pb) and Copper (Cu) on AAS 7000 at Central Agmark Laboratory, Nagpur. The samples were received from different parts of India. Table 1 showed the Analytical

conditions for analyzing heavy metal in Rolled oats

samples for AAS.

Table 1. Analytical Conditions of AAS 7000 SP for analyzing heavy metals in White Pepper

Parameter	Lead	Copper
Wavelength (nm)	217	324.7
Slit width (nm)	0.4	0.2
Lamp current (mA)	4.0	2.0
Types of Flame	Air-Acetylene	Air-Acetylene
Fuel Gas pressure (M Pa)	0.0	0.10
Burner Height (mm)	8.0	8.0
Fuel Gas Flow rate (L/mm)	1.70	1.70
Combustion-supporting gas	Air	Air
Sampling speed	10	50
Integral time (s)	1.0	2.0
Smooth curve factor	1	10
Units Ppm		

Table 2. Level of Lead (Pb) in ppm in Rolled oats samples obtained from different parts of India

S.No	Region	Lead (Pb) content (ppm)	S.No	Region	Lead (Pb) content (ppm)	S.No	Region	Lead (Pb) content (ppm)
1	Amritsar	0.120	21	Nagpur	0.009	41	Nagpur	0.049
2	Amritsar	0.103	22	Nagpur	0.005	42	Nagpur	0.049
3	Chennai	0.081	23	Nagpur	ND	43	Nagpur	0.045
4	Bhopal	0.039	24	Nagpur	0.049	44	Nagpur	0.048
5	Bhopal	0.035	25	Nagpur	0.104	45	Nagpur	0.067
6	Bhopal	0.039	26	Nagpur	0.096	46	Nagpur	0.067
7	Bhopal	0.044	27	Nagpur	0.095	47	Nagpur	0.026
8	Bhopal	0.021	28	Nagpur	0.033	48	Nagpur	0.055
9	Bhopal	ND	29	Nagpur	0.027	49	Nagpur	0.046
10	Nagpur	ND	30	Nagpur	0.032	50	Nagpur	0.082
11	Nagpur	0.009	31	Nagpur	0.020	51	Nagpur	0.047
12	Nagpur	0.013	32	Nagpur	0.038	52	Nagpur	0.052
13	Nagpur	ND	33	Nagpur	0.046	53	Nagpur	0.044
14	Nagpur	0.046	34	Nagpur	0.038	54	Nagpur	0.057
15	Nagpur	0.025	35	Nagpur	0.033	55	Nagpur	0.043
16	Nagpur	0.051	36	Nagpur	0.040	56	Nagpur	0.027
17	Nagpur	0.013	37	Nagpur	ND	57	Nagpur	0.036
18	Nagpur	0.020	38	Nagpur	ND	58	Nagpur	0.059
19	Nagpur	ND	39	Nagpur	0.119	59	Nagpur	0.021
20	Nagpur	ND	40	Nagpur	0.051			

ND- Not detected and may be taken as "0".

Lead (Pb) content in Rolled oats

It has been found that out of 59 rolled oats samples, 51 samples were found to be positive for Lead (Pb). Lead (Pb) is Not Detected i.e 0.00 ppm in 8 samples. The range of Lead (Pb) content in 51 rolled oats samples ranges from 0.005 ppm to

maximum of 0.120 ppm. Table 2 indicates the level of Lead Content in ppm in rolled oats.

Copper (Cu) content in Rolled oats

It has been found that out of 59 rolled oats samples analysed, 58 samples were found to be positive for copper (Cu). The Copper (Cu) content

has not been detected i.e '0.00' ppm in one sample of rolled oats. The Copper (Cu) content in 58 samples ranges from 0.028 ppm to maximum of

1.095 ppm in rolled oats. Table 3 indicates the copper concentration in ppm in rolled oat samples received from different parts of India.

Table 3. Level of Copper (Cu) in ppm in Rolled oats obtained from different regions of India

S.No	Region	Copper (Cu) content (ppm)	S.No	Region	Copper (Cu) content (ppm)	S.No	Region	Copper (Cu) content (ppm)
1	Amritsar	0.641	21	Nagpur	0.440	41	Nagpur	0.213
2	Amritsar	0.594	22	Nagpur	0.402	42	Nagpur	0.284
3	Chennai	0.176	23	Nagpur	1.044	43	Nagpur	0.338
4	Bhopal	1.075	24	Nagpur	0.561	44	Nagpur	0.182
5	Bhopal	0.786	25	Nagpur	1.078	45	Nagpur	0.114
6	Bhopal	1.004	26	Nagpur	0.688	46	Nagpur	0.088
7	Bhopal	0.709	27	Nagpur	1.045	47	Nagpur	0.028
8	Bhopal	0.262	28	Nagpur	0.707	48	Nagpur	0.206
9	Bhopal	0.661	29	Nagpur	0.293	49	Nagpur	0.237
10	Nagpur	0.582	30	Nagpur	0.668	50	Nagpur	0.306
11	Nagpur	1.026	31	Nagpur	0.720	51	Nagpur	0.213
12	Nagpur	0.725	32	Nagpur	1.095	52	Nagpur	0.127
13	Nagpur	1.035	33	Nagpur	0.660	53	Nagpur	0.181
14	Nagpur	0.898	34	Nagpur	1.029	54	Nagpur	0.085
15	Nagpur	0.696	35	Nagpur	0.703	55	Nagpur	0.184
16	Nagpur	0.568	36	Nagpur	0.281	56	Nagpur	0.134
17	Nagpur	0.404	37	Nagpur	0.742	57	Nagpur	0.104
18	Nagpur	0.448	38	Nagpur	0.884	58	Nagpur	0.212
19	Nagpur	0.065	39	Nagpur	0.783	59	Nagpur	ND
20	Nagpur	0.410	40	Nagpur	0.272			

ND- Not detected and may be taken as "0".

DISCUSSION

LEAD (Pb)

The permissible level for Lead (Pb) as per FSSAI (Food Safety and Standards Authority of India) under category "foods not specified" in India is 2 ppm (max). In Rolled Oats, the maximum Lead content (Pb) was 0.120 ppm which was found to be within the permissible limit. Hence all the samples of Rolled oats analysed were safe for human consumption with respect to Lead (Pb) content. Flores-Margez et al [9] determined heavy metal in oat and soil treated with lime stabilized biosolids and reclaimed waste water. It has been found that concentration of metals in oats samples was 0.07, 0, 6.69 and 5.88 mg/kg for Cadmium (Cd), Chromium (Cr), Nickel (Ni) and Lead (Pb) respectively. This suggests that increases in soil metal content caused by water and biosolids were

significantly related to increase in heavy metals in plant.

COPPER (Cu)

The permissible level of Copper (Cu) as per FSSAI under category "foods not specified" is 30 ppm (maximum) in India. In Rolled oats, the maximum Copper content (Cu) was 1.095 ppm which was found to be within the permissible limit. Hence all the samples of rolled oats analysed were safe for human consumption with respect to Copper (Cu) content.

The Lead (Pb) content and Copper (Cu) Content in the present study was within the permissible limits as defined by the Indian legislation. Hence, it does not pose a serious health risk. Rolled oats samples analysed may not produce health risk for human consumption, if other sources of toxic metals contaminated food are not taken.

CONCLUSION

Screening of 59 samples of Rolled oats received from Amritsar, Bhopal, Chennai and Nagpur revealed that all the Rolled oats samples were found to contain Lead (Pb) and Copper (Cu) within the permissible limit as specified by Indian legislation. In view of this, it has been concluded that consumption of Rolled oats may not produce any health risk for human consumption, if other sources of toxic metals contaminated food are not taken.

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