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ORIGINAL ARTICLE

Effect of different cooking methods on iodine losses

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Abstract Iodine Deficiency Disorders (IDD) is a public health problem in India. It is because of poor iodine availability to the body either due to loss of iodine from iodized salt or due to cooking. Since there is lack of scientific evidence on loss of iodine during different cooking methods, present study was undertaken to study the effect of different cooking methods on iodine losses. Methods used were boiling, roasting, shallow frying, deep frying, pressure cooking and microwave cooking. The loss of iodine ranged from 6.58% to 51.08%. Minimum losses were found during shallow frying where cooking time of salt was 1 min and 15 s and maximum during pressure cooking where cooking time of salt was 26 min. Losses during boiling, roasting, deep frying and microwave cooking were found to be 40.23%, 10.57%, 10.40% and 27.13% respectively. From the obtained results, authors have concluded that the loss of iodine depends upon type of cooking method and time of addition of salt during cooking.

Keywords Iodine · Loss · Cooking method · Salt · Time

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Introduction

Iodine is one of the essential micro-nutrient for normal growth and development (Kapil et al. 2002). Iodine Deficiency Disorders (IDD) is a public health problem in 130 countries and affects 13% of world's population. In India, no state is free from iodine deficiency and 200 million people are 'at risk' of IDD (Vir 2002). Universal salt iodization is recommended as main strategy to achieve elimination of iodine deficiency disorders (WHO/UNICEF/ICCIDD 2007). Salt is recommended as the preferred vehicle for iodine fortification because it is widely consumed in a constant amount, its production is generally centralized and therefore easy to monitor, its sensorial characteristics are not affected by iodization, and the intervention can be implemented at a reasonable cost. For normal individuals, WHO has recommended average consumption of salt to be <5 g/day to achieve maximum health benefits (WHO 2007). According to Zimmermann (2011) salt intake should be 5 g a day or less, but all salt consumed should be iodized.

Daily iodine requirements for humans is 150 μg/day, excluding children <2 years, school aged children (6–12 years), pregnant women and lactating women (WHO 2007). About 90% of this comes from food and 10% from water. Iodine content of foods depends upon the iodine content of the soil in which it is grown. Iodine content in foods varies with geographical location because there is a large variation in the iodine content of the inorganic world (Koutras et al. 1985). The inadequate iodine content of food is supplemented by the addition of iodine in salt in more than 100 countries. Iodine is added to salt in the form of potassium iodide or iodate either as a dry solid or aqueous solution at the time of production (Mannar and Dunn 1995). Since iodine readily sublimes at ambient temperature, the effectiveness of salt iodization programs depends on the stability of the iodine carrier. As iodine is required in very minute quantities per person per day, the dosage of iodine in salt is extremely small. Salt consumption could be anywhere in the range of 5–12 g within a given region or country. Normally the iodine content in salt is fixed in the range 30–100 μg of iodine in 1 g of salt (Mannar and Dunn 1995). This dosage is determined after taking into account anticipated losses during transportation and storage. In India, salt is iodized at a level of 30 μg of iodine in 1 g of salt at production level and it is expected to be 15 μg of iodine in 1 g of salt at consumer level.

Inspite of availability of fortified salt in the market, the problem of IDD continues to prevail in the country. Hence it was of interest to study the losses of iodine during different cooking methods.

Materials and methods

Six Indian recipes *namkeen dalia, chapati, parantha, poori, chhole* and *upma* were cooked using iodized salt to see the effect of boiling, roasting, shallow frying, deep frying, pressure cooking and microwave cooking, respectively on iodine loss. All the recipes were cooked twice (first and second cooking) using standardized household kitchen-tested procedures/recipes (Table 1). Iodized salt (potassium iodate) of tata company (leela business park, andheri kurla road, andheri (E), Mumbai) was used for cooking all the recipes.

Determination of iodine content in raw ingredients

All the raw ingredients were weighed separately and then dried overnight in oven (hot air oven) maintained at 40 °C, and then ground in mixer. Total weight of raw ingredients was recorded. This ground sample was used for determining iodine content in raw ingredients. Mean iodine content of raw ingredients (as a recipe) was estimated using iodine content in raw ingredients (dry matter) and iodine content in water used for cooking.

Determination of iodine content in cooked products

All the raw ingredients were weighed separately and cooked (time of addition of salt was recorded), and then dried in oven, and ground in mixer. The final weight of cooked product was recorded. This ground form of cooked sample was used for determination of iodine content in cooked product.

All the estimations were done in triplicate.

Moisture content (AOAC 1975) of raw ingredients and cooked products were recorded separately and later estimations were done on dried food samples. Iodine content of salt was analyzed using iodometric titration method (Tayabji 1990). Iodine content of water and food samples was estimated using colorimetric method (Raghuramulu et al. 2003). The samples were fixed with potassium carbonate, ashed with zinc sulfate, and then iodine was determined by colorimetric method with Ce-As-I catalytical reaction.

Results and discussion

Moisture content of raw ingredients and cooked products

Mean moisture content of raw ingredients of *namkeen dalia, chapati, parantha, poori, chhole* and *upma* was 7.7%, 10.4%, 9.3%, 8.7%, 7.8% and 9.8% respectively. Mean moisture content of cooked products like *namkeen dalia, chapati, parantha, poori, chhole* and *upma* was 63%, 32%, 32%, 25%, 77% and 68% respectively. Highest moisture content was found in *chhole* as good amount of water was used in pressure cooking. *Namkeen dalia* and *upma* contained more moisture as they were cooked using wet heat method. The moisture content of *chapatti, parantha* and *poori* was less as compared to other recipes as they were cooked using dry heat method. Table 2 shows that except in *poori* (cooked product) no significant differences were found in moisture content of raw ingredients and their cooked products during first and second cooking.

Verma and Raghuvanshi (2002) has reported that moisture content of *namkeen dalia* cooked in different states ranges between 50% and 77.83% and moisture content of *upma* between 65% and 68% as per the cooking procedures of Karnataka and Andhra Pradesh. The range of moisture content in *chhole* of different states is between 65.80% and 80.91%; this depends on the expected thickness of curry in different states. Moisture content of *chapati* cooked in different states ranges between 27.60% and 38.98%. Moisture content of *chapati* as prepared in Uttar Pradesh and Maharashtra is 30.50% and 32.81% respectively which is near to the mean moisture content of *chapati* cooked for the experiment. Range for moisture content of *parantha* cooked in different states is between 20.37% and 34.82%. Moisture content of *poori* ranges between 15.46% and 26.60%.

When we compared the moisture content of our recipes with those reported by Verma and Raghuvanshi (2002), we found that all 6 recipes had similar moisture content. Hence we can say that our cooking procedures/recipes are representative of the recipes prepared in different states of India. As in India, there are wide variations in cooking procedures.

Iodine content of iodized salt and water used for cooking

Iodine content of salt ranged from 33.9 ppm to 34.9 ppm. Ranganathan (1995) reported that iodized salt at the

Table 1 Standard household procedures/recipes

1. *Namkeen dalia* (boiling)		
Ingredients	Total cooking time	Cooking time of salt
Broken wheat (dalia), water, spices, oil and salt	19 min	10 min
Preparation		
Oil was heated → spices were added and fried slightly → water was added and allowed to boil → broken wheat and salt was added → mixed well and cooked till done		
2. *Chapati* (roasting)		
Ingredients	Total cooking time	Cooking time of salt
Wheat flour, water and salt	1 min 15 sec	1 min 15 sec
Preparation		
Dough was prepared by mixing wheat flour, water and salt → kept aside for 15 min → divided into balls of equal size → Flattened and rolled to uniform thickness and size (shape-round) → roasted on hot *tawa* (pan)		
3. *Parantha* (shallow frying)		
Ingredients	Total cooking time	Cooking time of salt
Wheat flour, water, oil and salt	1 min 15 sec	1 min 15 sec
Preparation		
Dough was prepared by mixing wheat flour, water and salt → kept aside for 15 min → divided into balls of equal size → Flattened and rolled to uniform thickness (by applying little oil) and size (shape-triangle) → shallow fried on hot *tawa* (pan) by applying oil on both sides		
4. *Poori* (deep frying)		
Ingredients	Total cooking time	Cooking time of salt
Wheat flour, water, oil and salt	50 sec	50 sec
Preparation		
Dough was prepared by mixing wheat flour, water, oil and salt → kept aside for 15 min → divided into balls of equal size → Flattened and rolled to uniform thickness (by applying oil) and size (shape-round) → deep fried in hot oil		
5. *Chhole* (pressure cooking)		
Ingredients	Total cooking time	Cooking time of salt
Bengal gram (whole), water, spices, oil and salt	35 min	26 min
Preparation		
Bengal gram was soaked in water for overnight → boiled for 20 min in pressure cooker with addition of salt		
Oil was heated → spices were added and fried slightly → Bengal gram was added and cooked for 15 min		
6. *Upma* (microwave cooking)		
Ingredients	Total cooking time	Cooking time of salt
Semolina, water, spices, oil and salt	14 min	4 min
Preparation		
Semolina was roasted (microwave oven)		
Oil was heated → spices were added and fried slightly → water and salt were added → allowed to boil → roasted semolina was added and cooked till done		

consumer level should have iodine content more than 15 ppm. Mean iodine content in salt was found to be 34.56±0.5 ppm. This suggests that tata salt was adequately iodized (>15 ppm). Iodine content of water was determined to estimate the contribution of iodine through water. Mean iodine present in water was found to be 0.008±0.002 ppm. Raghuvanshi (1994) reported that iodine content of hand pump water and artesian well water in Pantnagar ranges from 0.004 ppm to 0.012 ppm and 0.0066 ppm to 0.015 ppm respectively. Iodine content of drinking water can be used for determining iodine content of soil.

Effect of different cooking methods on iodine loss

As shown in Table 3 there is difference in iodine content of raw ingredients and cooked products. It was found that mean iodine content of cooked product was less than that of mean iodine content of raw ingredients. The loss of iodine ranged from 6.58% to 51.08%. It can be stated that the retention of iodine ranged from 48.92% to 93.42%. Minimum loss was found during shallow frying and maximum during pressure cooking. This may be due to the reason that *parantha* was prepared using shallow frying (dry heat method) in which salt was cooked for short period, whereas *chhole* was

Table 2 Percent moisture content of raw ingredients and their cooked products

Recipe	Items	Moisture (1st cooking)	Moisture (2nd cooking)
Namkeen dalia	RI	7.7±0.02	7.7±0.07
	CP	63.9±1.82	62.7±0.90
Chapatti	RI	10.5±0.22	10.3±0.15
	CP	31.8±2.38	31.8±2.39
Parantha	RI	9.3±0.18	9.3±0.10
	CP	32.1±0.60	32.6±1.28
Poori	RI	8.7±0.11	8.7±0.05
	CP	25.8±2.04*	24.9±1.09*
Chhole	RI	7.7±0.05	7.8±0.02
	CP	78.9±0.26	75.9±0.95
Upma	RI	9.8±0.11	9.7±0.07
	CP	67.7±3.5	69.0±0.76

*significant ($p<0.05$), RI - raw ingredients & CP - cooked products

prepared using pressure cooking (wet heat method) in which salt was cooked for a longer period.

More loss was found in boiling, medium loss in microwave cooking and fewer losses in roasting, and deep frying. Roasting and deep frying had relatively less cooking time than other recipes. Losses during roasting and deep frying were similar though *poori* had been cooked for less time as compared to *chapati*. However, *poori* had been cooked at high temperature due to deep fat frying. More loss during boiling could be due to the fact that during boiling, water is used for cooking the food. Salt is hygroscopic in nature and hence, it absorbs water and the iodine present in the salt is leached out and lost while water is not required as a cooking medium during roasting, shallow frying and deep frying. Apart from water, time duration for which salt was cooked also plays a major role in iodine loss. Time of cooking of salt is higher in boiling (10 min) and pressure cooking (26 min), medium in microwave cooking (4 min) and minimum in deep frying (50 s), shallow frying (1 min and 15 s) and roasting (1 min and 15 s). For comparison of iodine losses in different cooking procedures ANOVA was used. Statistical analysis showed non significant difference for roasting, shallow frying and deep frying ($p>0.05$).

Goindi et al. (1995) reported mean loss of iodine during different cooking procedures ranges from 6% (roasting) to 37% (boiling). Wang et al. (1999) reported that the loss of iodine vary with the kind of foods and is also influenced by water content of food. In general, the loss of iodine during cooking varies considerably from 14% to 66%. According to Chavasit et al. (2002) garlic, fresh chili, pepper and green curry paste cause high loss of iodine. However in present study these spices have not been used. Verma and Raghuvanshi (2001) stated that there is loss of up to 70% of iodine through cooking. However in present study the maximum loss was found up to 51.08%. As we know that natural iodine content of foods is not adequate enough to meet our daily iodine requirements and iodized salt is the main source of iodine in our diet. Hence, we must prevent the loss of iodine during cooking as much as we can. There is a need to provide information to the population, regarding cooking losses of iodine. Nutrition Health Education on iodine losses during cooking should target women mainly, because they are the ones who are adding iodized salt in our diet. Government can start public awareness campaign, with key messages focusing on proper methods for storage of iodized salt, keeping the salt away from flame, adding salt towards the end of cooking etc. Banners and posters can be placed on railway stations, bus stations, and near *Anganwadi* centers.

Conclusion

The results showed that the loss of iodine depends upon type of cooking method and cooking time of salt. Thus, to prevent iodine losses while cooking, it is advisable to sprinkle salt on food after cooking (wherever possible)

Table 3 Loss of iodine during different cooking methods

Recipe	Amount of raw ingredients (dry matter) g	Iodine content in raw ingredients (dry matter) μg (A)	Amount of water in raw ingredients (dry matter) g	Iodine content in water μg (B)	Mean Iodine content in raw ingredients μg (C=A+B)	Amount of cooked product (dry matter) g	Mean Iodine content of cooked product μg (D)	Iodine loss μg (E=C-D)	Percent loss
Namkeen dalia	231	216.5	273	2.18	218.7±3.05	380	130.7±2.62	88.0	40.2
Chapatti	102	98.1	65	0.52	98.6±6.41	144	88.2±5.76	10.4	10.5
Parantha	111	102.6	65	0.52	103.1±7.16	164	96±6.04	6.7	6.5
Poori	119	104.1	65	0.52	104.6±3.43	150	93.7±4.33	10.8	10.4
Chhole	198	210.3	637	5.09	215.4±2.47	527	105.4±1.84	110.0	51.0
Upma	148	172.0	273	2.18	174.2±20.93	338	126.9±18.87	47.2	27.1

rather than adding salt while cooking as is done traditionally in India. Further, storage of salt in hot and humid condition near the cooking area should be avoided. The results on loss of iodine after cooking shall help in creating awareness among population on desirable cooking method so that the population gets iodine in adequate amount after cooking. The information would be helpful in long run for improving the nutritional status of the population and reducing medical cost of the families.

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