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Research Paper :

Effect of conventional, microwave and solar processing on vitamin C content and bacterial load of some foods

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ABSTRACT

Foods are composed of "nutrients", which when consumed in adequate amounts, fulfill all the functions of the body. Vitamins are the "accessory nutrients" involved in small quantities in the regulation of body processes. Vitamins are found in plant and animal tissues. Vegetables and fruits are good sources of vitamins. Cooking of food is the use of heat to bring about desirable changes in foods being consumed. Most foods are cooked before they are accepted. Cooking by different methods affects the nutritional quality as well as microbial population of food. A study on effect of conventional, microwave and solar cooking on three recipes namely sweet corn (*Zea mays*), potato (*Solanum tuberosum*) sabji and Spinach (*Spinacia oleracea*) sabji on vitamin C and bacterial load study showed that while conventional and microwave cooking retained more vitamin C compared to solar cooked foods, bacterial survival rate was higher in the former two methods.

Key words : Conventional, Microwave, Solar, Vitamin C, Heat labile, Micro-organisms

Ascorbic acid is the most unstable of all known vitamins. It easily gets oxidized, especially on exposure to heat. Oxidation is accelerated in the presence of copper and alkaline pH. Since ascorbic acid is soluble in water and easily oxidized, it is susceptible to loss during cooking and processing of food. It is readily lost via leaching from cut or bruised surface of food. Prolonged cooking at high temperature and undue exposure to oxygen, copper and iron result in loss of the vitamin. Nutritive value of most foods is affected by cooking irrespective of methods either in commercial establishment or at households.

Conventional methods of cooking have been in use since ages. Microwave cooking, a recent trend has transformed the lifestyle of people all over the world by dramatically reducing the hours spent by housewives in the kitchen. The solar cooker an ideal kitchen appliance that offers multipurpose uses, is ecologically and economically beneficial. With all these sources of energy, and different methods available for cooking, it becomes necessary to select the best ones in terms of nutrient retention.

The changes in reduced and total ascorbic acid contents in four potato cultivars after cooking by different methods were studied by Shirsat and Thomas (1998). Cooking of tubers in boiling water showed maximum loss in vitamin C content, whereas pressure and microwave cooking recorded least losses. Greater retention of vitamin B_6 in chicken (Wing and Alexander, 1972), thiamine in pork (Kylen *et al.*, 1964), and ascorbic acid in vegetables (Gordon and Noble, 1959) was reported in foods cooked electronically. Destruction of microorganisms by thermal means is dependent not only on the temperature but also on the length of time the food is heated. A greater bacterial survival in meat cooked electronically had been reported. The quick rise in lethal temperature and maintenance of that temperature for only short periods of time allows more bacteria to survive. Riboflavin and vitamin C are sensitive to cooking. Solar cooking, which is a slow process at low cooking temperatures, retains these nutrients in selected vegetables to a much higher extent than those cooked by absorption method (Chandrasekhar and Kowsalya, 1997).

The present study was undertaken to compare the effect of different cooking methods, *viz.*, conventional, microwave and solar on vitamin C and bacterial load of sweet corn, spinach sabji and potato sabji.

METHODOLOGY

Three recipes namely, sweet corn, potato sabji and spinach sabji were prepared by conventional method, microwave and solar cooking.

Sweet corn:

Two and half kilogram sweet corn cobs (8 no.) were deseeded. 200 g sample was taken for four different cooking methods (two conventional *viz.,* pressure cooking and broiling, one microwave, one solar), and one for analysis of raw corn. Lower portion of all 8 cobs was left without deseeding and was used for making broiled corn.

200 g sample was obtained from broiled corn. Cooking time was - conventional methods – broiling – 3 min medium heat, and pressure cooking – 5 min; microwave – 5 min, solar cooking –1 hour.

Potato sabji (Suki Bhaji):

Table 1: Potato sabji - ingredients and amount

Ingredients	Amount	Ingredients	Amount
Potato	250 g	Turmeric powder	50 mg
Salt	1.3 g	Red chili powder	450 mg
Oil	18 g	Cumin seeds	700 mg

Method of preparation:

Potatoes (1 kg) were weighed, peeled, washed, diced and divided into four equal portions. Three portions were used for preparing sabji and one was kept for raw analysis. For each sabji, cumin seeds were added to heated oil. Diced potatoes and the remaining ingredients were added and the sabji was cooked. Cooking time was - conventional cooking (sautéing) – 5 min, low heat; microwave – 5 min; solar cooking – 40 min.

Spinach sabji:

Table 2 : Palak sabji - ingredients and amount

Ingredients	Amount	Ingredients	Amount
Spinach	125 g	Salt	500 mg
Oil	5 g	Turmeric powder	250 mg
Cumin seeds	1 g	Cumin-coriander powder	500 mg

Method of preparation:

Spinach (500 g edible portion) was washed, cut and divided into four portions, one for analysis of raw spinach and remaining three for different cooking methods. Oil was heated, cumin seeds were added. Remaining ingredients were added and the sabji was cooked. Cooking time was - conventional cooking (sautéing followed by simmering in covered pan with little water on the lid – 7 min; microwave – 3.30 min; solar cooking – 30 min.

All three recipes namely sweet corn, potato sabji and Spinach sabji were analysed in triplicate for vitamin C content by titration with 2,6 dichloro phenol indophenol (Sadasivam and Manickam, 1991). Bacterial load was studied using standard plate count method. All the analyses were done in triplicate. Statistical analysis of data was done using F-Ratio and percentage ratio.

FINDINGS AND DISCUSSION

The findings obtained from the present investigation are presented below:

Corn:

Vitamin C retention in pressure cooked, broiled, microwave and solar cooked corn was 83.3%, 74.9%, 83.3% and 66.7% vitamin, respectively. Statistical analysis at 5 % level showed significant difference among vitamin C content of raw and all cooked samples as well as between (i) pressure cooked and solar (ii) microwave and solar cooked samples.

Vitamin C is heat sensitive and cooking results on 0-100% loss of vitamin C as reported by Potter and Hotclikiss (1996). In the present study, vitamin C loss was seen to be the highest in solar cooked corn followed by broiled corn. Microwave cooked and pressure cooked corn retained equal amount of vitamin C. Researchers like Rachel and Ogale (1987) and Chandrasekhar and Kowsalya (1997) have reported that solar cooked foods retain more vitamins compared to other methods of cooking. The findings of present study are not in agreement with these reports. Microwave cooking retains more vitamin C compared to other cooking methods. This finding has been supported by several researchers like Gordon and Noble (1959), Kaur *et al.* (1999) and Premakumar and Khurdiya (2002). As indicated by present study, microwave and pressure cooking of corn resulted in equal loss of the vitamin. Shirsat and Thomas (1998) reported greater loss of vitamin C in boiled potatoes compared to microwave and pressure cooked ones.

Potato sabji:

Vitamin C being heat labile suffers the highest loss on cooking. Solar cooked potato sabji suffered the maximum loss of 61.5%. Retention of vitamin C was the highest in microwave cooked sabji, being 76.9%, *i.e.* a loss of 33.1%. Sauteed sabji retained 53.8% vitamin C. While microwave and solar cooked sabji were covered and cooked, conventionally cooked sabji was cooked without lid or cover and yet retained more vitamin C as compared to solar cooked sabji. As solar cooking takes longer time, continued prolonged heat exposure could have resulted in greater loss of vitamin. Several workers as mentioned earlier have reported on higher retention of vitamin C by microwave as well as solar cooking. The result of this study supports the findings on microwave cooking, while does not agree with those on solar cooking. Statistical analysis showed significant difference at 5 % level in vitamin C content of raw and all cooked samples, and also among all samples prepared by different cooking

Table 3: Effect of cooking methods on vitamin C (mg/100 g) content

Recipe	Vitamin C (mg/100 g)				
	Raw	Conventional $_1$	Conventional $_2$	Microwave	Solar
Sweet corn	8.82	7.35*	6.61	7.35	5.88
Potato sabji	19.26	10.37**	-	14.81	7.41
Palak sabji	26.5	19.5***	-	16.5	6.0

Conventional $_1$ - *Pressure cooked ** Sauteed *** Sauteed and simmered Conventional $_2$ - Broiled

methods.

Spinach sabji:

Spinach is a good source of vitamin C. 26.5 mg vitamin C in raw Spinach showed losses ranging from 26.4% in conventionally cooked sabji to 87.4% in solar cooked sabji. Vitamin C content of conventionally cooked sabji was 19.5 mg. Highest retention of the vitamin could be because the sabji was cooked in closed/covered vessel. Oil used as cooking medium also could have protective effect on the vitamin by preventing the losses due to oxidation. Solar cooking, due to longer time of cooking resulted in very high destruction of vitamin C. Vitamin C content varied significantly among the following treatments – raw and all cooked samples as well as among (i) conventional and solar (ii) microwave and solar (Table 3).

Sweet corn:

Broiling resulted in minimum destruction of microorganisms in sweet corn. Corn cooked by broiling got cooked in very short time, and the temperature at endpoint was also the least of all cooking methods. As cooking span was short, and the final temperature attained was low, the number of bacteria destroyed was the lowest. Pressure cooked corn resulted in complete destruction of bacteria. As solar cooking takes longer to cook, continued low but consistent temperature maintained for longer time resulted in greater destruction of bacteria. Microwave cooking caused quick rise in temperature of food, but the cooking time was shorter, as a result of which internal temperature attained by the food was not maintained for long period as in case of solar cooking. This resulted in greater number of surviving cells. Higher bacterial count in perishables could be attributed to handling and higher number of microorganisms on the surface of the food. Statistical analysis by percentage ratio showed highly significant difference among the bacterial count of all sweet corn samples processed by different cooking methods.

Potato sabji:

In potato sabji, conventional cooking and microwave cooking took shorter time compared to solar cooking. This could result in lower internal temperature. It is necessary to hold food at high temperature for some time for maximum destruction of microorganisms. In solar cooking, this requirement was fulfilled and hence a minimum bacterial load was observed. Statistical analysis by percentage ratio suggested significant difference among bacterial count of potato sabji cooked by different methods.

The non uniform heating characteristic of microwave energy has been reported by Co and Livingston (1969). Copson (1975) also postulated that there are regions within a microwave oven where organisms remain unharmed. It was well documented by Goldblith and Wang (1967) and Lechowich and Beauchat (1969) that death of microorganisms exposed to microwaves was due to thermal effects and not to microwaves *per se*.

Spinach sabji:

Conventionally cooked and microwave cooked Spinach sabji showed a high bacterial count of 3.4 x 10^2 and 3.9 x 10^2, respectively. Solar cooked sabji showed a comparatively low count of bacteria (1.4 x 10^2). Solar cooking takes longer to cook, and the food is held at high temperature for considerably long time which destroys larger number of microorganisms. Conventional and microwave cooking took less time to cook and hence resulted in larger number of surviving cells (Table 4).

Table 4 : Effect of processing methods on bacterial count (cfu/ml) of sweet corn, potato sabji and palak sabji

Recipe	Conventional		Microwave	Solar
Sweet corn	0*	4.5 x 10^{2**}	2.0 x 10^2	1.0 x 10^2
Potato sabji	----	6 x 10***	7.5 x 10	3 x 10
Palak sabji	----	3.4 x 10^{2****}	3.9 x 10^2	1.4 x 10^2

* Pressure cooked ** Broiled *** Sauteed *** Sauteed and simmered

Statistical analysis by percentage ratio showed significant difference in the bacterial count of Spinach sabji made by following methods – (i) conventional and solar (ii) microwave and solar cooking.

Conclusion:

Retaining nutrients is crucial to maintain the quality of food consumed. While solar cooking proves to be a good choice as far as destruction of bacteria is concerned, it is detrimental to the retention of vitamin C. Conventional and microwave cooking retain more vitamin C, but the survival rate of bacteria is higher. A judicious combination of different cooking methods should be done to maintain the overall quality of food.

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