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Effect of thermal processing on nutritional and Anti-nutritional factors of amaranthus (*Amaranthus viridis* Linn.) Leaves

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Abstract
The leafy vegetables, namely Amaranthus (*Amaranthus viridis* Linn.) is a good source of nutrients and minerals but they also contain some anti-nutritional factors i.e. oxalate, saponins and nitrates. In the present study, an attempt was made to reduce these anti-nutritional factors and maintain their quality by thermal processing methods (conventional and microwave blanching) at different time intervals. Among blanching treatments leaves of amaranthus subjected to microwave for 15 seconds had the highest β-carotene (23.52 mg/100g), crude protein (3.11%) and iron (52.61 mg/100g) while it was lowest i.e. 12.28 mg/100g β-carotene content, 2.95% crude protein and 41.39 mg/100g iron in leaves blanched conventionally for 6 minutes. Later, leaves of amaranthus were cooked (conventional cooking, cooking under pressure and microwave cooking). The β- carotene (22.36 mg/100g), crude protein (3.23%) and iron (50.69 mg/100g) content was highest in amaranthus leaves cooked by microwave whereas, antinutrients i.e. oxalates (23.07 mg /100g) and saponins (1.26 mg/100g) were lowest in microwave cooking. On the basis of sensory evaluation, the overall acceptability of leafy vegetable of amaranthus was considered to be best in microwave cooking.

Keywords: Amaranthus, oxalates, saponins, blanching, conventional

Introduction

Vegetables are an important part of food, nutritional security and have ability to generate on-farm and off-farm employment. There has been increasing demand for fresh vegetables mainly because of their nutritional significant. The leafy vegetables like amaranthus (*Amaranthus viridis* Linn.) is good source of vitamins, minerals, proteins and fibers and are locally available in surrounding areas. *Amaranthus viridis* belongs to the family of Amaranthaceae. It is a multipurpose crop whose leaves and grains are of good taste and high nutritional value. Moreover, an inexpensive rich source of protein and dietary fiber (Shukla *et al.*, 2010) [36]. It also has anti- inflammatory properties, immunomodulatory activity, anti-androgenic activity and anthelmintic properties (Alegbejo, 2013) [5]. These vegetables also contain some anti-nutritional factors which prevent us from getting benefits from the nutrients that they provide. Examples of anti-nutritional factors are phytates (phytic acid), nitrates, oxalates, tannins, protease inhibitors, lactins, saponins etc. More or less, these plant chemicals known to be deleterious for health or evidently advantageous to human and animal health if consumed at appropriate amounts (Ugwu and Oranye, 2006) [37]. Many thermal processing treatments like blanching, cooking and drying have been reported to reduce these anti-nutritional factors. The main role of blanching is to inactivate the enzymes. This also helps in modifying the texture while maintaining the nutritional value of vegetables. To some extent, destructive effect on heat sensitive nutrient contents. So, it is essential to correlate the suitable enzymatic inactivation by thermal blanching and nutrients loss, unwanted color changes, and texture degradation of product (Bamidele *et al.* 2017) [9]. The purpose of this study, an attempt was made to optimize blanching treatment for leafy vegetable of amaranth (*Amaranthus viridis*) to reduce anti-nutritional factors and maintain quality.

Material and Methods

The fresh leafy vegetables namely amaranthus (*Amaranthus viridis* Linn.) were procured from Jammu (J&K) taken for further processing. The experiment was conducted in the Department of Food Science and Technology, SKUAST-Jammu. About 800g of fresh amaranthus leaves were taken, cleaned of foreign materials and stalks and washed thoroughly 6 - 7 times into the running water. The leaves were divided into different parts of 100 g each, subjected to blanching for different time interval i.e. conventionally and microwave blanching as shown in figure 1. Fresh leaves were cleaned and washed thoroughly. The leaves were blanched conventionally and by microwave for reduction of anti-nutritional factors. After optimization of blanching process, the leafy vegetable was cooked by different methods i.e. conventional cooking, cooking under pressure and microwave cooking to enhanced acceptability. In conventional cooking, 10 ml of oil was placed onto a preheated pan, and then 100 g of amaranthus leaves was placed in the pan and stir fried for 15 minute. The oil temperature was ranging from 125 to 140 °C. The temperature of the vegetables was 100 °C after stir frying. The amaranthus eaves (100 g) were boiled in 150 ml of water at 98°C in a stainless pressure cooker on a moderate flame for 5 min, mimicking the traditional method of cooking, drained. Take (100g) amaranths leaves vegetables were placed in a glass dish with 12 ml of water for 15 min in a microwave oven (Defy) (household) working at 2,450 MHz−900 W for 3 min. afterwards, they were drained. These samples were cooled rapidly on ice-cold water after each of the above-mentioned household cooking technique to stop further post-cooking biochemical changes.

Physico-chemical analysis of *Amaranthus viridis* Linn

Physico-chemical analysis of fresh leaves and blanched leaves were conducted for different parameters following standard procedures. β-carotene content was determined by optical density (OD) was taken at 452 nm and the reading was compared with standard curve (Ranganna, 2003) [30]. Crude fiber and ash content were calculated as per the method outlined by AOAC, 2007 [7]. Crude protein content was estimated by micro- kjeldhal method, using the factor 6.25 for converting nitrogen content into crude protein (AOAC, 2002) [6]. Iron content was determined by optical density (OD) was taken at 540 nm on a spectrophotometer (Spectronic-21) within 30 min (AOAC, 2012) [8]. Oxalate content was determined by titration method as described (Day and Underwood, 1986) [10]. Saponin content was estimated as per the method of Nahapetian and Bassiri, 1975. The data obtained was analyzed statistically (Gomez and Gomez, 1984) [14] using Completely Randomized Design (CRD) for interpretation of results through analysis of variance at p= 0.05.

Results and Discussions

The physicochemical characteristics of *Amaranthus viridis* Linn. is presented in Table 1. Fresh leaves contained 24.01 mg/100g β- carotene, 3.14 per cent crude protein, 1.92 per cent crude fibre, 53.14 mg per 100g iron, 47.03 mg per 100 g oxalates, 4.42 mg per100g saponins.

Effect of Blanching on Nutritional Composition of Amaranthus Leaves

The data on effect of blanching on nutritional composition of amaranthus leaves was summarized in Table 2. β-carotene was highest (24.01mg/100g) in T_1 (control) and lowest (12.28 mg/100g) in T_7 (C.B for 6 min.). β-carotene of green leafy vegetable decreased during blanching. The loss could be due to blanching temperature or may be leaching out with water. The results of this study are similar to the findings of Negi and Roy (2000) [23]. According to them, the loss of β- carotene was higher in savoy beet, amaranth and fenugreek leaves during blanching. The decrease in β- carotene content due to blanching has also been reported by Traore *et al.,* (2017) in amaranthus, black nightshade and jute mallow leaves. Crude protein was highest (3.14%) in T_1 (control) and lowest (2.95%) in T_4 (C.B for 6 min.).Crude protein content of amaranthus leaves slightly decreases after blanching. A gradual decrease in the crude protein content could be attributed to the severity of thermal process during blanching that leads to protein degradation as reported by Acho *et al.* (2015) [2]. According to Yakubu *et al.* (2012) [38], during blanching the crude protein content also decreased in Vernonia amygdalina (Bitter leaf). Highest crude fibre (2.16%) was found in T_7 (M.B for 45 sec.) and it was minimum (1.93%) in T_1 (control). The crude fibre of leafy vegetables slightly increased during blanching. The increase of temperature during blanching leads to the hydrolysis of glycosidic linkages of polysaccharides which could make the dietary fibre of amaranth leaves slightly increase during blanching as also reported by Funke, (2011) [13]. Increase in the crude fibre content of cowpea leaves during blanching also analyzed Owade *et al*., (2020). The highest (53.14 mg/100g) iron content was observed in T_1 (control) and lowest (41.39mg/100g) in T_4 (C.B for 6 min.). Iron content of amaranthus leafy vegetable decreased after blanching. These observed reductions may be due to leaching of the mineral compounds into the boiling water as reported by Ajala, (2009) [4]. The iron (19%) content decreased in cauliflower leaves due to blanching as also reported by Aggarwal and Khanna (2019) [3]. Saranya *et al*., (2017) [35] also reported that blanching caused significantly higher reduction in the iron content of *Alternanthera sessilis, Cardiospermum helicacabum* and *Celosia argentea* leafy vegetables.

Effect of blanching on antinutritional factors of amaranths leaves

From Table 3, the effect of blanching on anti-nutritional factors of *Amaranthus viridis* leaves were analyzed. It was observed that the highest oxalates (47.03 mg/100g) and saponins (4.42 mg/100g) were found in T_1 (control) and lowest 32.76mg/100g and 1.61 mg/100g in T_7 (M.B for 45 sec.) respectively. Reduction in level of oxalates by blanching ranged from 8.01 to 30.34 per cent and saponins 27.82 to 63.57 per cent. The highest oxalates and saponins contents were found in T_1 (control) and lowest in T_7 (M.B for 45 sec.) respectively. Blanching caused significant reduction in oxalates from of 8.01% to 30.34% in amaranthus leaves. The reductions in oxalate contents during blanching could improve the health status of consumers because oxalate reduces the bioavailability of calcium, magnesium, zinc and iron by chelating action (Sandberg, 2002) [33]. Ekop and Eddy (2005) [11] reported that blanching appears as detoxification technique of leafy vegetables by removing anti-nutritional factors. The oxalate content decreased in bathua leaves with the increased in blanching time as also reported by Patel *et al*., (2018) [28]. Sallau *et al*., (2012) [32] also reported that blanching of *Moringa oleifera* leaves caused reduction in the level of oxalate content. The reduction in saponins content in leafy vegetables was in range from 27.82% to 63.57% in amaranths leaves. Although toxic, saponins are poorly absorbed by the body and most pass straight through without any problem. They are also broken down to a large extent in the cooking process (Poonia and Upadhayay, 2015) [29] The blanching also proved to reduce saponins content on moringa leaves as reported by Indriasari and Kumalaningsih, (2016) [17]. Fadupin, *et al*., (2014) [12] also reported that blanching caused reduction in saponin content of pumpkin (*Cucurbita pepo*) leaves.

Effect of Cooking on Nutritional Components of Amaranthus Leaves:

It was observed in Table 4 that effect of cooking on nutritional components of leafy vegetable of amaranthus leaves was highest in conventional cooking and lowest in microwave cooking. The highest iron was found in microwave cooking and lowest was found in cooking under pressure. β-carotene content was highest (22.36 mg/100g) in microwave cooking and lowest (22.15 mg/100g) in conventional cooking. β-carotene decreased during cooking but vegetables cooked by microwave retained more β-carotene as compared to conventional cooking as well as cooking under pressure. Sandhya, (1999) [34] reported that the percent lost also depends on time and thus, shorter cooking time helped in better retention of β-carotene. β-carotene also decreased in the spider plant (*Cleome gynandra*) and African nightshade (*Solanum nigrum*) due to traditional cooking methods as reported by Musotsi *et al*, (2019) [21]. Cooking caused slightly increase in the protein content of all the greens which was due to greater moisture loss. Similar results have been reported by Kala and Prakash (2004) [18] in nutrient composition and sensory profile of differently cooked green leafy vegetables of amaranth (*Amaranthus gangeticus*), kilkeerai (*Amaranthus tricolor*), shepu (*Peucedanum graveolens*), and spinach (*Spinacia oleracea*) increased by microwave cooking as compared to conventional cooking. The highest crude protein content (3.23%) was found in microwave cooking and lowest (3.04%) in conventional cooking, whereas highest value crude fibre content (2.34%) was found in conventional cooking and it was lowest (2.21%) in microwave cooking. The crude protein increased in microwave cooking as comapared to conventional cooking of Lady's finger (*A. esculentus L.*) and cucumber (*C. sativus L.*) as also reported by Rashid *et al*., 2016 [31]. The cooking caused a slightly increased in the crude fibre content of both leafy vegetable. McDougall *et al*., (1996) reported that slightly increase in the fiber content may probably be due to hydration or polymerization of its fractions. The crude fibre increased in pumpkin (*T. occidental*) leaves by microwave cooking as compared to conventional cooking as also reported by Okibe *et al*., (2016) [25]. The iron content (50.69 mg/100g) was found in microwave cooking and lowest 49.32 mg/100g in iron was found in cooking under pressure. The iron of leafy vegetable was decreased by different cooking methods. The iron content decreased in Nine fresh vegetables i.e., broccoli, fennel, cabbage, carrots, peas, green broad beans, potatoes, sweet potatoes, and spinach due to blanching as reported by Abu-Salem *et al*., (2007) [1]. Habwe *et al*., (2009) [15] also reported that high reduction of iron content as a result of wet frying as compared to boiling for 5 minutes in *Amaranthus hybridus*.

Effect of Cooking on Antinutritional Factors of Amaranthus leaves

It was observed in Table 5 that the highest of oxalates (27.69 mg/100g) and saponins (1.51 mg/100g) were found in leafy vegetable of amaranthus by conventional cooking and as lowest 23.07 mg/100g and 1.26 mg/100g in microwave cooking respectively. In leafy vegetable of amaranthus and bathua reduction of anti-nutrients was observed by cooking methods. The oxalates reduced in all cooking methods but in microwave cooking it was more. The different cooking methods caused a significant reduction in saponin contents of the leafy vegetables. However, microwave cooking caused more reduction in saponins. Issa *et al*., (2020) [16] reported significant reduction of oxalates in vegetable leaves of sweet potato, *Moringa oleifera*, *jute mallow* and *Amaranthus hybridus* in both boiling and wet frying. Ojo *et al*., (2016) [24] also reported reduction of oxalates in *Solanum marcrocarpon* vegetables by cooking. The saponins caused reduction by cooking in *Laportea peduncularis* and *Urtica dioica* as also reported by Mahlangeni *et al*., (2016) [19].

Fig 1: Fresh amaranthus (*Amaranthus viridis*) leafy vegetable

Table 1: Physico-chemical parameters of amaranthus leaves

Characteristics	*Amaranthus viridis (fresh leaves)*
B- carotene (mg/100g)	24.01
Crude protein (%)	3.14
Crude fibre (%)	1.92
Iron (mg/100g)	53.14
Oxalates (mg/100g)	47.03
Saponins (mg/100g)	4.42

Table 2: Effect of blanching on nutritional composition of amaranthus leaves

Treatments	β-Carotene (mg/100g)	Crude protein (%)	Crude fibre (%)	Iron (Mg/100g)
T1(Control)	24.01	3.14	1.93	53.14
T2 (C.B for 2 min.)	19.21	3.09	1.96	48.88
T3 (C.B for 4 min.)	15.36	3.01	2.04	44.96
T4 (C.B for 6 min.)	12.28	2.95	2.10	41.39
T5 (M.B for 15 sec.)	23.52	3.11	1.95	52.61
T6 (M.B for 30 sec.)	22.76	3.05	2.07	52.08
T7 (M.B for 45 sec.)	22.49	2.99	2.16	51.35
Mean	19.94	3.04	2.03	49.23
C.D ($P \leq 0.05$)	0.11	0.03	0.04	0.21

C.B = Conventional Blanching M.B = Microwave Blanching

Table 3: Effect of blanching on anti-nutritional factors of amaranthus leaves

Treatments	Oxalates (mg/100)	Saponins (mg/100)
T1(Control)	47.03	4.42
T2 (C.B for 2min.)	43.26	3.19
T3 (C.B for 4min.)	38.93	2.27
T4 (C.B for 6 min.)	32.97	1.67
T5 (M.B for 15sec.)	45.12	3.51
T6 (M.B for 30sec.)	39.25	2.59
T7 (M.B for 45sec.)	32.76	1.61
Mean	39.90	2.75
C.D ($P \leq 0.05$)	1.10	0.90

C.B = Conventional Blanching M.B = Microwave Blanching

Table 4: Effect of cooking on nutritional composition of amaranthus leaves

Treatment	β-carotene (mg/100g)	Crude protein (%)	Crude fibre (%)	Iron (mg/100g)
T1 (Conventional cooking)	22.15	3.04	2.34	50.11
T2 (Cooking under pressure)	22.29	3.11	2.26	49.32
T3 (Microwave cooking)	22.36	3.23	2.21	50.69
Mean	26.63	3.12	2.27	50.04
C.D ($P \leq 0.05$)	0.05	0.04	0.03	0.06

Table 5: Effect of cooking on anti-nutritional factors of amaranthus leaves

Treatment	Oxalates (mg/100g)	Saponins (mg/100g)
T1 (Conventional cooking)	27.69	1.51
T2 (Cooking under pressure)	26.04	1.39
T3 (Microwave cooking)	23.07	1.26
Mean	25.61	1.39
C.D ($P \leq 0.05$)	0.30	0.09

Conclusion

From the present investigation, it was concluded that thermal processing leads to reduction in anti-nutritional factors. Both conventional and microwave blanching methods resulted in a highly significant reduction of oxalates, saponins and nitrates. Based on the results of this study, blanching can therefore be recommended as an effective method for reducing anti-nutritional factors in leafy vegetables. The nutritional quality of vegetable cooked by microwave oven was found to be better as compared to conventional cooking. Likewise, there was higher retention of nutrients in the microwave cooking. There was efficiency in operation, energy saving, reduced cooking time, increased retention of nutrients and also resulted in reduction of anti-nutritional factors.

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