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Attributes of Seabuckthorn (*Hippophae rhamnoides L.*) to Meet Nutritional Requirements in High Altitude

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ABSTRACT

The diet of humans living in different geographical and climatic regions of the earth varies greatly in both quantity and composition of foods. Evidence is accumulating that indicates that there is a high risk of malnutrition at high altitude because of the usual lack of fresh food and environmental factors. Lack of nutritious diet in the difficult terrain is a potential stressor that elicits oxidative stress. The excretion of minerals from the body is higher in high altitude condition. The altered nutritional requirement can be met to a large extend by regular consumption of locally grown fruits and vegetables. Results of analysis of Seabuckthorn growing in Leh valley of Trans-Himalaya showed the presence of high content of multivitamins including vitamin C (275 mg/100g), vitamin A (432.4 IU/100g), vitamin E (3.54 mg/100g), Riboflavin (1.45 mg/100g), Niacin (68.4 mg/100g), Pantothenic acid (0.85 mcg/100g), vitamin B-6 (1.12 mg/100g), and vitamin B-2 (5.4 mcg/100g). Similarly, mineral elements composition revealed high amount of minerals including potassium (647.2 mg/l), calcium (176.6 mg/l), iron (30.9 mg/l), magnesium (22.5 mg/l), phosphorous (84.2 mg/l), sodium (414.2 mg/l), zinc (1.4 mg/l), copper (0.7 mg/l), manganese (1.06 mg/l) and selenium (0.53 mg/l).

Keywords: *Hippophae rhamnoides L.,* high altitude, nutrition, Seabuckthorn

1. INTRODUCTION

A significant portion of world's geography lies above 10,000 feet above mean sea level, an arbitrary designation that separates moderate and high altitude. Some of these mountainous high altitude lands are populated by indigenous people. Due to strategic reason and unique landscape, a large number of soldiers, adventurers, and tourists from low land travel to high altitude for work or recreation, exposing themselves to several environmental challenges. Physiological stresses from reduced partial pressure of oxygen, cold temperature, intense solar radiation, high winds, difficult terrains, and a lack of nutritious diet, all contribute to decrease physical and mental performance at high altitudes.

Nutritional requirement of the people, who travel to high altitude, forms an important consideration for maintaining highest level of mental and physical fitness. Due to environmental factors, the nutritional requirements at high altitude are different from that of sea level. Increased energy expenditure ranging, from 6.9 per cent to 25 per cent has been reported at high altitude[1,2] primarily due to increase in basal metabolic rate during initial days of acclimatization. Heavier load carried by the people as cold protective garments and efforts in walking on snowbound hilly terrains also demands high energy expenditure[3]. The energy expenditure by Indian troops at 2700 to 4500 m and >4500 m works out to 3800 kcal/day and 4270 kcal/day, respectively as compare to 3511 kcal/day at sea level. Negative nitrogen balance is reported at high altitude mainly due to decrease in food intake. Investigation on nitrogen metabolism during acute induction and after long-term stay at high altitude of Indian soldiers indicates positive nitrogen balance at dietary intake of 75 g protein. As regards the electrolyte balance, increased urinary excretions of Na^+ and K^+ on exposure to hypoxia are reported by some workers[4-6], while others[7,8] have found only increase in Na^+ with decrease in K^+ excretion. Chatterjee[9], *et al*. have found decrease level of magnesium and calcium excretion along with increased level in serum during acute hypoxic exposure in human at altitude of 3770 m. Urinary excretion of Zn^+ is found more during an expedition to Mt Everest. Reduced zinc level is associated with anorexia. There is no evidence to show any increase requirement of iron[10]. A balance between the blood formation and destruction at high altitude is found and it is documented that 10 mg to 15 mg of iron along with the blood stores could meet the needs of increased hemoglobin synthesis during course of physiological readjustment, those take place at the time of early phase of high altitude stay[11]. It is therefore, possible to achieve normal balance of most of the ions at high altitude with adequate intake of mineral-rich diet.

A considerable body of literature exists documenting that the production of free radicals increases in human

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exposed to the environment associated with high altitude. Free radicals may be very damaging since these induce oxidation, which causes membrane damage, protein modification, and DNA damage. Thus, oxidative damage is considered to play a causative role in aging and several degenerative diseases associated with it, such as heart disease, cataracts, cognitive dysfunction and cancer[12]. Potential sources of stressors that might elicit the oxidative stress response at high altitudes include exercise, ultra violet radiation, catecholamines, anoxia/reoxygenation, hypoxanthine, xanthine oxidase, and reductive stress. In addition to the natural constraints, nutritional needs play a vital role[13]. The defence system, that prevents the body from free radicals' damage, is called as antioxidants. Human being have evolved antioxidant systems to protect against free radicals. These systems include some endogenous antioxidants produced in the body and exogenous antioxidant obtained from the diet. Well-established dietary antioxidants are vitamin C, E, A, and carotenoids. Besides these antioxidants, other substances in plants such as polyphenols are an important class of defence antioxidants. Antioxidant nutrients as well as selenium, copper, zinc, and manganese may, therefore, be required in greater amount in high altitude environment to prevent oxidative stress. These antioxidants act in a concerted manner to combat the oxidative stress arising from different sources. β-carotene protects against photo-immuno-suppression caused by long-wave UV radiation encountered in outdoor condition[14]. Antioxidant vitamin C is recommended in high altitude during rough weather when supply of fresh fruits and vegetables becomes limited[15,16].

Providing required nutritional support to those who travel to high altitude need to take into consideration local availability of food material with desired nutritional qualities. Due to difficult terrain and logistic constraints at high altitudes, it is not always possible to ensure supply of fresh fruits and vegetables from low land. Among the fruits and vegetable that grow at high altitude, seabuckthorn is a promising plant species, which has potential to meet diverse nutritional needs at high altitudes thereby contributing towards ameliorating high altitude maladies.

Figure 1. Seabuckthorn fruit berry.

Seabuckthorn (*Hippophae rhamnoides* L.) is a unique and valuable plant species for cold arid region. It bears red, orange or yellow fruit (Fig. 1). Every part of the plant, viz., fruit, leaf, twig, root, and thorn has been traditionally used as medicine, nutritional supplement, fire wood, and as fence. Seabuckthorn fruits are among the most nutritious of all berries and have immense medicinal properties. The plant has been extensively exploited for treatment of sluggish digestion, stomach malfunctioning, thrombosis, hepatic injury, tendon and ligament injuries, ulcer and cancer. Seabuckthorn extract possess antibacterial activities and also shows protective effect against the toxic effect of mustard gas, a chemical warfare agent. It has potential to play a crucial role in the development of cold arid fragile areas and provides nature's cure to a number of diseases.

Many of the claims associated with seabuckthorn are related to high nutritive value in terms of vitamins, carbohydrate, macro and micronutrient elements. The present study is an attempt to assess biochemical composition of seabuckthorn growing in Leh valley in Trans-Himalaya. Such information is expected to help people who travel to high altitude to use locally available wild fruit for offsetting some of the deleterious effects of stay at high altitude through nutritional supplementation. The result of this study will also help in optimising the composition of various seabuckthorn products and to identify the mechanisms behind the physiological effects.

2. MATERIALS AND METHODS

Fresh and ripe fruit berries were manually collected during September 2008 from 96 randomly selected healthy mother plants from Leh valley in Trans-Himalaya. Equal quantities of the berries from each plant were pooled together and juice was extracted. The biochemical constitutes and mineral element composition of the pooled sample was performed following standard methodologies. The parameters studied along with standard test methods were moisture (IS 4706:1978); total sugar (IS 4079:2000); minerals including calcium, iron, manganese, phosphorous, potassium, sodium, zinc, copper, manganese, selenium (AOAC). Vitamins including riboflavin, niacin, pantothenic acid, vitamin B-6, vitamin B-12, vitamin A, vitamin E, vitamin C were determined by High Pressure Liquid Chromatography technique while energy was determined by National Institute of Nutrition standard technique.

3. RESULTS AND DISCUSSIONS

The nutritive value of seabuckthorn berries of cold desert Leh valley is summarised in Table 1. The nutritive values of other important fruit crops like mango, apricot, banana, orange and peach are also presented in the Table for comparison. Energy release by 100 g seabuckthorn berry pulp was 62.9 kcal, which is higher than that of apricot (48 kcal), orange (45 kcal) and peach (39 kcal). It contains 2.86 per cent total sugar of which glucose and

Table 1. Nutritional value of seabuckthorn pulp and its comparison with raw mango, apricot, banana, orange juice, peach

Constituents	Fruit crops					
	Sea buckthorn	Mango[20]	Apricot[20]	Banana[20]	Orange[20]	Peach[20]
Moisture, %	83.94	81.71	86.35	74.91	88.3	88.87
Energy, kcal/100g	62.9	65	48	89.0	45	39
Total sugar, %	2.86	14.8	9.24	12.23	8.4	8.39
Minerals						
Calcium, mg/l	176.6	100	130	50	110	60
Iron, mg/l	30.9	1.3	3.9	2.6	2.0	2.5
Magnesium, mg/l	22.5	90	100	270	110	90
Phosphorous, mg/l	84.2	110	230	220	170	200
Potassium, mg/l	647.2	1560	2590	3580	2000	1900
Sodium, mg/l	414.9	20	10	10	10	0
Zinc, mg/l	1.4	0.4	2.0	1.5	0.5	1.7
Copper, mg/l	0.7	1.1	0.78	0.78	0.44	0.68
Manganese, mg/l	1.1	0.27	0.77	2.7	0.14	0.61
Vitamins						
Riboflavin, mg/100g	1.45	0.057	0.04	0.073	0.030	0.031
Niacin, mg/100g	68.4	0.584	0.6	0.665	0.4	0.806
Pantothenic acid, mg/100g	0.85	0.160	0.24	0.334	0.19	0.153
Vitamin B-6, mg/100g	1.12	0.134	0.054	0.367	0.04	0.025
Vitamin B-12, mcg/100g	5.4	0	0	0	0	0
Vitamin C, mg/100g	275	27.7	10.0	8.7	50.0	6.6
Vitamin A, IU/100g	432.4	765	1926	64.0	200	326
Vitamin E, mg/100g	3.45	1.12	0.89	0.1	0.04	0.73

fructose accounts for 86.3 per cent. The seabuckthorn berries therefore contain lesser sugar than other fruits.

Seabuckthorn is rich in antioxidant vitamins including vitamin C, E, and A. The seabuckthorn pulp of Leh valley region contains 275 mg vitamin C per 100g pulp. In comparison to other fruits, seabuckthorn as a rich source of vitamin C is evident. Vitamin C is a natural water-soluble antioxidant which inhibits peroxidation of membrane phospholipids and acts as scavenger of free radicals[17]. It also plays a major role in regeneration of vitamin E. The vitamin E content of the pulp was found 3.54 mg/100g, which is higher than that of mango (1.12 mg), apricot (0.89 mg), banana (0.1 mg), orange (0.04 mg) and peach (0.03 mg). Vitamin E is a fat-soluble vitamin known to be one of the most potent antioxidant. It breaks the propagation of the free radical chain reaction in the lipid of biological membrane[18]. Deficiency of vitamin E influenced the endogenous antioxidant, system and hence, important in high altitude diet. The antioxidant vitamin A concentration in seabuckthorn was found 432.4 IU/100g which is higher than that of banana (64), orange (200) and peach (326). The vitamin possesses antioxidant activity somewhat analogous to that of vitamin E and therefore forms important constituent of high altitude diet. There are indications that oxidative stress is a causative factor in health hazards associated with high altitude including chronic or intermittent hypoxia, acute mountain sickness (AMS), high altitude pulmonary edema (HEPE) and high altitude cerebral edema (HACE). Antioxidant supplementation in the diet, therefore, forms an important consideration to reduce oxidative stress at high altitude. The body endogenous antioxidant system is somewhat decreasing at high altitude. It appears that exposure to high altitude decreases the activity and content of some antioxidant enzymes. Moreover, the effectiveness of thiol system is also reduced by high altitude. High UV radiation, which increases with increase in altitude, results in enhanced free radical formation contribute to oxidative stress. There are indications that antioxidant supplementation seems to be an important and natural tool to reduce the induced oxidative stress[19].

Seabuckthorn pulp also contains high amount of riboflavin (1.45 mg/100g), niacin (68.4 mg/100g), pantothenic acid (0.85 mcg/100g), vitamin B-6 (1.12 mg/100g), and vitamin B-2 (5.4 mcg/100g) in comparison to other fruits (Table 1). Source of multivitamin from a single fruit type is of special interest in cold desert, high altitude environmental conditions. Difficult terrain and logistic constrains at high altitude often pose problem in making available fresh fruits and vegetables, especially during winter months. Therefore, seabuckthorn products can act as locally available alternate substitute to fresh fruits and vegetables to meet nutritional requirements at high altitudes.

Seabuckthorn is rich source of minerals. Potassium (647.2 mg/l) is the most abundant of all the elements investigated. Mineral element composition revealed a high content of calcium (176.6 mg/l), iron (30.9 mg/l), magnesium (22.5 mg/l), phosphorous (84.2 mg/l), sodium (414.2 mg/l), zinc (1.4 mg/l), copper (0.7 mg/l), manganese (1.06 mg/l) and selenium (0.53 mg/l) (Table 1). The seabuckthorn content of calcium, iron, sodium, zinc and manganese is much higher than mango, apricot, banana, orange and peach. Requirement of mineral is generally high at high altitude condition because of increased excretion of electrolytes. There is a greater requirement of selenium, copper, zinc and manganese at high altitude to prevent oxidative stress. Use of seabuckthorn as nutritional supplement can help to maintain a normal balance of most of the ions.

4. CONCLUSIONS

Seabuckthorn is a rich source of vitamins and mineral elements. High content of vitamins and minerals in a single fruit type is of special interest in difficult terrain of high altitude with logistic constraints. The berries are a good source of antioxidant vitamins as well as minerals like copper, zinc and manganese which are required in greater amount at high altitude environment to prevent oxidative stress. Nutritional analysis of seabuckthorn berries suggests that the fruit can fulfill most of the nutritional requirements at high altitude. Consumption of the berries also indicates attenuating at least a portion of high altitude induced oxidative damage. The efficacy of seabuckthorn in human facing hostile high altitude environmental conditions needs evaluation.

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