Dehydration of Green Leafy Vegetable: Review

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***Abstract*- India rank second in vegetable production in the world. Green leafy vegetable are mostly are seasonal so that they can not be available throughout the year. Dehydration is the best option to preserve the green leafy vegetable during abundant production. Dehydrated green leafy vegetables are rich in protein, total phenolics compounds, natural antioxidants, vitamins, minerals and fiber so it can be used in different products for enrichment. Dehydration process concentrates the nutrients. Blanching is one of the pretreatment given to vegetable before dehydration to minimize the microbial load and deactivate the enzymatic activity to prevent the browning reaction. Iron deficiency is the common problem developing countries and the green leafy vegetable is the rich source of iron. Dehydrated vegetable powder can be used in different traditional as well as commercial products for value addition purpose.**

***Index Terms* – Ascorbic acid, Blanching, Dehydration, Green leafy vegetables, Traditional products**

I. INTRODUCTION

India's diverse climate ensures availability of all varieties of fresh fruits and vegetables. India ranks second in fruits and vegetables production in the world, after China. In India more than 40 kinds of vegetables belonging to different groups, like Solanaceous, Cucurbitaceous, Leguminous, Cruciferous, root crops and leafy vegetables are grown in tropical, subtropical and temperate regions. As per National Horticulture Database published by National Horticulture Board of india, during 2012-13 India produced 162.19 million metric tonnes of vegetables with cultivated area of 9.21 million hectares [1]. The leafy vegetables are highly perishable in nature and therefore have very short shelf life. Green leafy vegetables represent an excellent component of the habitual diet in the tropical and temperate countries [2]. Vegetables are important protective foods and highly beneficial for the maintenance of health and prevention of disease. Dietary fiber concentrates from vegetables showed a high total dietary fiber content and better insoluble and soluble dietary fiber ratios than cereal bran's [3]. Vegetable wastes are inexpensive, available in large quantities, characterized by high dietary fiber content resulting with high water binding capacity and relatively low enzyme digestible organic matter [4]. The green leafy vegetables are rich sources of vitamins as well as minerals and fiber [5]. Studies have repeatedly shown that increasing colon and stomach cancer correlate with low vegetable meals, and suggests that vegetables may help to resist these types of cancers [6, 7]. The dark green leaves and deep yellow fruits provide a high amount of carotene, ascorbic acid minerals which play an important role in nutrient metabolism and slowing down of degenerative diseases [8].

Green leafy vegetables occupy an important place among the food crops as these provide adequate amounts of many vitamins and minerals for humans. They are rich source of vitamin like β-carotene, ascorbic acid, riboflavin, folic acid and minerals like calcium, iron and phosphorous. In nature, there are many underutilized greens of promising nutritive value, which can nourish the ever increasing human population. Many of them are adaptive and tolerant to adverse climatic conditions. Although, they can be raised at lower management costs even on poor marginal lands, they have remained underutilized due to lack of awareness and popularization of technologies for utilization. Nowadays, underutilized foods are gaining importance as a means to increase the percapita availability of foods [9].

II. NEED OF DEHYDRATION OF GREEN LEAFY VEGETABLES

Being rich in nutrients the leaves of the vegetables may be utilized for the purpose of enrichment of nutritional inferior/deficient products. [10] reported that green leafy vegetables constitute an indispensable constituent of human diet. These

vegetables if not preserved within few days after harvest will begin to decay. In an attempt at preserving these vegetables from being decayed, drying as one of the oldest methods of food preservation is often used [11]. Drying like all methods of preservation, often result in loss of some nutrients. [12] reported Nutritional changes that occur during drying include the followings; Caloric content does not change, but is concentrated into a smaller mass as moisture is removed. No change into fiber content. Vitamin A fairly well retained under controlled heat methods. Vitamin C mostly destroyed during blanching and drying of vegetables. The water soluble vitamin like Thiamin, riboflavin, niacin destroyed slightly during blanching but fairly good retention. Minerals may be loss during dehydration if soaking water is not used. Iron is not destroyed by drying. There are many factors affecting the drying rate of the agricultural products. Among these factors, we have air temperature, the relative humidity and the air velocity and initial moisture content of the product. From literatures, the best range of temperature for drying fruits and vegetables is between 55 to 75°C. Many Pretreatments and methods employed before drying influence the physicochemical and enzymatic changes that occur during drying and help to enhance the keeping quality of dried products. Drying conditions including time, temperature and relative humidity influence the final quality of dehydrated product. Blanching is one of the pretreatment given to vegetable before drying to minimize the microbial load and deactivate the enzymatic activity to prevent the browning reaction. Some important works pertaining to the drying of vegetables and vegetable leaves are discussed below:

III. EFFECT OF BLANCHING ON QUALITY OF GREEN LEAFY VEGETABLE

Blanching is one of the pretreatment given to vegetable before drying to minimize the microbial load and deactivate the enzymatic activity to prevent the browning reaction.

[13] reported that blanching pretreatment did not improve the drying rate and rehydration capacity of dried lettuce leaves but influenced the colour of the final product. It has been reported that the blanching could reduce the greenness degradation of dried lettuce leaves.

[14] Studied the effect of various pretreatments and drying methods on coriander leaves. Coriander leaves were pretreated by dipping in potassium metabisulphite solution for 15 minutes at room temperature; blanching in boiling water for 30s followed by dipping for 15 minutes in solutions either of magnesium chloride (0.1%), sodium bicarbonate (0.1%) or potassium metabisulphite (2.0%) in water at room temperature; dipping for 15 minutes in solutions of magnesium chloride (0.1%) + sodium bicarbonate (0.1%) + potassium metabisulphite (2.0%) at 60°C. After pretreatments, the samples were dried in cabinet (55°C), open sun, forced convection air, domestic solar dryer with covered and uncovered trays, minimulti-rack solar dryer (45°C) and portable farm type solar dryer. The results indicated that, the pretreatments did not influence the time taken for drying. Minimum time was taken by cabinet drier while under open sun drying, domestic solar drier with uncovered trays and minimulti-rack solar drier took nine hours.

[15] studied the chlorophyll retention in dried coriander leaves. The leaves were blanched at 80°C for three minutes in hot water prior to drying under cabinet drier at 45, 50, 55, 60 and 65°C. The result shows that, hot water blanching significantly increased the chlorophyll retention. The retention of chlorophyll in the dried product decreased with the increase in temperature of drying and was at a maximum when leaves were dried at 45°C.

[16] carried out an experiment on dehydration of drumstick leaves. Drumstick leaves were subjected to steam blanching for three minutes and blanching followed by sulphitation for three minutes at room temperature and all the pretreated leaves were shade dried. It has been reported that the time taken for drying to a constant weight was less for unblanched leaves as compared to blanched and sulphited green leafy vegetables.

[17] studied the dehydration characteristics of four commonly consumed green leafy vegetables. The vegetables were cut into shreds and blanched in hot water at 90°C for two minutes and immersed in 0.2 per cent potassium metabisulphate solution. The blanched leaves when dried at 60 ± 2°C with 55-60 per cent relative humidity, required four hours for complete dehydration in cabinet drier and two days for drying under sun (25°C), to reach desired moisture level (9-10%).

[17] studied the effect of blanching on compositional quality of commonly consumed green leafy vegetables. The result revealed that, unblanched leaves showed lowered retention of chlorophyll as compared to blanched leaves. The maximum retention was observed for blanched bathu, while spinach had minimum. The blanched fenugreek, mustard leaves, bathu and spinach showed higher ascorbic acid content than the unblanched samples. The dietary fiber content was maximum in mustard leaves.

IV. EFFECT OF DEHYDRATION ON CHEMICAL COMPOSITION OF LEAFY VEGETABLE

Dehydration is a simple method of preservation of green leafy vegetables. While it is of great importance to produce dehydrated vegetables without marked loss of nutrients during preparation and dehydration, it is equally important to prevent considerable losses during the period between dehydration and consumption.

[11] studied the effect of solar drying on the quality of three species of vegetables namely amaranthus, vernonia and fluted pumpkin. Proximate analysis and microbial load analysis were carried out on the vegetable samples after each day of drying for a total of 5 days. The solar irradiation for the period varied from 89 W/m^2 to 203 W/m^2. Both analyses reveal that the nutritional composition of the fresh vegetable and their microbial load decreases with each day of drying. However, for storage purposes, two days of drying is sufficient to prevent spoilage and at the same time retain an average 70% of fat, 80% ash, 70% carbohydrate, and 60% protein of their initial nutritional composition.

[18] studied the effect of different methods of dehydration on composition of green leafy vegetables. Fenugreek, shepu, spinach, rajagira and kiraksali leaves were subjected to pretreatments viz., blanching (1 min), sulphitation (1 min), blanching and sulphitation. The leaves were then dried under microwave oven (2250 MHz frequency, at 100% power), hot air oven (60°C), sun (38-42°C) and shade (24.5-25°C) drying. The results revealed that, rehydration ratio was found to be higher in microwave dried leaves (6.29) while sun dried samples exhibited lowest (4.10) irrespective of pre-drying treatments. Microwave drying of rajagira resulted in highest chlorophyll content (12.40 mg/g) irrespective of the treatments followed by drying in hot air oven (12.38 mg/g), and sun drying resulted in minimum chlorophyll content (6.85 mg/g).

[19] assessed the effects of drying conditions on the quality of dehydrated leafy vegetables. The leaves were blanched and dried under cabinet (58-60°C), (40-50°C, 60-80% RH) and low temperature drier (40 ± 2°C and 25-40% RH). The moisture content was found to be higher in dried drumstick leaves dried in cabinet (5.5%), solar (6.1%) and low temperature (6.7% driers). Ascorbic acid and chlorophyll contents were maximum in curry leaves (212.4 and 130.3 mg/100g respectively) and minimum in palak (14.2 and 70mg/100g).

[20] studied on leaves of savoy beet (Beta vulgaris var bengalensis), amaranth (*Amaranthus tricolor*) and fenugreek (*Trigonella foenum graecum*) and subjected to different blanching and drying treatments to establish the retention of β-carotene, ascorbic acid and chlorophyll. The vegetables were blanched at 95°C for 3min. in (I) water, (ii) water followed by potassium metabisulphite (KMS) dip, (iii) salt solution, (iv) salt solution followed by KMS dip, and (v) mixture of sodium bicarbonate, magnesium oxide and KMS and dried in (a) sun, (b) shade, (c) solar drier, (d) cabinet drier, and (e) low temperature drier. Method (ii) was found most suitable for blanching and selected for subsequent drying and method (e) had least drastic effect on β-carotene, ascorbic acid and chlorophyll content of the processed product.

[21] investigated the effect of dehydration on nutritional composition of green leafy vegetables, herbs and carrot. The leaves and carrot were blanched for 10-15 s and one minute respectively, followed by drying in hot air oven at 40 ± 5°C for four to six hours and 50 ± 5°C for 16-18h respectively. The results revealed that, dried mint and cauliflower leaves possessed higher amounts of protein (30.99 and 29.98% respectively) compared to coriander (22.34%), bengal gram leaves (26.17%) and carrot (9.82%) whereas ascorbic acid content was higher in amaranthus (96.92 mg/100g). β-carotene retention was found to be higher in spinach (60.25mg/100g). Bengal gram leaves had maximum retention of total and ionizable iron (84.44 and 4.65 mg/100g).

[22] studied effect of dehydration of green leafy vegetables provitamin A i.e on β-carotene content. Irrespective of pretreatment and drying, harvi

recorded highest amount of β- carotene (6832.97µg/100g) while hakkarki registered lower values (1545.34 µg/100g). Among pretreatments blanched harvi retained 88 percent and hakarki had lower retention of 61 percent. Sulphited harvi and hakarki retained 92.41 and 65.36 % respectively. Sulphited leaves recorded significantly higher β-carotene values than blanched samples.

[23] studied the quality changes in pretreated dehydrated dasheen leaves. The results revealed that, drying at 40-70°C and under natural convection resulted in complete loss of vitamin-C (91.6 to 93.0 %). Under forced convection, it ranged from 81.8 to 72.6 percent. Ascorbic acid losses increased by blanching in steam, water and magnesium carbonate infusion prior to dehydration. This was reduced under forced convection drying and was particularly evident for the steam, water and unblanched dehydrated vegetables.

[24] carried out an experiment to study the effect of home processing on ascorbic acid and β-carotene of spinach and amaranth leaves. The leaves were divided into batches and processed, which includes drying in oven at 65°C and sun for 10h, after blanching for 5, 10 and 15 minutes. All the samples were analyzed for ascorbic acid and β-carotene content. The results indicated that, loss of ascorbic acid was 83.4 and 82.5 % (amaranth leaves) and 90.5 and 90.0 % (spinach) on sun and oven drying respectively. On the other hand, loss of β-carotene was higher (49%) in both the leaves on sun drying compared to oven drying (14%). Blanching for 15 minutes exhibited 93.2 (spinach) and 92.6 % (amaranth leaves) loss of ascorbic acid, while five minutes blanching lead to approximately 52 % loss in both the leaves. About 26 and 24.2 % loss was registered on blanching for 15 minutes in spinach and amaranth leaves respectively and approximately 8.3 % loss was observed in both the leaves on five minutes blanching.

V. EFFECT OF DEHYDRATION ON SENSORY QUALITY OF DEHYDRATED VEGETABLE

Some of the studies related to effect of dehydration on sensory quality of dehydrated vegetables are reviewed below

[25] studied the effect of processing on sensory quality of curry leaves. He concluded that The leaves dried at ambient condition retained maximum green color and aroma followed by convectional drying at 40°C and sun drying. Drying at 100, 140 and 180°C exhibited better flavor but leaves turned brown.

[19] studied effect of drying conditions on the sensory quality of dehydrated green leafy vegetables. Amaranth, fenugreek, spinach and curry leaves were blanched, dried under cabinet drier, solar drier and further evaluated for overall acceptability. The results revealed that, all the green leafy vegetables dried under cabinet drier received excellent scores for sensory quality. Amaranth was excellent in color, flavor and good in texture. Curry leaves and palak scored excellance in flavor and texture while good in color.

[26] revealed that, the acceptability of rehydrated green leafy vegetables ranged from average to excellent. It was found that blanching prior to dehydration, retained bright green color of the leaves. However, the original flavor could be retained in gogu and amaranth compared to curry leaves and mint.

[17] studied the sensory evaluation of rehydrated green leafy vegetables on a four point scale. A desirable color was obtained in cabinet drying while that of sun dried products was unacceptable. Flavor of sun dried vegetables were scored higher compared to cabinet dried. The overall acceptability of cabinet dried fenugreek and spinach was better than sun dried. But in case of bathu and mustard leaves drying methods did not influence the sensory quality.

VI. UTILIZATION OF DEHYDRATED GREEN LEAFY VEGETABLES INTO PRODUCTS DEVELOPMENT

Multiple micronutrient deficiencies are more common than single deficiencies in developing countries and there is their high prevalence of low dietary intake by populations. Iron deficiency is the most common nutritional problem worldwide, and contributes to maternal deaths in pregnancy [27]. The principle manifestation of iron deficiency is anemia. Iron deficiency also compromises the immune system and is associated with limited cognitive development in children. [28] reported that among preschool aged children worldwide, 23% suffer from iron deficiency anemia. [29] reported that in India, 79% of children between 6 to 35 months and women between 15 to 49 years of age are anemic. The food based approach for

combating micronutrient malnutrition, is difficult and of a long duration, although its effect is predicted to be long lasting. Green leafy vegetables are nature's gift to mankind they provides more nutrients. Green leafy vegetable are the inexpensive sources of micronutrients, however their utilization seems to be limited either due to ignorance or the inability to use them in many products to overcome this malnutrition problem the number of researchers have conducted studies on drying of vegetables and utilized the dehydrated vegetable for the preparation of various products either as main or supporting ingredient which can be incorporated in various forms. Some of the studies related to uses of dehydrated vegetable in some products are reviewed below.

[27] studied on utilization of micronutrient-rich dehydrated green leafy vegetables in formulation of traditional products. Annae (*Celosia argentea*) and curry leaf (*Murraya koenigii*) were steam-blanched after chemical pretreatment and dried in an oven. Dried greens were analyzed for proximate analysis, anti-nutrients and bioavailable minerals. Dehydrated greens were incorporated into Dhokla and chutney powder at 4, 8 and 12 % levels. Analysis of chemical composition showed no significant losses in the proximate and anti-nutrient contents of dehydrated greens. It was observed that addition of dehydrated greens increased the nutrient content of all products.

[9] studied on preparation of value added products from the leaf powders of dehydrated less utilized green leafy vegetables. Leaf mixtures (LM) prepared from the less utilized leaves of beet root (*Beta vulgaris*), carrot (*Daucus carota*), cauliflower (*Brassica oleracea*) and turnip (*Brassica rapa*) which are usually discarded or are used as animal fodder in this study, these leaves were used for preparation of value added products and concluded that development of products based on these vegetables will increase the nutritional value of the regular Indian diet.

[30] studied acceptability of recipes prepared from different varieties of betel leaves. Three recipes namely coconut burfi, cutlet and muthia were developed and the recipes prepared from spinach served as control.

[26] studied the sensory qualities of the dehydrated leaf powders and blends. The dried leaves were powdered and incorporated in various recipes either alone or in blended combination. The products were evaluated by the trained panel of judges on a five point scale. From the evaluation it was evident that all recipes and blends of powder were rated good (4) with respect to color, appearance, texture or consistency, taste, flavor and overall acceptability.

[16] studied retention of β-carotene in the products of dehydrated drumstick leaves. The cleaned leaves were dehydrated and rehydrated prior to use in recipes. Percent incorporation of dried leaves varied in three different products namely a shallow fried product dhebra (6%), steamed product muthia (14%) and boiled soup (19%). The products were most acceptable by the panel members. Incorporation of dehydrated leaves into recipes resulted in losses of β-carotene which amounted to about one-third in shallow fried and steamed recipes but was much higher (about two-third) in the soup.

VII. CONCLUSION

Dehydration is one of the best methods of preservation of green leafy vegetables. Being rich in essential micro - nutrients the green leafy vegetables can be utilized for the purpose of enrichment of nutritional deficient products. Pretreatment like blanching is also responsible for the retentation of the nutrients. During blanching it was observed that retentation of β - carotene occurs. Dehydrated green leafy vegetable powder can be used in many traditional as well as commercial products for value addition purpose to overcome the health related problems.

REFERENCES

[1] http://www.apeda.gov.in/apedawebsite/six_head_product/FFV.htm, **"**Fresh Fruits & Vegetables," 2013.

[2] A. C. K. Kumar, M. S. Divya Sree, A. Joshna, S. Mohana Lakshmi, D. Satheesh Kumar, "A review on south indian edible leafy vegetables," Journal of Global Trends in Pharmaceutical Sciences Volume 4, Issue 4, pp -1248-1256, 2013.

[3] N. Grigelmo-Miguel & O. Martin-Belloso, "Comparison of dietary fibre from by-products of processing fruits and greens and from cereals," LWT – Food Science and Technology, 503–508, 1998.

[4] A. Serena & B. Kundsen, "Chemical and physicochemical characterisation of co-products from vegetable food and agro industries,"

Animal Feed Science and Technology, 139, 109–124, 2007.

[5] Fathima, K. Begum and D. Rajalakshmi, "Microwave Drying of selected greens and their sensory characteristics," Plant food for human nutrition 56: 303-311, 2001.

[6] E. N. Whitney, E. M. N Hamilton and S. R. Rolfes, "Understanding Nutrition," (5th edn).West publishing Company, St. Paul, USA, p.543,1990.

[7] S. S. Gropper, J. I. Smith and J. I. Groff, "The antioxidant nutrients, reactive oxygen species and disease in advanced nutrition and human metabolism," 4th edition, Thomson Wadsworth, Belmont, pp.368 – 377, 2005.

[8] Yi-Fang, S. Jie, W. U. Xian-Hong and L. Rui-Hai, "Antioxidant and antiproliferative activities of common vegetables," Rev., Journal of agricultural food chemistry. 50: 6910 -6916, 2002.

[9] P. Joshi and B. Mathur, "Preparation of value added products from the leaf powders of dehydrated less utilized green leafy vegetables" Journal of horticulture and forestry volume. 2(9) pp. 223 – 228, 2010.

[10] T. Oguntona and C. R. B. Oguntona, "Proximate Composition of three leafy vegetables Commonly in North-eastern Nigeria," M.Sc (Biochemistry) Thesis, University of Ibadan, Nigeria. 1985 (Unpublished), 1985.

[11] Awogbemi, Omojola and Ogunleye, I. Olusola, "Effects of drying on the qualities of some selected vegetables," IACSIT International Journal of Engineering and Technology Vol.1, No.5, ISSN: 1793-8236, 2009.

[12] P. Kendall, P. DiPersio and J. Sofos, "Drying Vegetables" Available: http://www.ext.colostate.edu/PUBS/FOODNUT, 2006.

[13] P. Duangrat and S. Prasong, "Effect of pre-treatments on drying characteristics and colour of dried lettuce leaves," Asian journal of food and agro - industry. 3(06), 580-586, 2010.

[14] P. Kaur, A. Kumar, S. Arora, and G. B. Singh, "Quality of dried coriander leaves as affected by pretreatments and method of drying," 223: 189-194, 2006.

[15] J. Ahmed, U. S. Shivhare and G. Singh, "Drying characteristics and product quality of coriander leaves," Trans I Chem E, 79: 103-106, 2001.

[16] S. Seshadri, M. Jain and D. Dhabhai, "Retention of storage stability of β-carotene in dehydrated drumstick leaves (*Moringa olifera*)" International journal of food science and nutrition, 48: 373-379, 1997.

[17] H. Singh, A. S. Bawa, and J. Ahmed, "Dehydration characteristics of green leafy" Indian Food Packer, 51 (2): 5-13, 1997.

[18] S. L. Karva, "Enrichment of traditional foods with green leafy vegetables for iron security of adolescent girls," M.H.Sc. Thesis, Uni. Agri. Sci., Dharwad, 2008.

[19] U. Singh, V. R. Sagar, T. K. Behera and S. P. Kumar, "Effect of drying conditions on the quality of dehydrated selected leafy vegetables" Journal of food science and technology, 43(6): 579- 582, 2006.

[20] P. S. Negi and S. K. Roy, "Effect of Blanching and Drying Methods on b-Carotene, Ascorbic acid and Chlorophyll Retention of Leafy Vegetables" Lebensm.-Wiss. u.-Technol., 33, 29, 2004.

[21] G. Singh, Kawatra Asha, S. Sehgal and Pragati, "Effect of storage on nutritional composition of selected dehydrated green leafy vegetable powders" Plant Foods for Human Nutrition, 58: 1-9, 2003.

[22] A. S. Seema, "Effect of processing and storage on ß-carotene content of selected fruits and vegetables" M.H.Sc. Thesis, University of agriculture and science, Dharwad, 1997.

[23] V. Maharaj and K. C. Sankat, "Quality changes in dehydrated dasheen leaves: effects of blanching pre-treatments and drying conditions," Fd. Res. Int, 29 (5-6): 563-568, 1996.

[24] S. K. Yadav and S. Sahgal, "Effect of home processing on ascorbic acid and β- carotene content of spinach (*Spinacia oleracia*) and amaranth (*Amaranthus tricolor*) leaves," Plants Foods for Human Nutrition, 47: 125-131, 1995a.

[25] M. D. Manchekar, U. M. Zende and K. R. Naik, "Processing and value addition to curry leaves through drying and dehydration," International Drying Symposium, pp.706-708, 2008.

[26] Lakshmi and V. Vimala, "Nutritive value of dehydrated green leafy vegetable powders,"

Journal of food science and technology, 37 (5): 456-471, 2000.

[27] S. Gupta and J. Prakash, "Nutritional and sensory quality of micronutrient-rich traditional products incorporated with green leafy vegetables," International Food Research Journal, 18: 667-675, 2010.

[28] A. Gegios, R. Amthor, B. Maziva-Dixon, C. Egesi, S. Mallowa, R. Nungo, S. Gichuki, A. Mbanaso and M. J. Manary, "Children consuming cassava as a staple food are at risk for inadequate zinc, iron, and vitamin A intake," Plant Foods for Human Nutrition 65: 64-70, 2010.

[29] K. Krishnaswamy, "The problem and consequences of the double burden- brief overview," Programme and abstracts, Symposium on Nutritional Security for India- Issues and Way Forward, Indian National Science Academy, New Delhi, pp.5-6, 2009.

[30] P. Nande, S. Dudhmogre and S. A. Vali, "Evaluation of nutritive value and acceptability of recipes prepared from spinach and betel leaves," The Indian Journal of nutrition and dietics, 44: 476-483, 2007.