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Changes in quality of microwave blanched vegetables: A Review

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Abstract
Blanching is a heat treatment widely applied in the agro-food sector and particularly important in the processing of green vegetables. It increases the shelf life of fruits and canned food. The main objectives of blanching are: to inactivate the enzymes, prevent possible deterioration reactions, off-flavours and undesirable changes in colour; to reduce microbial load and to soften tissues to obtain products with specific texture. There are different types of blanching. Currently, hot water blanching is commercially adopted blanching method as it is simple and easy to implement. However, consumes large amount of water. In addition, water-soluble nutrients, such as vitamins, flavours, minerals, carbohydrates, sugars, and proteins, can leach out into the blanching water. As a further consequence, lowers somewhat the mass of vegetables thus process profitability can be affected by overtreatment. To mitigate those shortcomings, several novel blanching technologies have been developed and reported, e.g., Microwave blanching. It is considered as a dry technique, the volume of wastewater generated could be diminished and therefore losses of water-soluble nutrients could be minimized. It allows for efficient heat transfer, effectively inactivates deteriorative enzymes, better green colour retention. Microwave-blanched vegetables retain nutrients and provides better quality.

Keywords: blanching, microwave, enzyme inactivation, ascorbic acid content, flavor, color and quality

Introduction
Blanching is an important thermal treatment carried out before several preservation processes like drying, canning, freezing, and for the most part determines the product quality (Xiao *et al*., 2014) [43]. The main objectives of blanching are: 1) to inactivate the enzymes (such as oxidase, POD and polyphenol oxidase, PPO) to prevent attainable deterioration reactions, off-flavours and undesirable changes in color (Lago and Norena, 2014) [23]; 2) to reduce microbial load to prolong shelf-life (Afoakwa *et al*., 2013) [1]; 3) to eliminate air within the intracellular space to increase the rate of heat and mass transfer and prevent oxidization (Ruiz-Ojeda and Penas, 2013); [36] and 4) to soften tissues to get product with specific texture (Xiao *et al*., 2014) [43]. Moreover, proper blanching will result in generation of superficial micro-cracks, which may enhance moisture transfer throughout drying method (Filho *et al*., 2016; Wang *et al*., 2017) [17, 41].

With numerous necessary roles, blanching is widely employed in the food processing industry. There are different types of blanching like wet blanching and dry blanching. Currently, hot water blanching is the most typical commercially adopted blanching methodology because it is easy and simple to implement (Mukherjee and Chattopadhyay, 2007) [28]. In typical hot water blanching, product is immersed in hot water (from 70 ^{o} to 100^{o} C) for many minutes. The blanched samples are drained and cooled before being sent to subsequent process operation. In general, after a certain amount of blanching time, blanching water has to be replenished because it becomes saturated with nutrients leached from the product. This step not solely consumes large amounts of water however additionally causes excessive energy consumption (Bingol *et al*., 2014) [6]. To preserve color of the product and to inactivate microbial activity, chemical reagents like sodium sulfite and sodium metabisulfite are usually added to the blanching water. This makes it tougher to treat the spent water from the blanching operation. Also, water-soluble nutrients, like vitamins, flavours, minerals, carbohydrates, sugars, and proteins, will leach out from the plant tissue into the blanching water.

Commercial blanchers employed in the vegetable canning industry are relatively intensive in energy and water consumption. Energy utilization is affected by the instrumentation used and also by the configuration of the following freezing step. Moreover, conventional blanching produces waste water that reduces the nutritional value of vegetables via leaching of soluble compounds, and later increase the pollutant charge (Williams *et al*., 1986) [42]. The rise in demand of minimally processed and high-quality product has aroused the development of recent technologies that reduces the adverse effects of vegetable processing (Picouet *et al*., 2009; Ramesh *et al*., 2002) [31, 35]. Microwave blanching of vegetables is one amongst these technologies that appear to produce a much better nutrient retention than alternative conventional methods (Gunes and Bayindirli, 1993; Kidmose and Martens, 1999) [18, 22]. Thus, microwave processing may be an attractive alternative because of advantages like lower processing time or an improved heating efficiency. Moreover, microwave blanching is taken into account as a dry technique, the degree of waste generated might be diminished and thus losses of soluble nutrients might be reduced (Gunes and Bayindirli, 1993; Quenzer and Burns, 1981) [18, 33].

In Microwave blanching, polar materials absorb microwave energy and convert it into heat by dielectric heating caused by molecular dipole rotation and agitation of charged ions inside a high-frequency alternating electric field (Chandrasekarane *et al*., 2013) [10]. Microwave blanching offers some advantages such as volumetric heating, low nutrient loss and high-quality products (Bingol *et al*., 2014) [6]. It was determined that compared to steam or hot water blanching, microwave blanching resulted in higher antioxidant activity and better green color retention of asparagus (Sun *et al*., 2007) [40], required shorter processing times and yielded higher ascorbic acid retention in green beans (Ruiz-Ojeda and Penas, 2013) [36] and enhances antioxidant activity of pepper through the formation of derivatives of phenolics during blanching. (Dorantes-Alvarez *et al*., 2011) [14].

Here in this review, we are highlighting some relevant aspects of blanching and their types, microwave blanching, advantages and their effects on quality.

Types of blanching

Blanching may be categorized into dry and wet blanching based on requirement of water for the process (Fig. 1).

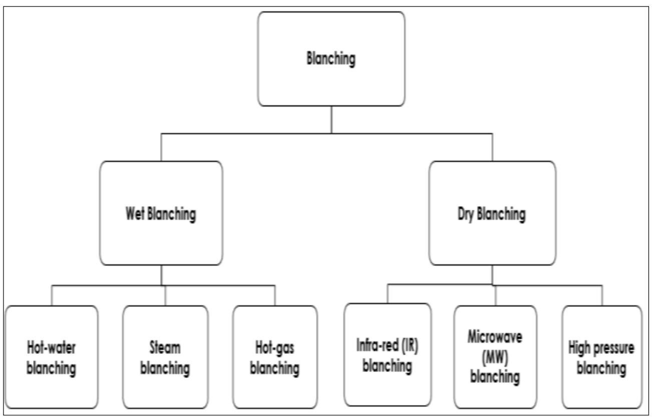

Fig 1: Types of blanching

1. Wet blanching

When water or steam is used to blanch samples then the technique is referred to as wet blanching. Furthermore, based on the type of water used, wet blanching again can be categorized as hot water blanching, steam blanching and hot gas blanching (Fig. 1).

Hot water blanching

It is performed at temperatures ranging typically from 70º to 100ºC. Techniques used for hot water blanching are: LTLT (low temperature for longer time), HTST (high temperature for shorter time) or a combination of both (Agblor and Scanlon, 2000) [2]. In typical hot water blanching, products are immersed in hot water (from 70º to 100°C) for several minutes. The blanched samples are drained and cooled before being sent to the next processing operation. This step not only consumes large amounts of water but also causes excessive energy consumption. (Bingol *et al*., 2014) [6]. In addition, water-soluble nutrients, such as vitamins, flavors, minerals, carbohydrates, sugars, and proteins, can leach out from the plant tissue into the blanching water.

Steam blanching

In steam blancher, a product is transported by a chain or belt conveyor through a chamber where ‘‘food-grade’’ steam at approximately 100°C is directly injected. Steam blanching is usually used for cut and small products. It is recommended for some vegetables like broccoli, pumpkin, sweet potatoes and winter squash. Each steaming and boiling are satisfactory methods. Steam blanching, however, takes about 1.5 times longer duration than hot water blanching. A combination of steam and hot water blanching is also in practice (Sheetal *et al*., 2008) [39].

Hot gas blanching

In hot gas blanching, combustion of flue gases and steam is employed to increase humidity and avoid product dehydration. It has the advantage of reducing waste production and is equivalent to conventional blanching with respect to nutrient retention. However, this usually leads to product weight loss. This approach is not presently employed in industries and need to be further investigated and optimized (Jack *et al*., 1973) [20].

There are many disadvantages of wet blanching. It requires longer processing time and a large amount of energy. As a result, there is a more leaching of minerals, nutrients, phytochemicals and flavour. Additionally, wet blanching creates high temperature gradients between the centre and the surface of the food product increasing chances of “over-blanching” or “under-blanching.” Also, wet blanching may cause undesirable changes in product texture and produce effluents with large biological oxygen demand (BOD). In order to overcome these disadvantages, dry blanching may be an alternative (Castro *et al*., 2008) [9].

2. Dry blanching

Dry blanching is achieved using microwaves (Kalathur *et al.*, 2013) [21] and high pressure (Matser *et al.*, 2000; Castro *et al.*, 2008) [25, 9]. It has been reported that dry blanching has many advantages over conventional blanching. These primarily include lower time required for the inactivation of enzyme complexes that cause degradation in quality and little or no leaching of vitamins, volatiles, pigments, carbohydrates and other water soluble components.

Infrared blanching

Infrared radiation energy with specific wavelengths penetrates the food product and directly heats the water and moisture in foods to achieve blanching effect and drying. Water in food absorbs heat energy very efficiently in the range of medium and far infrared wavelengths with peak wavelengths at 3, 4.7 and 6 µm (Zhongli and Griffith, 2010) [45]. It is highly effective for energy transfer to food since the medium IR and far IR energy does not heat the air and surrounding environment.

High pressure (HP) blanching

It is yet another alternative available for wet blanching techniques. It involves high pressure treatment of food products, normally contained in heat sealed packages. The pressure range is varied between 50 and 700 MPa, depending on the product characteristics, but generally between 100 and 200 MPa is recommended (Castro *et al*., 2008) [9]. Some high pressure blanching procedures also incorporate dipping the food product into liquids like citric acid. High pressure blanching has shown to be an efficient technique for inactivation of enzymes that can cause degradation, as shown in the case of inactivation of peach polyphenol oxidase enzymes when peach slices were treated with high pressure.

Microwave blanching

Microwaves are form of electromagnetic radiation with wavelengths ranging from about one meter to one millimeter; with frequencies between 300 MHz (1m) and 300 GHz (1mm). Microwaves are located between radio waves and infrared in the electromagnetic spectrum with a wavelength range of 1mm–30 cm. (Mudgett, 1986) [26]. Microwave frequencies of 915 MHz and 2.45 GHz can be utilized for industrial, scientific, and medical applications.

The importance of blanching is well-known. Research reports indicate that microwave blanched vegetables retain nutrients better when compared to conventional steam or water blanching (Quenzer and Burns, 1981; Muftugil, 1986) [33, 27] due to the reduction of leaching losses during blanching. Because of its thermal resistance, peroxidase is generally used as an indicator enzyme to evaluate the adequacy of blanching (Gunes and Bayindirh, 1993) [18].

The penetration ability of microwaves in foods is restricted. For normal wet foods, the penetration depth from one side is around 1-2 cm at 2450 MHZ. This suggests that the distribution energy inside the food will vary. The control of the heating uniformity of microwave process is difficult and is seen as the major drawback in its industrial application. A very important demand of microwave processing within the food industry is that the ability to properly control the heating uniformity. The varied factors influencing the heating pattern of the product are frequency of microwave processing, microwave power and speed of heating, mass of the product, mobility of the product within the oven (rotation/non rotation), moisture content of the product, density, dielectric constant of the product, physical geometry (size, thickness, shape), conductivity, and specific heat. These factors are mentioned by Schiffmann 1986 [37] and IFT in 1989. Continuous microwave heating of food materials has been reported to an uneven temperature distribution or native hot spots. This has restricted microwave processing of food materials. Pulsed microwave heating, intermittently turning the magnetron ON and OFF, will improve temperature uniformity of microwave-processed foods (Yang and Gunasekaran, 1998) [44]. This demands that any study associated with microwave processing ought to invariably include the study of temperature and absorbed power level distribution.

Several studies on microwave blanching, either severally or together with steam or water heating have been reported (Ramaswamy and Fakhouri, 1998) [34]. However, these studies haven't included the comparison of temperature distribution and vitamin retention under pulse microwave blanching. Microwave blanching causes heating of materials that have a dielectric medium. Alignment of dielectric materials towards the oscillating electromagnetic (EM) field causes heating effects. Once a microwavable container with food is placed in a microwave oven, the food at the edge of the container heats quicker and a temperature gradient develops between the Centre and also the edges.

Mechanism

Dipolar Interaction: Once microwave energy is absorbed, polar molecules like water molecules within the food can rotate in keeping with the alternating magnetic force field. The water molecule is "dipole" with one positively charged end and one negatively charged end. Similar to the action of magnet, these "dipoles" can orient themselves once they are subject to electromagnetic field. The rotation of water molecules would generate heat for cooking.

Ionic Interaction: In addition to the dipole water molecules, ionic compounds (i.e. dissolved salts) in food can even be accelerated by the electromagnetic field and collided with alternative molecules to supply heat. (Ohlsson, 1993) [29].

Advantages

Microwave blanching has been assessed over the years in an exceedingly sort of fruits and vegetables, and, in general, has been found to be superior to conventional blanching methods (Kidmose and Martens 1999; Ramesh *et al*., 2002) [22, 35].The main advantage of Microwave blanching system is that it is capable of creating heat internally and its bigger penetration depth too; attributable to that "retention" of thermolabile constituents is improved. Microwave blanching resulted in higher antioxidant activity and better green color retention (Sun *et al*., 2007) [40]. It has low nutrient loss and high-quality products (Bingol *et al*., 2014) [6]. Microwave blanching needs very little or no water for efficient heat transfer in food, it will reduce the amount of nutrients lost by leaching as compared with hot water immersion. In a nut shell, Microwave blanching considered as one of the most effective HTST systems for thermal treatment (Collins and McCarty, 1969; Dietrich *et al*., 1970) [12, 13].

Food quality

Quality characteristics of food includes appearance (size, shape, colour, gloss, and consistency), texture, and flavor etc. It is an important food manufacturing requirement. The colour of food is important for its acceptability (Eagerman, 1978) [15] and a slight change in the odour of processed food may affect the overall quality of the product (Vadivambal and Jayas, 2007) [11]. The quality changes that can happen during microwave blanching are described below.

Effects of microwave blanching on Weight loss

Weight loss is a serious problem for certain fruits and vegetables, which not only reduces the profitability but also has some negative effect on the product quality such as poor texture, shrinked shape and bad color. Ruiz-Ojeda and Peas (2013) [36] compared conventional hot-water and microwave blanching of green beans, and found that the water blanching had a higher weight loss than microwave blanching and the weight loss increased with the increasing of microwave power.

Effects of microwave blanching on moisture content

Muftugil (1986) [27] observed the effect of different types of blanching methods on moisture content of green beans. He noticed moisture uptake was less in microwave blanched samples than those blanched in water, steam and in the convection oven. Begum and Brewer (2001) [4] evaluated the effects of microwave blanching on moisture content of tomatoes prior to and after frozen storage. The lowest moisture content occurred in Microwave blanched tomatoes before (92%) and after (86%) frozen storage. After blanching, Microwave blanched tomatoes were lowest in moisture content. On the other hand, after frozen storage, Microwave blanched tomatoes continued to have the lowest moisture content followed by Steam blanched, boiling water blanched and microwavable blanching in boilable bag.

Effects of microwave blanching on enzyme activities

Many methods (boiling water, steam, microwave) have been shown to inactivate peroxidase in a variety of vegetables (Begum and Brewer, 2001) [5]. Microwave blanching effectively inactivates deteriorative enzymes. According to Ramesh *et al*., (2002) [35] when three vegetables, spinach, carrot, and bell peppers were blanched conventionally in water and using pulsed microwave at 95 ±2 ºC. Minimum adequate blanch time for 90% of the initial value of peroxidase enzyme inactivation was considered. The blanching times for this were different for different vegetables. They were comparable for microwave and water blanching of carrots and bell peppers, but were significantly different for a leafy vegetable such as spinach. As the pulsed microwave blanching was adopted restricting the temperature to less than 98ºC, the enzyme inactivation was slower as compared to that of water blanched or continuous (where the magnetron was ON throughout the blanching process) microwave blanched samples. When water blanching and pulsed microwave blanching results are compared, it is evident that, it takes a longer time for inactivation of enzyme in pulsed microwave heating. Ruiz-Ojeda and Penas, (2013) [36], found that the activity of PPO and POD of blanched samples decreased with increasing microwave power.

Effects of microwave blanching on vitamin C or ascorbic acid content

In vegetables, ascorbic acid is one of the most heat labile nutrients; it is water soluble, pH-, light and heat-sensitive and readily oxidizable by the naturally occurring enzyme system, ascorbic acid oxidase (Campbell *et al*., 1958; Brewer *et al*., 1994) [8, 7]. It is demonstrated that snow peas that were microwave blanched (MW) and those microwave blanched in a heat-sealed bag (MWB) retained more ascorbic acid than did unblanched snow peas or those blanched using conventional methods (Begum and Brewer, 2001) [4].

Muftugil, (1986) [27] compared both hot water and microwave blanching methods based on their effect on the retention of ascorbic acid in green beans. Microwave blanched samples showed better retention in ascorbic acid as compared with hot water blanched samples. Furthermore, superior retention of ascorbic acid in microwave blanched frozen spinach over hot water blanched sample has been reported (Ponne *et al*., 1994) [32]. Such higher retention rates of ascorbic acid are more likely due to blanching in minimal water for a reduced time using microwaves.

Effects of microwave blanching on flavor

Schnepf and Driskell (1994) [38] found that microwave cooked peas had more intense flavor scores than did boiled peas. It has been reported that microwave blanching in a bag resulted in umami flavor equivalent to peas that were steam or boiling water-blanched (Lin and brewer, 2005) [24].

Effects of microwave blanching on colour

Eheart and Gott (1964) [16] reported complete retention of the carotene in carrots heated in water in a conventional oven, and in a microwave oven with or without water. Although total carotene content does not change as vegetables are heated in water, there is a shift in the visual color: orange carrots may become more yellow, and red tomatoes may become orange-red (Penfield and Campbell, 1990) [30]. According to study conducted by Lin and Brewer (2005) microwave-blanched peas were adequate to or a lot of inexperienced than peas blanched by different ways, and that they attended to be darker than conventionally blanched peas. On comparing, microwave blanching to steam or hot water blanching, microwave blanching resulted in better green colour retention of asparagus (Sun *et al*., 2007) [40].

Effects of microwave blanching on sensory quality

Begum and Brewer (2001) [4] results imply that blanching snow peas in a very heat-sealable microwave bag, before frozen storage, produces a product of equivalent sensory quality and superior organic process quality compared with a lot of typical blanching ways.

Conclusion

The importance of blanching is well-known. It increases the shelf life of the food by decreasing the microbial load and lowering the concentration of enzymes that causes degradation Blanching has its own merits and demerits. Wet blanching lowers the nutritional value because of leaching. So, dry blanching like microwave blanching can be a better alternative to wet blanching. It needs very little or no water for efficient heat transfer in food. It was observed that it resulted in higher antioxidant activity and better green color retention. Furthermore, it required shorter processing times and yielded higher ascorbic acid retention. It could be concluded that vegetables blanched with microwave energy were more nutritious and of better quality than those heated to the same temperature by conventional water blanching.

References

1. Afoakwa EO, Mensah-Brown H, Hinneh M. Optimization of blanching time, sodium metabisulphite concentration and processing time on vitamin C content, microbial quality and sensory characteristics during canning of green pepper using response surface methodology. Journal of Food Science and Engineering. 2013; 3(6):285-298.
2. Agblor A, Scanlon MG. Processing conditions influencing the physical properties of French fried potatoes. Potato Research. 2000; 43:163-177.
3. Association of Official Analytical Chemists Inc. Official methods of analysis, 1990, 15th edition. Arlington, Virginia, USA.
4. Begum S, Brewer MS. Physical, chemical and sensory quality of microwave-blanched snow peas. Journal of Food Quality. 2001; 24:479-493.
5. Begum S, Brewer MS. Chemical, Nutritive and Sensory characteristics of tomatoes before and after conventional and microwave blanching and during frozen storage. Journal of Food Quality. 2001; 24:1-15.
6. Bingol G, Wang B, Zhang, A, Pan Z, McHugh TH. Comparison of water and infrared blanching methods for

processing performance and final product quality of French fries. Journal of Food Engineering. 2014; 121:135-142.
7. Brewer MS, Klein BP, Rastogi BK, Perry AK. Microwave blanching effects on chemical, sensory and color characteristics of frozen green beans. Journal of Food Quality. 1994; 17(3):245-260.
8. Campbell CL, Lin TY, Proctor BE. Microwave vs. conventional cooking: Reduced and total ascorbic acid in vegetables. Journal of American Dietetics Association. 1958; 34:365-369.
9. Castro SM, Saraiva JA, Lopes-da-Silva JA, Delgadillo I, Van Loey A, Smout C, *et al*. Effect of thermal blanching and of high pressure treatments on sweet green and red bell pepper fruits. Food Chemistry. 2008; 107(4):1436-1449.
10. Chandrasekaran S, Ramanatham S, Basak T. Microwave food processing-a review. Food Research International. 2013; 52:243-261.
11. Vadivambal R, Jayas DS. Changes in quality of microwave-treated agricultural products—a review. Biosystems engineering. 2007; 98:1-16.
12. Collins JL, McCarty IE. Comparison of microwave energy with boiling water for blanching of whole potatoes. Food Technology. 1969; 23(3):63-66.
13. Dietrich WC, Huxsoll CC, Guadagni DG. Comparison of microwave, conventional, and combination blanching of brussel sprouts for frozen storage. Food Technology. 1970; 24(5):105-109.
14. Dorantes-Alvareza L, Jaramillo-Floresa E, Gonzaleza K, Martinez R, Paradab L. Blanching peppers using microwaves. Procedia Food Science. 2011; 1:178-183.
15. Eagerman BA. Orange juice colour measurement using general purpose tristimulus colorimeters. Journal of Food Science. 1978; 43(2):428-43.
16. Eheart MS, Gott C. Conventional and microwave cooking of vegetables. Journal of American Dietetics Association. 1964; 44:116-119.
17. Filho LM, Frascareli EC, Mauro MA. Effect of an edible pectin coating and blanching pretreatments on the air-drying kinetics of pumpkin. Food and Bioprocess Technology. 2016; 9(5):895-871.
18. Gunes B, Bayindirli A. Peroxidase and lipoxygenase inactivation during blanching of green beans, green peas and carrots. Food Science and Technology. 1993; 26:406-410.
19. IFT. Microwave food processing; A scientific status summary by the IFT Expert panel on food safety and nutrition. Food Technology. 1989; 43(1):117-126.
20. Jack WR, Harry JM, Nabil LY, Douglas H, Mark Z, Walter AM. In-plant, continuous hot-gas blanching of spinach. Journal Food Science. 1973; 38:192-194.
21. Kalathur HV, Girish KG, Hebbar UH. Infrared assisted dry-blanching and hybrid drying of carrot. Food Bioproduct Processing. 2013; 91:89-94.
22. Kidmose U, Martens, HJ. Changes in texture, microstructure and nutritional quality of carrot slices during blanching and freezing. Journal of the Science of Food and Agriculture. 1999; 79:1747-1753.
23. Lago CC, Norena CPZ. Kinetic and thermodynamic of thermal inactivation of the peroxidase, polyphenol oxidase and inulinase activities during blanching of Yacon juice. Food and Bioprocess Technology. 2014; 7(12):3560-68.
24. Lin S, Brewer MS. Effects of blanching method on the quality characteristics of frozen peas. Journal of Food Quality. 2005; 28:350-360.
25. Matser AA, Knott ER, Teunissen PGM, Bartels PV. Effects of high isostatic pressure on mushrooms. Journal Food Engineering. 2000; 45:11-16.
26. Mudgett ER. Microwave properties and heating characteristics of foods. Food Technology. 1986; 40(6):84-93.
27. Muftugil N. Effect of different types of blanching on the colour, ascorbic acid, and the chlorophyll content of green beans. Journal Food Processing Preservation. 1986; 10:69-76.
28. Mukherjee S, Chattopadhyay PK. Whirling bed blanching of potato cubes and its effects on product quality. Journal of Food Engineering. 2007; 78(1):52-60.
29. Ohlsson T. Domestic use of microwave ovens. Encyclopaedia of Food Science Technology and Nutrition. 1993; 2:1232-1237.
30. Penfield PM, Campbell AM. Evaluation Food by Objective Methods. Handbook of Food Science, Technology, and Engineering. 1990; 3:28-29.
31. Picouet PA, Landl A, Abadias M, Castellari M, Vinas I. Minimal processing of a Granny Smith apple puree by microwave heating. Innovative Food Science and Emerging Technologies. 2009; 10:545-550.
32. Ponne CT, Baysal T, Yuksel D. Blanching Leafy Vegetables with Electromagnetic Energy. Journal of Food Science. 1994; 59(5):1037-1041.
33. Quenzer NM, Burns EE. Effects of microwave, steam and water blanching on freeze-dried spinach. Journal of Food Science. 1981; 46:410-413.
34. Ramaswamy HS, Fakhouri MO. Microwave blanching: Effect on peroxidase activity, texture, and quality of frozen vegetables. Journal Food Science Technology. 1998; 35:216-222.
35. Ramesh MN, Wolf Tevini WD, Bognar A. Microwave blanching of vegetables. Journal of Food Science. 2002; 67(1):390-398.
36. Ruiz-Ojeda LM, Penas FJ. Comparison study of conventional hot-water and microwave blanching on 361 quality of green beans. Innovative Food Science & Emerging Technologies. 2013; 20:191-197.
37. Schiffmann RF. Food product development for microwave processing. Food Technology. 1986; 40(6):94-98.
38. Schnepf M, Driskell J. Sensory attributes and nutrient retention in selected vegetables prepared by conventional and microwave methods. Journal of Food Quality. 1994; 17:87-99.
39. Sheetal G, Jyothi LA, Jamuna P. Effect of different blanching treatments on ascorbic acid retention in green leafy vegetables. Natural Product Radiance. 2008; 7:111-116.
40. Sun T, Tang J, Powers JR. Antioxidant activity and quality of asparagus affected by microwave-circulated water combination and conventional sterilization. Food Chemistry. 2007; 100:813-819.
41. Wang J, Fang XM, Mujumdar AS, Qian JY, Zhang Q, Yang XH, *et al*. Effect of high-humidity hot air impingement blanching on drying and quality of red pepper. Food Chemistry. 2017; 220:145-152.
42. Williams DC, Lim MH, Chen AO, Pangborn RM, Whitaker JR. Blanching of vegetables for freezing which

indicator enzyme to choose. Food Technology. 1986; 40:130-140.
43. Xiao HW, Bai JW, Sun DW, Gao ZJ. The application of superheated steam impingement blanching in agricultural products processing–a review. Journal of Food Engineering. 2014; 132:39-47.
44. Yang H, Gunasekaran S. Pulsed microwave heating of agar gel. Madison, Wis: Biological Systems Engineering Department, University of Wisconsin-Madison, 1998. Available from http://114.92.76.98/Lab/calvin.html.
45. Zhongli P, Griffiths GA. Infrared Dry Blanching; Infrared Heating for Food and Agricultural Processing, Taylor and Francis. 2010; 1:169-201.