

Nutrient Loss in Home Cooking: How Different Methods Affect Vitamin Retention

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Abstract—Food preparation and cooking are essential home science processes that significantly influence nutritional quality while enhancing palatability, digestibility, and food safety. This review examines how various cooking methods—boiling, steaming, microwaving, pressure cooking, stir-frying, baking, and grilling—affect vitamin retention in commonly consumed foods.

Water-soluble vitamins, particularly vitamin C and B-complex vitamins (thiamine, riboflavin, folate, niacin), are highly vulnerable to heat, light, oxygen, and leaching into cooking water. Fat-soluble vitamins (A, D, E, K) demonstrate greater stability but can undergo oxidative losses during prolonged high-temperature cooking. Research indicates that methods involving minimal water contact and shorter cooking times, such as steaming and microwaving, preserve significantly higher vitamin content compared to traditional boiling, which can cause 40-70% nutrient loss in certain vegetables.

Pressure cooking efficiently reduces cooking time while maintaining nutrient integrity through limited heat and oxygen exposure. Stir-frying with minimal oil preserves both vitamin types when executed at optimal temperatures for brief durations. Utilizing cooking water in soups or gravies helps recover leached nutrients, promoting zero-waste kitchen practices. Understanding nutrient retention principles empowers families to make informed decisions about food preparation techniques that maximize nutritional benefits while maintaining food safety and sensory appeal. This knowledge is particularly crucial for vulnerable populations—children, elderly individuals, and those with specific dietary requirements—who depend on home-cooked meals for optimal nutrition.

Keywords—vitamin retention, cooking methods, nutrient loss, home science, water-soluble vitamins, thermal degradation, food preparation

I. INTRODUCTION

The kitchen represents the first line of defense in maintaining family health and nutrition. Every day, millions of households engage in food preparation

activities that fundamentally alter the chemical composition and nutritional profile of raw ingredients. While the primary purposes of cooking include improving taste, texture, digestibility, and eliminating pathogenic microorganisms, these thermal processes inevitably lead to modifications in nutrient content.

The relationship between cooking and nutrition has gained considerable attention in recent decades as public health researchers recognize that nutrient adequacy depends not only on food selection but equally on preparation methods. Home science practitioners, nutritionists, and health-conscious families increasingly seek evidence-based guidance on optimizing cooking techniques to preserve maximum nutritional value while ensuring food safety.

Vitamins, unlike macronutrients such as proteins, carbohydrates, and fats, are required in minute quantities but play indispensable roles in metabolic processes, immune function, growth, and disease prevention. Their susceptibility to degradation during cooking varies considerably based on their chemical structure, solubility characteristics, and the specific cooking conditions employed. Understanding these vulnerabilities enables informed decision-making in home kitchens.

This comprehensive review synthesizes current scientific knowledge regarding vitamin retention across various cooking methodologies commonly employed in domestic settings. By examining the mechanisms of nutrient loss and preservation, this article aims to equip home scientists with practical strategies for maximizing the nutritional quality of prepared meals.

II. CLASSIFICATION AND PROPERTIES OF VITAMINS

2.1 Water-Soluble Vitamins

Water-soluble vitamins include vitamin C (ascorbic acid) and the B-complex group comprising thiamine (B1), riboflavin (B2), niacin (B3), pantothenic acid (B5), pyridoxine (B6), biotin (B7), folate (B9), and cobalamin (B12). These vitamins dissolve readily in aqueous solutions and are not stored in significant amounts within the human body, necessitating regular dietary intake.

The water-soluble nature of these vitamins makes them particularly vulnerable to leaching when foods are cooked in water. Additionally, many water-soluble vitamins exhibit thermal instability, degrading when exposed to elevated temperatures for extended periods. Vitamin C stands out as exceptionally fragile, susceptible to destruction by heat, oxygen, light, and alkaline conditions.

2.2 Fat-Soluble Vitamins

Fat-soluble vitamins A, D, E, and K are absorbed along with dietary fats and can be stored in the liver and adipose tissues. Their lipophilic nature provides some protection against water-based cooking losses; however, they remain vulnerable to oxidative degradation, particularly during cooking methods involving high temperatures and prolonged exposure to air.

Vitamin A (retinol and carotenoids) serves critical functions in vision, immune response, and cellular differentiation. Vitamin D regulates calcium metabolism and bone health. Vitamin E functions primarily as an antioxidant protecting cell membranes from oxidative damage. Vitamin K plays essential roles in blood clotting and bone metabolism. While generally more stable than water-soluble vitamins during cooking, fat-soluble vitamins can still experience significant losses under certain conditions.

III. MECHANISMS OF NUTRIENT LOSS DURING COOKING

3.1 Thermal Degradation

Heat-induced chemical reactions constitute a primary mechanism of vitamin loss during cooking. Elevated temperatures accelerate the breakdown of vitamin molecular structures through various pathways. The extent of thermal degradation depends on cooking temperature, duration of heat exposure, and the specific vitamin involved.

Vitamin C demonstrates particular sensitivity to heat, with degradation rates increasing exponentially at temperatures above 70°C. Thiamine (B1) similarly undergoes substantial losses at high temperatures, particularly in alkaline environments. Folate exhibits moderate heat sensitivity, with losses proportional to cooking time and temperature.

3.2 Leaching into Cooking Water

When foods are immersed in water during cooking, water-soluble vitamins readily diffuse from food matrices into the surrounding liquid. This leaching process occurs regardless of temperature, though heating accelerates the rate of nutrient migration. The magnitude of leaching depends on several factors including water volume, cooking time, food surface area exposed to water, and initial vitamin concentration in the food.

Boiling vegetables in large volumes of water maximizes leaching losses, potentially eliminating 50-80% of vitamin C and significant proportions of B vitamins. The discarded cooking water carries substantial nutritional value that could otherwise contribute to dietary intake if incorporated into soups, stews, or gravies.

3.3 Oxidation

Exposure to oxygen during food preparation and cooking promotes oxidative degradation of vitamins, particularly vitamin C and carotenoids. Cutting, chopping, and grinding foods increases surface area exposed to air, accelerating oxidative losses even before cooking begins. During cooking, oxygen dissolved in cooking water or present in the surrounding atmosphere continues oxidizing vitamins.

Antioxidant vitamins such as vitamin E and vitamin C are especially vulnerable to oxidation. Interestingly, vitamin C can serve a protective function, preferentially oxidizing to prevent degradation of other nutrients. This sacrificial role explains why foods rich in vitamin C often show better overall nutrient retention.

3.4 Light Exposure

Riboflavin (vitamin B2) exhibits exceptional photosensitivity, degrading rapidly when exposed to light. This characteristic has practical implications for food storage and preparation. Milk, a significant riboflavin source, traditionally packaged in opaque

containers, demonstrates this vulnerability. During cooking, minimizing light exposure helps preserve photosensitive vitamins.

IV. COMPARATIVE ANALYSIS OF COOKING METHODS

4.1 Boiling

Traditional boiling involves complete immersion of food in water heated to 100°C at standard atmospheric pressure. While widely practiced globally due to simplicity and effectiveness in softening tough fibers and eliminating pathogens, boiling represents one of the most nutrient-destructive cooking methods.

Research consistently demonstrates substantial vitamin losses during boiling. Studies show that boiling broccoli for ten minutes results in 50-60% loss of vitamin C, while boiling spinach causes 35-50% reduction in folate content. The combination of high temperature, water immersion, and often excessive cooking duration creates optimal conditions for both thermal degradation and leaching.

The nutritional impact of boiling can be partially mitigated by minimizing water volume, reducing cooking time to the minimum necessary for safety and palatability, and incorporating cooking water into final dishes. Starting with boiling water rather than cold water reduces overall cooking time and subsequent nutrient losses.

4.2 Steaming

Steaming cooks food through contact with water vapor rather than direct immersion in boiling water. This method operates at similar temperatures to boiling but dramatically reduces leaching losses since food does not directly contact cooking liquid. Steaming has emerged as a superior method for vitamin retention in numerous comparative studies.

Investigations reveal that steamed broccoli retains approximately 80-90% of vitamin C compared to only 40-50% retention after boiling. Similarly, steamed carrots preserve significantly more beta-carotene than their boiled counterparts. The shorter cooking times typically required for steaming, combined with minimal water contact, explain these superior outcomes.

Steaming represents an particularly excellent choice for leafy greens, cruciferous vegetables, and delicate foods where texture preservation matters. Modern steam ovens and traditional bamboo steamers both deliver excellent results, making this method accessible across various cultural contexts and economic circumstances.

4.3 Microwaving

Microwave cooking utilizes electromagnetic radiation to generate heat directly within food through molecular agitation, particularly of water molecules. This unique heating mechanism offers several advantages for nutrient retention including rapid cooking, minimal added water requirements, and even heating throughout the food matrix.

Multiple studies identify microwaving as among the best methods for preserving water-soluble vitamins. Research comparing cooking methods for various vegetables consistently ranks microwaving alongside steaming for vitamin C retention. Microwaved spinach retains approximately 77% of folate compared to only 23% after boiling.

The effectiveness of microwave cooking depends significantly on proper technique. Using minimal water, covering foods to trap steam, and avoiding overcooking maximize nutrient preservation. The speed of microwave cooking minimizes thermal exposure time, reducing degradation of heat-sensitive vitamins.

4.4 Pressure Cooking

Pressure cookers create sealed environments where steam pressure elevates the boiling point of water to approximately 120°C, dramatically reducing cooking time. While the higher temperature might theoretically increase vitamin degradation, the substantially shortened cooking duration typically results in net nutrient preservation.

Studies examining pressure cooking demonstrate favorable vitamin retention profiles, particularly for heat-sensitive nutrients. Pressure-cooked legumes retain higher levels of thiamine and folate compared to conventional boiling. The sealed environment limits oxygen exposure, reducing oxidative losses. Additionally, pressure cooking requires minimal water, further limiting leaching.

Modern electric pressure cookers offer precise temperature and time control, enabling consistent results. This method proves especially valuable for foods requiring extended cooking times such as beans, tough cuts of meat, and root vegetables, where alternative methods would necessitate prolonged nutrient-degrading heat exposure.

4.5 Stir-Frying

Stir-frying, a technique originating in Asian culinary traditions, involves cooking small pieces of food in minimal oil at high temperatures (150-200°C) for brief durations with constant agitation. The combination of high heat and short cooking time produces distinctive flavors and textures while maintaining favorable nutrient profiles.

The rapid cooking characteristic of stir-frying minimizes thermal degradation time despite high temperatures. Studies show that stir-fried vegetables retain 70-85% of vitamin C, comparable to steaming. The small amount of oil used can enhance absorption of fat-soluble vitamins and carotenoids, providing an additional nutritional advantage.

Successful stir-frying requires proper technique: preheating the cooking vessel, using high heat, keeping food moving constantly, and cooking in small batches to maintain temperature. Adding vegetables in stages based on cooking time requirements prevents overcooking while ensuring thorough heating for food safety.

4.6 Baking and Roasting

Baking and roasting cook food through dry heat in an enclosed oven environment, typically at temperatures ranging from 150-230°C. These methods prove particularly suitable for larger food items, whole vegetables, and dishes requiring even heating throughout.

Nutrient retention during baking depends significantly on temperature and duration. Lower temperatures and shorter baking times generally preserve more vitamins. Root vegetables like potatoes and sweet potatoes retain substantial amounts of vitamins when baked with skins intact, as the protective outer layer minimizes nutrient migration and oxidation.

Research indicates that baking vegetables can result in 15-30% vitamin C losses, moderate compared to

boiling but higher than steaming or microwaving. However, the enhanced flavor and palatability achieved through caramelization and Maillard reactions may encourage increased vegetable consumption, potentially offsetting nutritional losses.

4.7 Grilling and Broiling

Grilling exposes food to direct heat from below, while broiling applies intense heat from above. These high-heat methods create characteristic flavors through surface caramelization but can result in significant vitamin losses if practiced improperly. The primary concern with grilling relates to the formation of potentially harmful compounds when meat is charred. From a vitamin perspective, surface vitamins exposed to intense heat degrade rapidly. However, the interior portions of grilled foods often retain nutrients comparable to other cooking methods since actual internal temperatures remain moderate.

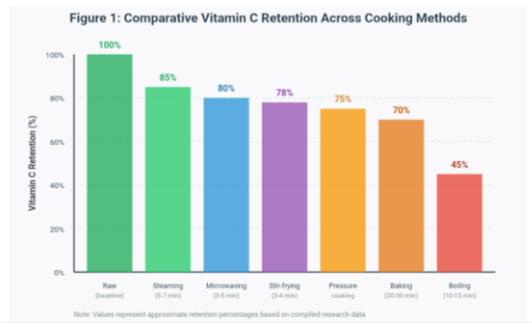
Marinating foods before grilling provides some protective effect against nutrient losses. Acidic marinades help preserve vitamin C, while oil-based marinades protect fat-soluble vitamins. Avoiding excessive charring and turning foods frequently to prevent burning helps minimize both nutrient losses and formation of undesirable compounds.

V. SPECIFIC VITAMIN STABILITY ACROSS COOKING METHODS

5.1 Vitamin C (Ascorbic Acid)

Vitamin C stands as the most vulnerable vitamin during cooking, serving as a useful indicator of overall nutrient retention. Its instability results from sensitivity to heat, oxygen, light, and alkaline conditions. Cooking method comparisons consistently reveal the following approximate retention rates:

- Steaming: 75-90% retention
- Microwaving: 70-85% retention
- Stir-frying: 70-85% retention
- Pressure cooking: 65-80% retention
- Baking: 65-75% retention
- Boiling: 40-55% retention



These figures vary based on specific foods, cooking times, and conditions. Leafy greens generally show greater losses than dense vegetables. Minimizing cooking time and water contact represents the most effective strategy for preserving vitamin C.

5.2 B-Complex Vitamins

B vitamins display variable stability during cooking. Thiamine (B1) proves relatively heat-sensitive, particularly in alkaline conditions, losing 15-40% during typical cooking. Riboflavin (B2) exhibits good heat stability but degrades rapidly in light. Niacin (B3) demonstrates exceptional stability, remaining largely intact across cooking methods. Folate shows moderate heat sensitivity with substantial leaching losses in water-based methods, retaining only 20-50% after boiling but 60-80% after steaming or microwaving.

5.3 Fat-Soluble Vitamins

Vitamin A and carotenoids display moderate heat stability but undergo oxidative degradation during prolonged cooking at high temperatures. Cooking can actually enhance carotenoid bioavailability by breaking down plant cell walls, improving absorption despite absolute losses. Cooking tomatoes increases lycopene accessibility, while cooking carrots enhances beta-carotene bioavailability.

Vitamin E, an antioxidant, sacrifices itself during cooking to protect other nutrients. Deep-frying at very high temperatures causes significant vitamin E losses, while moderate-heat methods preserve most of this nutrient. Vitamin K demonstrates good stability across cooking methods, with minimal losses under typical home cooking conditions.

VI. PRACTICAL STRATEGIES FOR MAXIMIZING NUTRIENT RETENTION

6.1 Pre-Cooking Considerations

Nutrient preservation begins before cooking commences. Proper storage maintains initial vitamin content—storing vegetables in cool, dark, humid conditions preserves vitamins longer than room-temperature storage. Minimizing time between purchase and preparation reduces deterioration.

Preparation techniques matter significantly. Washing vegetables before cutting rather than after prevents vitamin leaching. Cutting vegetables into larger pieces reduces surface area exposed to heat and oxygen. Preparing vegetables immediately before cooking minimizes oxidative losses during storage of cut produce.

6.2 Cooking Technique Optimization

Several universal principles optimize nutrient retention across cooking methods:

Minimize cooking time: Cook vegetables until just tender rather than overly soft. Crisp-tender vegetables retain significantly more vitamins while remaining palatable and safe.

Reduce water volume: Use minimal water necessary for cooking. Steaming, microwaving, and pressure cooking naturally limit water contact. When boiling, use just enough water to cover food.

Cover cooking vessels: Covering pots and pans reduces oxygen exposure and retains heat, shortening cooking time.

Avoid overcrowding: Cooking in batches maintains proper temperature and ensures even cooking, preventing some pieces from overcooking while others remain underdone.

Start with hot water: Beginning with boiling water reduces overall cooking time compared to heating food and water together from cold.

6.3 Utilizing Cooking Liquids

Cooking water, broths, and juices contain substantial leached nutrients. Incorporating these liquids into soups, stews, sauces, or gravies recovers much of the nutritional value otherwise lost. Indian cooking traditions exemplify this principle, regularly utilizing cooking liquids in dal preparations and curries.

When boiling pasta or rice, the nutrient-rich cooking water can be cooled and used for watering plants rather than discarding it down the drain. This practice, while not directly benefiting human nutrition, demonstrates awareness of the nutrients present in cooking water.

6.4 Combining Raw and Cooked Foods

Balancing cooked vegetables with raw preparations in meals ensures adequate vitamin intake even when cooking causes some losses. Salads accompanying cooked main dishes, fresh fruit desserts, and raw vegetable garnishes contribute heat-sensitive vitamins potentially degraded in cooked components.

This approach recognizes that cooking offers benefits—improved digestibility, enhanced flavors, food safety—while acknowledging that some nutrients survive better without heat. The Mediterranean dietary pattern exemplifies this balance effectively.

VII. SPECIAL CONSIDERATIONS FOR VULNERABLE POPULATIONS

7.1 Children's Nutritional Needs

Children require adequate vitamins for growth, development, and immune function. Their smaller body size means absolute vitamin requirements are lower but relative needs per kilogram body weight are higher than adults. Parents and caregivers should prioritize cooking methods that maximize nutrient retention while ensuring food safety.

Steamed vegetables, microwaved preparations, and stir-fried dishes preserve vitamins effectively while often proving more appealing to children than boiled vegetables, which can become mushy and unappealing. Involving children in meal preparation increases their willingness to consume vegetables, making nutrient-dense cooking methods more effective.

7.2 Elderly Individuals

Aging often brings decreased appetite, reduced digestive efficiency, and potential malabsorption issues, making nutrient-dense food preparation increasingly important. Elderly individuals may have difficulty chewing raw vegetables, making cooking necessary for consumption. Selecting cooking methods that preserve maximum nutrition while achieving appropriate texture becomes crucial.

Pressure cooking proves particularly valuable for elderly populations, efficiently softening tough foods while maintaining nutritional value. Soups and stews incorporating cooking liquids provide

easily consumed, nutrient-rich meals suitable for individuals with chewing or swallowing difficulties.

7.3 Individuals with Specific Dietary Requirements

People managing chronic conditions such as diabetes, cardiovascular disease, or compromised immune systems require optimal nutrition. Those with increased nutrient needs—pregnant and lactating women, individuals recovering from illness—benefit substantially from cooking practices that maximize vitamin retention.

Healthcare providers and nutritionists should educate patients about cooking methods that preserve nutrients relevant to their specific conditions. For example, individuals requiring higher folate intake benefit from understanding that steaming or microwaving leafy greens preserves significantly more folate than boiling.

VIII. CULTURAL PERSPECTIVES AND TRADITIONAL WISDOM

8.1 Traditional Cooking Practices

Many traditional cooking practices developed over centuries demonstrate remarkable nutritional wisdom, even in the absence of modern scientific understanding. Indian cooking extensively uses pressure cookers, a practice that scientific research now validates for nutrient retention. Chinese stir-frying techniques minimize cooking time and water contact, preserving vitamins effectively.

Traditional practices of consuming cooking liquids—using vegetable broths as soup bases, incorporating cooking water into dishes—recover leached nutrients. These customs, developed through generations of observation and experience, align closely with current scientific recommendations.

8.2 Modernizing Traditional Methods

Contemporary home science seeks to honor traditional cooking wisdom while incorporating scientific insights for optimization. Electric pressure cookers improve safety and convenience while maintaining the nutritional benefits of pressure cooking. Modern steamers offer precise control unavailable with traditional methods.

This integration respects cultural food traditions while applying evidence-based techniques to

enhance nutritional outcomes. The goal involves preserving culinary heritage while maximizing the health benefits of home-cooked meals.

IX. FUTURE DIRECTIONS AND EMERGING RESEARCH

Ongoing research continues refining our understanding of cooking impacts on nutrition. Emerging areas include investigation of how cooking affects phytonutrients beyond vitamins, interactions between cooking methods and bioavailability of minerals, and the role of the food matrix in protecting nutrients during thermal processing.

Advanced cooking technologies such as sous vide (precision low-temperature cooking) show promise for maximizing nutrient retention while ensuring food safety. Combination cooking methods—briefly steaming followed by quick sautéing—may optimize both nutrient preservation and flavor development.

Genetic variation in individual nutrient requirements and absorption efficiency represents another frontier. Personalized nutrition recommendations may eventually include cooking method guidance tailored to individual genetic profiles, health status, and nutritional needs.

X. CONCLUSION

The nutritional quality of home-cooked meals depends critically on preparation and cooking methods employed. While cooking inevitably causes some nutrient losses, understanding the mechanisms of degradation and the comparative impacts of different cooking techniques empowers home scientists to make informed decisions maximizing nutritional retention.

Steaming, microwaving, and pressure cooking emerge as superior methods for preserving water-soluble vitamins, while stir-frying offers efficient cooking with enhanced fat-soluble vitamin absorption. Traditional boiling, while sometimes necessary, results in the greatest nutrient losses and should be reserved for situations where other methods prove impractical.

Practical strategies for optimizing nutrient retention include minimizing cooking time and water volume, covering cooking vessels, starting with hot water, utilizing cooking liquids in final dishes, and balancing cooked foods with raw preparations. These evidence-based practices require minimal additional effort while substantially improving the nutritional value of prepared meals.

The knowledge synthesized in this review equips families, home science practitioners, and nutrition educators with tools to maximize the nutritional benefits of home cooking. As the foundation of family health, home-prepared meals deserve the attention and care that scientific understanding enables. By applying these principles, home kitchens truly become laboratories of nutrition, supporting optimal health across the lifespan.

REFERENCES

- [1] Bernhardt, S., & Schlich, E. (2006). Impact of different cooking methods on food quality: Retention of lipophilic vitamins in fresh and frozen vegetables. *Journal of Food Engineering*, 77(2), 327-333.
- [2] Dewanto, V., Wu, X., Adom, K. K., & Liu, R. H. (2002). Thermal processing enhances the nutritional value of tomatoes by increasing total antioxidant activity. *Journal of Agricultural and Food Chemistry*, 50(10), 3010-3014.
- [3] Fillion, L., & Henry, C. J. K. (1998). Nutrient losses and gains during frying: A review. *International Journal of Food Sciences and Nutrition*, 49(2), 157-168.
- [4] Galgano, F., Favati, F., Caruso, M., Pietrafesa, A., & Natella, S. (2007). The influence of processing and preservation on the retention of health-promoting compounds in broccoli. *Journal of Food Science*, 72(2), S130-S135.
- [5] Gharibzahedi, S. M. T., & Jafari, S. M. (2017). The importance of minerals in human nutrition: Bioavailability, food fortification, processing effects and nanoencapsulation. *Trends in Food Science & Technology*, 62, 119-132.
- [6] Jiménez-Monreal, A. M., García-Diz, L., Martínez-Tomé, M., Mariscal, M., & Murcia, M. A. (2009). Influence of cooking methods on antioxidant activity of vegetables. *Journal of Food Science*, 74(3), H97-H103.
- [7] Lee, S., Choi, Y., Jeong, H. S., Lee, J., & Sung, J. (2018). Effect of different cooking methods

- on the content of vitamins and true retention in selected vegetables. *Food Science and Biotechnology*, 27(2), 333-342.
- [8] Miglio, C., Chiavaro, E., Visconti, A., Fogliano, V., & Pellegrini, N. (2008). Effects of different cooking methods on nutritional and physicochemical characteristics of selected vegetables. *Journal of Agricultural and Food Chemistry*, 56(1), 139-147.
- [9] Nunn, M. D., Scheerger, S. B., & Butz, P. (2006). Nutrient retention in vegetables using different cooking methods. *Food Quality and Preference*, 17(6), 420-427.
- [10] Palermo, M., Pellegrini, N., & Fogliano, V. (2014). The effect of cooking on the phytochemical content of vegetables. *Journal of the Science of Food and Agriculture*, 94(6), 1057-1070.
- [11] Rungapamestry, V., Duncan, A. J., Fuller, Z., & Ratcliffe, B. (2007). Effect of cooking methods on glucosinolate content of vegetables. *Journal of Agricultural and Food Chemistry*, 55(18), 7628-7634.
- [12] Sikora, E., Cieřlik, E., Leszczyńska, T., Filipiak-Florkiewicz, A., & Pisulewski, P. M. (2008). The antioxidant activity of selected cruciferous vegetables subjected to aquathermal processing. *Food Chemistry*, 107(1), 55-59.
- [13] Subramanian, R., & Hebbar, H. U. (2015). Stability of water-soluble vitamins in food processing operations. In *Handbook of Food Chemistry* (pp. 859-881). Springer, Berlin.
- [14] Turkmen, N., Sari, F., & Velioglu, Y. S. (2005). The effect of cooking methods on total phenolics and antioxidant activity of selected green vegetables. *Food Chemistry*, 93(4), 713-718.
- [15] Vallejo, F., Tomás-Barberán, F. A., & García-Viguera, C. (2003). Effect of climatic and sulphur fertilisation conditions on phenolic compounds and vitamin C of broccoli. *European Food Research and Technology*, 216(5), 395-401.
- [16] Yuan, G. F., Sun, B., Yuan, J., & Wang, Q. M. (2009). Effects of different cooking methods on health-promoting compounds of broccoli. *Journal of Zhejiang University Science B*, 10(8), 580-588.
- [17] Zeb, A., & Mehmood, S. (2004). Carotenoids contents from various sources and their potential health applications. *Pakistan Journal of Nutrition*, 3(3), 199-204.
- [18] Zhang, D., & Hamauzu, Y. (2004). Phenolics, ascorbic acid, carotenoids and antioxidant activity of broccoli and their changes during conventional and microwave cooking. *Food Chemistry*, 88(4), 503-509.