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Review Article

Evaluation of the Sous Vide Technique in terms of Quality and Safety

Kalite ve Güvenlik Kavramları Bağlamında Sous Vide Tekniğinin Değerlendirilmesi

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Abstract

Emerging sensibilities in consumption have increased the importance of food safety and quality in food production. The techniques preferred during the food production stage should intend to ensure food safety in all processing, cooking and preservation phases, thus enabling the quality to be maintained at a maximum level. The purpose of this study is to evaluate the sous vide technique in terms of food safety and quality. Existing studies in the literature refer to sous vide as a technique that is effective and integrated with all stages of food processing, cooking and preservation. The main objective of the technique is to minimize the risk of oxidation by means of transferring food into vacuum-sealed packages after necessary preparations are made and by cooking the food at a constant temperature so as to increase microbiological quality as well as preserve its shelf life and sensory properties. The results of the analysis of different types of food show that the food cooked and preserved by the sous vide technique completely preserves their sensory properties. Another fact the results revealed is that the extracts added during the processing phase of the food create a rich taste. On the other hand, the technique lowers oxidation risk in food, which in turn extends their shelf life and microbiological quality. With the abovementioned features, the sous vide technique is preferable in terms of efficient stock management and sustainability of the supply chain for small- and medium-sized food production establishments.

Keywords: *Food, Sous Vide, Quality, Safety*

Özet

Tüketimde ortaya çıkan hassasiyetler gıda güvenliği ve kalitesi kavramlarının yiyecek üretimindeki önemini arttırmıştır. Yiyecek üretimi aşamasında tercih edilecek teknikler ile gıdaların işlenmesinden, pişirilmesine ve muhafazasına kadar süreçlerin tamamında gıda güvenliğinin sağlanarak kalitenin en üst düzeyde tutulması sağlanmalıdır. Bu çalışmanın amacı gıda güvenliği ve kalitesi açısından uygunluk teşkil eden sous vide tekniğinin incelenmesidir. Literatürde yapılan çalışmalar incelendiğinde sous vide tekniğinin, gıdaların işlenmesi, pişirilmesi ve muhafazası aşamalarının tamamında etkin ve entegre bir teknik olarak ifade edilmektedir. Tekniğin temel amacı, gıdaların gerekli ön hazırlıklar yapıldıktan sonra vakumlu paketlere aktarımı yoluyla oksidasyon riskinin en aza indirilmesi ve sabit ısıda gıdanın eşit olarak pişirilmesi böylece gerek mikrobiyolojik kalitenin yükselmesi gerekse raf ömrü ve duyusal karakteristiklerin muhafazasının sağlanmasıdır. Farklı gıdalar üzerinde yapılan analiz sonuçlarında sous vide tekniği ile pişirilen ve muhafaza edilen gıdaların duyusal karakteristik özelliklerinin aynen muhafaza edildiği yönündedir. Ayrıca gıdaların işlenmesi

aşamasında ilave edilen ekstraktların tat zenginliği oluşturduğu elde edilen diğer bir bilgidir. Diğer yandan tekniğin gıdaların oksidasyon riskini azaltması gıdaların mikrobiyolojik kalitesi ile raf ömürlerini uzatmaktadır. Bu özellikleri ile sous vide tekniği küçük ve orta ölçekli gıda üretimi yapan işletmelerde etkin stok yönetimi ve tedarik zincirinin sürdürülebilirliği açısından tercih edilebilirdir.

Anahtar Kelimeler: *Gıda, Sous Vide, Kalite, Güvenlik*

1. INTRODUCTION

With the increasing consumer awareness, food quality and safety have gained even greater importance over the last years. These two concepts, which directly affect the demand for food, prove benefits for businesses particularly in sustainable competition. The first of these concepts, food quality, is the degree by which food is accepted, which varies based on consumer's or user's perception. In other words, it is the consumer's perception towards the food (Taoukis et al., 1997: 356). Food quality can also be defined as a combination of the properties and characteristics of the food, which may affect the consumers' and users' degree of food acceptance (Robertson, 2010: 17). Assessment of food quality includes multiple factors. Caswell et al. (1998) categorizes these factors under five headings. These are; food safety properties, nutritional properties, taste, color and odor properties, packaging properties and properties regarding the production process. Another classification examines the food quality factors as the perception towards food origin, ethics in food production, affective and extrinsic characteristics of food (Botonaki et al., 2006: 80).

Food safety, is defined as keeping the consumer safe against potential injuries, biological effects or losses (Holleran et al., 1999: 670). In other words, food safety is the management of the process between food production and consumption by eliminating the harmful effects on the public health. Food safety is a major factor affecting food preference and consumption, as well as affecting food quality. In addition, food safety is the main factor for determining and managing food quality (Aung and Chag, 2014: 173). Factors affecting food safety, and indirectly, food quality vary according to time and type of food, while the main variables are as follows (Van Boakel, 2008: 144);

- **Chemical reaction:** Reactions that often take place due to oxidations, non-enzymatic browning etc. and pose a major threat to food safety, thus impairing the food quality.
- **Microbiological reaction:** Depends on bacterial development in the food under various factors, in particular, fermentation. It has a direct impact on the food quality, and at higher levels, it can also directly affect the public health.
- **Biochemical reaction:** It may include the emergence of dangerous enzymes such as lipolysis, proteolysis etc., which impair food quality, due to microorganisms or endogenous activities that occur during fermentation and maturation periods. These enzymes are created as a result of the microorganisms or endogenous enzymes that develop during fermentation and maturation periods. At higher levels, they not only threaten the public health, but also have a negative impact on the environment.
- **Physical reaction:** Certain food are heterogeneous and have a particular structure. Since these particles are unstable, it may lead to bonds, degradations etc. that will affect the food quality. This compromises the physical structure of the food, and has a negative impact on the food quality and safety.

As one can see, food safety and food quality are critical ıssues as they are important for the health and safety of the community. So, supply, production and presentation processes are required to be primary topics in food choice and consumption. Techniques that will not only preserve the features of the food like color, taste and smell, have lower risk for food safety and are compatible with the food's features but also enrich them during food preparation process are

essential. Methods used during food preparation process will also affect various factors like the preservation and microbiological quality of the food etc. One of the food preparation techniques in terms of food safety and quality that gets attention is the "sous vide" technique. Since the 1970s, this technique provides many advantages with regards to food quality and safety. The purpose of this study is to define sous vide technique and reveal its effects in terms of food safety and quality. Therefore, in this study sous vide was examined conceptually using the secondary data collected from the literature.

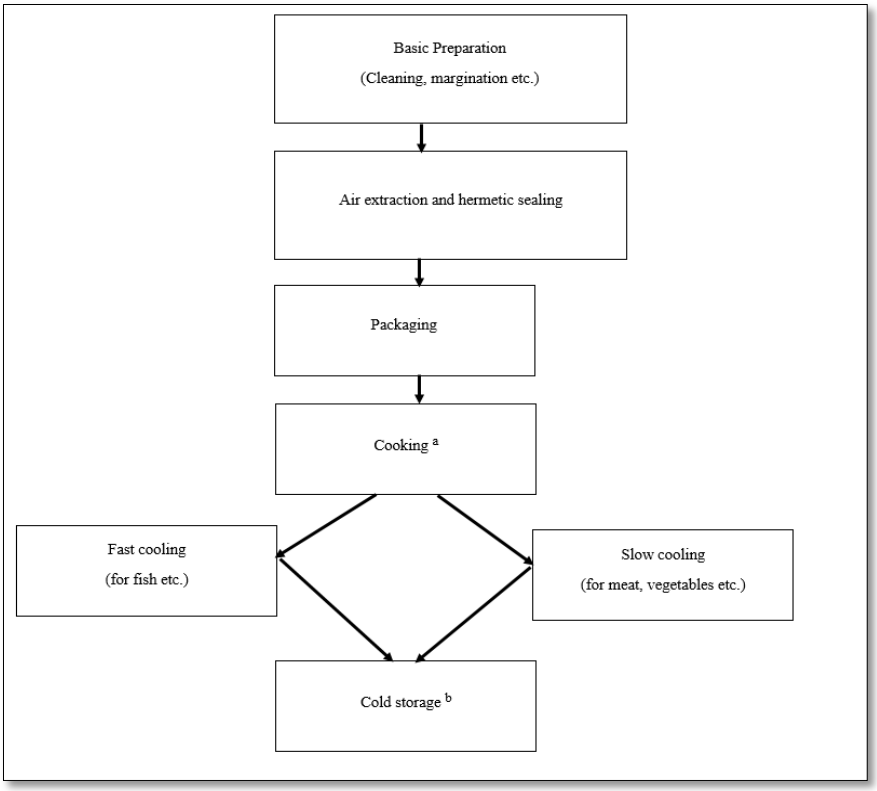
2. SOUS VIDE AND FOOD QUALITY

Sous Vide technique is one of the methods in which the food are subjected to as few procedures as possible that will affect the food's freshness and originality, including heat treating processes. Etymologically a French word; sous vide means "vacuumed". As a technique, sous vide expresses the preservation of raw food through directly or by cooking the end products of the raw food in controlled temperatures and preserving them in vacuumed packages with fixed temperatures. (Baldwin, 2012: 16).

As showed in Figure 1, just like in other food processing techniques, it involves; the preparation of raw material quality product, preliminary preparations (washing, treatment with sauce or other different materials), packaging, carrying out the vacuum packaging process with low oxygen permeability, cooking (through water bath usually under 100°C and between 65-90°C) and preservation of the product's internal temperature by decreasing it below 3,3°C (usually between 0-3°C) (Ceylan and Şengör, 2017: 9).

Basic purpose of the technique is to prevent the oxidation of the food products by reducing contact with oxygen and preserve them fresh without getting spoiled (Oz and Zikirov, 2015: 121). Method involves two basic principles. First of them is preventing the loss of smell during cooking under the effect of moisture and water vapor and the second is preventing taste loss by limiting oxidative changes of the food (Church and Parsons, 2000: 156). The most important factor is the vacuum packaging method used in the technique.

Figure 1. Flow Diagram of Sous Vide Process



Note: a: Generally under 100 °C, b: Generally between 0/3 °C

Source: Adapted from Sebastia et al., 2010: 966

Two aspects that differentiates Sous Vide technique from other cooking techniques are; low cooking temperatures (usually under 100°C) and longer cooking times (48 hours and longer) (Oz and Zikirov, 2015: 121). Higher temperatures (100°C and above) and longer cooking periods are used for traditional cooking methods. Lowest cooking temperatures are used for cooking fish and meat (for example 70°C) while higher temperatures are used for vegetables (for example 95°C) (Schellekens, 1996:256).

Contributions of the technique to taste and smell of the food are apparent (Bongiorno et al., 2018: 117). There are many studies in the literature exhibits the contributions of sous vide technique to the taste, smell and flavor of the food. In their sensory analysis, Church and Parsons (2000) revealed that the food prepared with sous vide technique get higher points in terms of smell, food juice and aroma compared to other cooking techniques that are not vacuumed. According to Creed and Reeve (1998) one of the most important advantages of sous vide technique is the impact on food quality as it keeps smell, color and aroma integrity of the food. Aside from that, Peterson (1993), Gonzalez-Fandos et al. (2005), Baldwin (2012) mentioned the contributions of sous vide technique to the taste, smell and flavor of food in their studies.

3. FOOD SAFETY AND SOUS VIDE

Food safety refers to microbiological quality and shelf life durations. Having long shelf life, breaking away from manipulation and at an acceptable microbiological quality is the intended result of food safety applications. When viewed from this aspect, sous vide technique is frequently preferred by restaurants because of its low microbiological manipulation risk and consequently easier food chain management (Roldan et al. 2013: 572). Another reason that this technique is preferred might be the lack of data for epidemic observation in academic literature and epidemic database, originating from food that were cooked with sous vide (Haskaraca and Kolsarıcı, 2013:

96). Another advantage of sous vide is the lower risk of bacterial growth. Analysis on different bacterial types were performed during studies on the microbiological quality of sous vide technique. Major ones are; *Clostridium botulinum* (Schellekens, 1996; Gould, 1999; Baldwin, 2012), *Listeria and Salmonella* (Roldan et al., 2013; Gonzalez-Fandos, et al., 2005; Sebastia et al., 2010), *Clostridium perfringens* (Sebastia et al., 2010; Aran, 2001; Juneja, 2006), *Enterobacteriaceae* (Diaz et al., 2009; Picouet et al., 2011;Garcia-Linares et al., 2004.). Research indicate that bacterial growth slows down and time frame is prolonged when food is cooked using sous vide technique.

Table 1. Total Plate Counts in Sous Vide Products over a Five-Week Storage Period at 3°C

Product	Raw Material Quality	Total plate count (CFU/g) after storage (weeks)					
		0	1	2	3	4	5
Rack of lamb (68°C)	1×10^4	<10	<10	6×10^2	1×10^3	7×10^2	4×10^7
Turkey breast (70°C/2 min)	7×10^3	<10	<10	<10	<10	4×10^2	2×10^3
Fish bandong (70°C/2 min)	2×10^4	2×10	3×10^3	5×10^2	4×10^2	2×10^2	2×10^5
Whole baby potatoes (90°C/5 min)	6×10^3	<10	<10	<10	<10	<10	3×10^1

Source: Nyati, 2000: 474

Nyati (2000) performed the microbiological quality of food which are processed with sous vide technique that *Listeria Monocytogenes, Salmonella, Clostridium Perfringens*, Bacillus cereus and *Enterobacteriaceae* screenings foodcan be seen in table 1. Observation of food that were prepared with different heat and cooking periods in 5 week storage periods and at 3°Cshowed that microbiological growth was in controllable levels because it was below 10-7×10^3 CFU/g in the first four weeks and average time would take till the end of the 5th week. Many similar research indicate, microbiological qualities of food that are prepared using the sous vide technique last for longer periods. This reveals that sous vide technique prolongs the shelf life of food positively.

Shelf life is the time period between production and consumption in which the food maintains its satisfactory quality (Kilcast and Subramaniam , 2000: 1). Shelf life is one of the important elements that determine the food product quality. Awareness of consuming fresh food, have avoided people from using food that are too much processed like frozen food and led to products that are processed less and kept fresh (Gonzalez-Fandos et al., 2005: 77). This has caused an increase in the demand of sous vide technique(Bongiorno et al., 2018: 117). Sous vide technique; vacuum packaging, enable to consume food without any loose or change on nutritional values while heat treating and cold storage methods extend the shelf life of food (Sing et al., 2016: 63).

Food that are prepared with sous vide technique; their contact with oxygen is eliminated and they put into vacuumed packages in order to avoid the risk of oxidation. This ensures that the food keeps its freshness under proper storage conditions. Also, extracts that are added inside the vacuumed packages provide richness in taste. Another benefit is that; fixed temperature and cooking process in equal duration and heat ensures that each part of the food processed equally so as a result, there are no raw parts left and bacterial growth is inhibited. Lastly, possible microbiological growth is inhibited through cold storage and lengthening of the shelf life is ensured.

Table 2. Some Heat, Time and Shelf Life for Sous Vide Products

Specified Centre Temperature	Specified Time	Shelf Life (1/8°C)
70°C	40 minutes	6 days chilled shelf life
70°C	100 minutes	21 days chilled shelf life
70°C	1000 minutes	42 days chilled shelf life
70°C	2 minutes	5 days chilled shelf life
80°C	26 minutes	up to 8 days
90°C	10 minutes	10 days chilled shelf life

Source: Adapted from Creed, 1998: 59

Even though it depends on the type of the food, time spans for average shelf lives and average temperatures are given in table 2. Shelf life for sous vide products depends on both cooking and storage temperatures. Depending on the characteristics of the food, it changes between 6-42 days following the application of a fixed heat and after that cooling between 1-8°C (Schellekens, 1996: 256). Studies on the relation between sous vide and shelf lives food are primarily focused on range of meat products consisting of fish, chicken and lamp. However, there also studies focused on vegetables. Effects of sous vide technique on the shelf lives of primary food groups are examined below.

3.1. Effect of Sous Vide Technique on the Shelf Life of Seafood Products

Research mostly focus on the cooking of salmon fish using sous vide technology and their features after the cooking process . Ceylan and Şengör (2016) indicated that processing salmon fillets for 20 minutes at 65°C will prolong its shelf life up to 6 weeks. They also stated that with the usage of a seasoning mix (basil, dill, garlic), sous vide can also improve the sensory properties of the fish. In a similar study, Diaz et al. (2009) noted that with a cooking process of 43 minutes at 80°C for vacuumed packages which are marinated with 200 grams olive oil, 18 days of shelf life is achieved without a loss in sensory properties on condition if it's preserved at 2°C. Gozalez-Fandos et al. (2005) claimed that the optimum cooking temperature for salmon fish is 90°C and cooking period of time is 15 minutes. Researchers stated that cooking at 90°C for 15 minutes ensures the longest shelf life.

Mol et al. (2010) determined that cooking bonito fish fillets with sous vide method at 85°C for 10 minutes in 4°C preservation environment, 28 days of shelf life can be achieved. On the other side, processing the same product at 85°C for 10 minutes and preserving it in a 12°C environment has a shelf life of 15 days. In a research on spotted seerfish (Scomberomorus guttatus) by Singh et al. (2019) no spore forming was found for up to 65 days with a process of 13,5 minutes at 89°C or 90°C which were preserved in a fridge.

Clam is another seafood that was tested for nutritional values, sensory properties and shelf life by cooking it with sous vide technique. Bongiorno et al. (2018) calculated the shelf life of the clam cooked at 85°C for 10 minutes both with and without brine. According to the results, the shelf life is up to 21 days under proper preservation conditions. Addition of brine can be prolonged the shelf life up to 30 days.

3.2. Effects of Sous Vide on the Shelf Life of Meat and Meat Products

Reserach focused on analyzing chicken meat and chicken products by cooking them with sous vide technique . There are many research studies conducted on the use of sous vide technique for the determination of shelf life and microbiological qualities of chicken meat and chicken products which normally have a very short shelf life and excessive microbiological growth . Rybka-Rodger (2001) stated that under the condition that the chicken meat is cooked at 71°C fixed heat and preserved at 8°C, it can have a shelf life between 2 or 5-8 weeks. In a similar study,

Church and Parson (2000) tested the shelf life under different heat and time conditions such as 2 minutes at 70°C, 10 minutes at 80°C and 30 minutes at 80°C. They determined the processed food that were preserved at 5°C had a shelf life between 2.5 and 7 days. Another outcome of the research is that there are no sensory properties loss in terms of the taste, juice aroma etc. Another research focused on chicken wings that they were vacuum packaged, liaison with oxygen was eliminated and they were cooked between 75°C and 90°C. Preserving between 2°C and 7°C, they had a shelf life of up to 7 weeks (Wang et al., 2004).

Using sous vide technique, Tikka masala, sauced chicken and Bolognese sauce were separately cooked at 70°C for 900 minutes. and at 90°C for 45 minutes. Even though the food are prone to spoiling because of the other substances inside them apart from meat which is the main ingredient, they reach up to 40 days of shelf life after cooking with a 1,5°C of preservation environment (Armstrong and Mellveen, 2000).

Red meat requires longer cooking time than the other meat and meat productsfood. In a research by Uttaro et al. (2019), a cooking process of double stage and single stage with different temperatures and periods of time were applied to the steak using sous vide technique. Double stage sous vide technique was applied for cooking at 39°C for 1 hour, at 49°C for 1 hour, 59°C for 5 hours and single stage was applied at 59°C for 4 hours. These products had a shelf life of 1 week at 2°C and 2 weeks at 1,5°C.

3.3. Effect of Sous Vide Technique on the Shelf Life of Vegetables

Vegetables differ from other food groups as they are fragile food and in regards to cooking times and shortness of shelf life. Sun and Brosnan (1999) stated that applying vacuumed cooking and sous vide techniques to vegetables is not only enriched sensory properties of the food like aroma and taste but also prolonged their shelf lives. Another research by Church and Parson (2001) applied different temperatures and times to potatoes which was processed together with chicken meat; at 70°C for 2 minutes, at 80°C for 10 minutes and at 80°C for 30 minutes. It was determined that together with chicken meat, potatoes had a shelf life between 2.5 and 7 days in a preservation environment of 5°C.

Other research conducted on different vegetables like broccoli, zucchini, potato and carrot, Sebastia et al. (2010) reached distinctive results with different temperatures and period of time regarding the shelf life. They applied 65°C for 20 minutes and 117 minutes, 85°C for 7-28 minutes and 100°C for 15-20 minutes to broccoli, potato and carrot vegetables. However, a cooking process of 5 minutes at the same temperatures was applied to zucchini. They reached a conclusion that after applying ice water under 3°C for 2 hours, vegetables have a shelf life of up to 30 days in preservation environment.

4. CONCLUSION and DISCUSSION

Excessive industrialization in every aspect of production has increased the sensitivity of consumers. Especially in nutrition which is the most basic need, people are highly sensitiveabout food safety and food quality issues. During the supplying, processing, and preserving processes of food, food safety and food quality should be taken into consideration. Therefore, the most efficient methods should be chosen. Sous vide is one of the appropriate methods. It's a technical, integrated method that affects the processing, preparation and preservation of food. In this study, the effects of sous vide technique on food safety and quality were examined.

The usage of vacuumed packages which is the main process of sous vide technique minimize the oxidation risk and prevent the taste, smell and appearance loss of the food. Apart from that, extracts that are put inside the vacuumed packages provide richness in taste and smell. Technique

also affects the food quality as food are cooked in vacuumed packages in hot water pools. By means of the cooking process at a fixed temperature, all parts of the food are cooked equally. This is important for the characteristics of the food to come out. According to the evaluations of people participatedin the sensory analysis tests on sous vide technique, juices and original tastes of food are generally preserved. This is also one of the main issues that affect the food quality.

Two main conclusions can be reached about sous vide technique with regards to food safety. One of this is microbiological quality and the other is shelf life. Sous vide technique contributes to the microbiological quality of food thanks to its cooking with equal heat and vacuumed packaging technologies. Research on different bacteria revealed that sous vide technique is more advantageous with regards to bacteria growth in food compared to classical cooking methods. This technique also affects shelf lives of food. Research reveal that different temperatures in different cooking period of times change the shelf lives of the food noteworthily. Therefore, this technique is critical especially for the cooking and preservation of more delicate food.

When all these conclusions are considered, it is obvious that use of sous vide technique will contribute to the food quality and security of small to mid-tier businesses. Especially regarding the stock management and supply chain management, businesses will have a competitive advantage. However, in industrial production, this method doesn't seem to be practical because of time and costs. This technique requires long times for application and maintenance. In addition, infrastructure and specialization issues increase the costs. This technique has both advantages and disadvantages. Future rstudies might provide insights especially in application of the technique and making comparisons of the advantages and disadvantages of the method.

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