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Novel Two-Step Sous-Vide Technique: An Innovative Strategy to Preserve Chicken Breast Quality and Freshness

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A R T I C L E I N F O

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A B S T R A C T

This study investigated the effects of single-step versus double-step sous-vide treatments on chicken breast quality under varying storage durations (0, 7, 14, and 21 days) and temperatures (4 °C and 10 °C). Chicken pectoralis major muscles were vacuum-sealed and cooked either at 60 °C for 120 min (single-step) or using a two-phase profile (50 °C followed by 60 °C) with equal total cooking times. Quality parameters including moisture content, cooking loss, colour (CIELAB), lipid oxidation (thiobarbituric acid reactive substances; TBARS), and odour acceptability were evaluated. The double-step method yielded significantly higher moisture retention and lower cooking loss than the single-step method, likely due to less muscle fibre shrinkage and improved protein solubility. Storage at 4 °C maintained superior colour stability, lower lipid oxidation, and better odour scores compared to 10 °C. By Day 21 at 10 °C, TBARS values exceeded the sensory threshold, resulting in off-odours and reduced acceptability. From a sustainability perspective, the double-step sous-vide approach can contribute to reduced food waste by extending shelf life and maintaining product quality over longer distribution periods. This sous-vide controlled heating profile may also improve energy efficiency compared to prolonged single-step high-temperature cooking. Aligning advanced cooking methods with optimal storage conditions thus supports more sustainable poultry production.

1. Introduction

Global demand for poultry meat has been steadily rising, largely owing to its health benefits and lower cost relative to other meat types. Between 2000 and 2020, worldwide consumption of meat, eggs, and milk saw an overall increase of 23–30%, with growth of 2–6% in developed countries and up to 60% in developing nations (*Food and Agriculture Organization of the United Nations*, 2021). Poultry production is expected to expand most prominently in Indonesia, Russia, Brazil, Japan, and India (*Uzundumlu & Dilli*, 2023). This surge in popularity can be attributed to poultry's high protein content, complete amino acid composition, and relatively greater levels of polyunsaturated fatty acids (PUFAs) compared to other meat sources (*Marangoni et al*., 2015). Concurrently, consumer behaviour has shifted: around 80% of poultry products are now offered as processed or cut-up portions, a striking departure from eight decades ago when most poultry were sold whole (*Barbut*, 2020). This transformation in production and consumption patterns also increases the urgency for sustainable processing solutions, as higher demand

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and more complex supply chains can amplify food waste and environmental impacts if product quality deteriorates before reaching consumers. Consumer acceptance is also influenced by sensory quality and sustainability-oriented assurance practices, making quality preservation essential for strengthening trust and reducing waste (*Ramadhanti & Tamimi,* 2025; *Tamimi* et al., 2025).

The growing demand for poultry-based ready-to-eat food products has spurred the development of processing methods that preserve both sensory quality and nutritional value. However, older adults may eat less poultry due to chewing and swallowing issues associated with various oral impairments (*Hong et al.,* 2015; *Rémond et al.,* 2007). This issue is particularly relevant to chicken breast muscles, which are often tougher and crumblier than leg muscles (*Hong et al.,* 2015; *Zhang et al.,* 2022). Therefore, the food industry needs to develop innovative poultry-based ready-to-eat products that not only improve texture and maintain nutritional value but also respond to broader sustainability concerns in poultry processing. Such efforts are increasingly important for enhancing resource efficiency, preserving product quality, extending shelf life, and minimizing waste across the poultry sector.

One increasingly popular approach is sous-vide cooking, which employs low-temperature, long-time (LTLT) processing to retain the meat's natural moisture, nutritional content, and flavour (*Zavadlav et al*., 2020). Sous-vide involves placing food in vacuum-sealed bags and cooking it at precisely controlled temperatures between 55–70 °C, thereby enhancing meat characteristics and minimizing moisture loss (*Gil et al*., 2022). Unlike conventional methods, sous-vide utilizes a sealed environment that mitigates oxidation and flavour deterioration while also reducing the risk of recontamination during storage (*Baldwin*, 2012). From a sustainability perspective, its controlled heating process can be more energy-efficient than traditional cooking, while the extended shelf life helps prevent premature disposal of products.

Although sous-vide cooking is typically conducted in a single step, a novel two-phase approach — referred to as the double-step method — has recently garnered attention. This technique has been reported to enhance meat texture by reducing shear force while increasing tenderness and chewiness compared to the single-step method (*Ismail et al*., 2019). In addition, it lowers cooking loss, improves oxidative stability, and boosts total protein solubility, thus contributing to an overall higher-quality final product (*Bıyıklı et al*., 2020; *Christensen et al*., 2011; *Karpińska-Tymoszczyk et al*., 2020). Notably, endogenous proteolytic enzymes in meat exhibit peak activity at 40–50 °C, leading to increased desmin degradation and, consequently, improved tenderness (*Akoğlu et al*., 2018). These improvements in moisture retention and oxidative stability have the added advantage of extending product usability during distribution, which supports waste reduction goals in the poultry industry (*Afidah et al.,* 2025).

Food safety remains a critical consideration in sous-vide processing. A study has shown that maintaining sous-vide treatments at 50 °C or 60 °C for 120 minutes achieves the necessary pasteurization standard, characterized by a three-log reduction of *Enterococcus faecalis* (*Hasani et al*., 2023). Additionally, chilling plays a vital role in preserving chemical, sensory, and nutritional properties while mitigating microbial and enzymatic degradation (*Fernandes et al*., 2016). Ensuring optimal storage conditions is also essential to preventing deteriorations in meat quality, encompassing reductions in moisture, texture, colour, and aroma (*Barbut & Leishman*, 2022). While sous-vide technology offers potential benefits in enhancing the quality and shelf life of poultry meat, challenges remain regarding post-cooking storage conditions. One study demonstrated that sous-vide products stored at 3 °C maintained minimal microbial growth and retained their sensory attributes for up to five weeks. However, products stored at higher temperatures showed unacceptable microbial growth after three weeks (*Nyati*, 2000). These findings underscore that proper integration of cooking and storage strategies is crucial, not only for quality retention but also for maximizing sustainability gains by reducing spoilage-related waste.

This study aims to investigate how differing storage durations (0, 7, 14, and 21 days) and temperatures (4 °C and 10 °C) affect the quality of sous-vide-treated chicken breast meat. Key parameters under examination include moisture content, cooking loss, colour, lipid oxidation, and odour acceptability. The results are expected to yield valuable insights into optimal storage conditions for sous-vide poultry products and to advance food technology by enhancing both the quality and shelf life of poultry products in the global market.

2. Materials and Methods

2.1 Experimental design

The objective of this study was to examine the effect of applying a two-step temperature approach with differing time ratios to sous-vide cooking of chicken breasts, as well as the impact of storage duration and temperature. Chicken breast samples were either cooked at a single temperature of 60 °C or subjected to two temperature steps (50 °C as the first step and 60 °C as the final step) under different time ratios but the same total cooking time (see Table 1). A two-way completely randomized design was employed, with three replicates for each sous-vide treatment. Chicken pectoralis major muscles (24 hours post-mortem, pH24 = 5.8 ± 0.12) were sourced from a slaughterhouse in Budapest, Hungary. The breasts were trimmed of excess fat and connective tissue, then cut into 2 cm-thick portions weighing approximately 105 ± 10 g each. The samples were vacuum-sealed (Multivac C100, MULTIVAC Sepp Haggenmüller SE & Co. KG, Germany) in PA/PE bags (200 × 250 mm²) prior to cooking.

In this investigation, sous-vide cooking was conducted using two thermostatic water baths (Laboratory Water Bath LP507/01). A Type-T thermocouple, inserted into the centre of the chicken breast samples, was employed to monitor the internal temperature throughout the cooking process. Following recommendations by the BC Centre for Disease Control and Prevention (2016), the cooked chicken breasts were chilled in ice water (1 °C) and subsequently stored in a cold environment (2 °C) for six hours to reduce their temperature below 4 °C (*BC Centre for Disease Control*, 2016). Rapid cooling in ice water helps to inhibit bacterial growth, while also halting the cooking process and preventing the poultry from becoming overcooked and dry.

The stability of sous-vide-cooked chicken breast samples, subjected to either the one-step or two-step temperature treatments, was assessed during storage at chilled (4 ± 0.5 °C) or mildly chilled (10 ± 0.5 °C) temperatures for a maximum of 21 days, with continuous temperature monitoring. On days 0, 7, 14, and 21, samples were collected to evaluate moisture content, cooking loss, colour, lipid oxidation, and aroma acceptability.

2.2 Moisture content and cooking loss

The standard AOAC International 950.46 method (2005) was utilized in triplicate to determine the moisture content, i.e., the proportion of water present in a material, expressed as a percentage of the dry weight relative to the wet weight, of chicken breasts (*AOAC*, 2002). Approximately 4 grams of the cooked chicken breast were weighed and then dehydrated in an air-forced oven (Labor Müszeripari Müvek, Hungary) at 105 °C for sixteen hours. For the cooking loss, sometimes called weight loss or drip loss, and denoting the mass of food lost during cooking, the initial weight of chicken breast samples was determined. Then after cooking treatment the chicken breast sample was weighed after removing the water content from its packaging.. The moisture content (%) and cooking loss (%) were calculated using equations (1) and (2).

Moisture content (%) = (dried sample weight/ raw sample weight) * 100 (1)

Cooking loss (%) = (initial weight-final weight)/ initial weight × 100 (2)

2.3 Colour measureme nt

The colour characteristics of the chicken breasts were evaluated using the CIELAB grading system. After calibrating the instrument, each sample's lightness (L*), redness (a*), and yellowness (b*) were measured with a Konica Minolta Sensing CR-410 colourimeter. Five parallel measurements were taken per sample, with three samples in total.

The L* axis, which ranges from 0 (black) to 100 (white), reflects the sample's lightness or darkness. Positive a* values indicate red, while negative values indicate green. Positive b* values indicate

Table 1. Sous-vide treatment of the cooked chicken breast groups

Group	Time at 50°C (min)	Time at 60 °C (min)	Treatment Time Ratio 50 °C/60 °C	Total Treatment Time (min)
T1	0	120	0:1	120
T2	40	80	1:2	120
T3	60	60	1:1	120

yellow, while negative values indicate blue. The total colour difference (ΔE) was then calculated using Equation (3).

$$\Delta E = \sqrt{(\Delta L *)^2 + (\Delta a *)^{2+} (\Delta b *)^2} \quad (3)$$

2.4 Lipid oxidation

A slightly modified version of the thiobarbituric acid reactive substances (TBARS) method described by *Dias et al.* (2013) was used to measure lipid oxidation in chicken breast samples (*Dias et al.*, 2013). First, a 5-g portion of chicken breast was homogenized for 2 minutes with 20 mL of 5% trichloroacetic acid (TCA) and 0.5 mL of the antioxidant, butylated hydroxytoluene (BHT), using a Digital Ultra-Turrax homogenizer. The mixture was then centrifuged for 10 minutes, and the supernatant was filtered through No. 1 filter paper before being adjusted to 25 mL in volumetric flasks using 5% TCA. Next, 2 mL of the filtrate was combined with 2 mL of 0.08% thiobarbituric acid (TBA) in glass tubes, which were heated at 95 °C in a water bath for 30 minutes. After heating, the tubes were cooled and vortexed, and the absorbance was measured at 532 nm with a U 2900 UV-visible spectrophotometer (Hitachi Ltd., Tokyo, Japan) against a blank mixture of 5% TCA and 0.08% TBA. Finally, TBARS values, expressed as milligrams of malondialdehyde per kilogram (mg MDA/kg) of meat, were calculated from the average of triplicate measurements.

2.5 Odour acceptability

Under aseptic conditions, each sample was opened and its odour assessed according to the method described earlier (*Youssef et al.*, 2014). A five-point scale was used to rate odour acceptability, where 1 = acceptable, 2 = slightly acceptable, 3 = neither acceptable nor unacceptable, 4 = slightly unacceptable, and 5 = unacceptable. Five panellists conducted the evaluation.

2.6 Statistical analysis

The statistical analyses were conducted using IBM SPSS (version 27.0). Descriptive statistics and analysis of variance (ANOVA) were utilized to examine the effects of treatment, storage duration, and storage temperature on parameters such as moisture content, cooking loss, colour characteristics (L*, a*, b*, and ΔE), TBARS, and odour acceptability. Tukey's post hoc test was then applied to determine significant differences among groups. Standard deviations were displayed as error bars in bar charts created with Microsoft Excel 2021.

3. Results and Discussion

3.1 Moisture content and cooking loss

The moisture content results are presented in Figure 1, whereas cooking loss findings are shown in Figure 2.

According to the ANOVA and post-hoc Tukey's test, each treatment (T1, T2, and T3) differed significantly in moisture content (%) and cooking loss (%) ($p < 0.05$). Moreover, the double-step treatments (T3 and T2) had substantially lower cooking loss (%) and higher moisture content (%) than the single-step treatment (T1). These findings align with previous research on pork loin, turkey, and chicken breast, which showed that as cooking

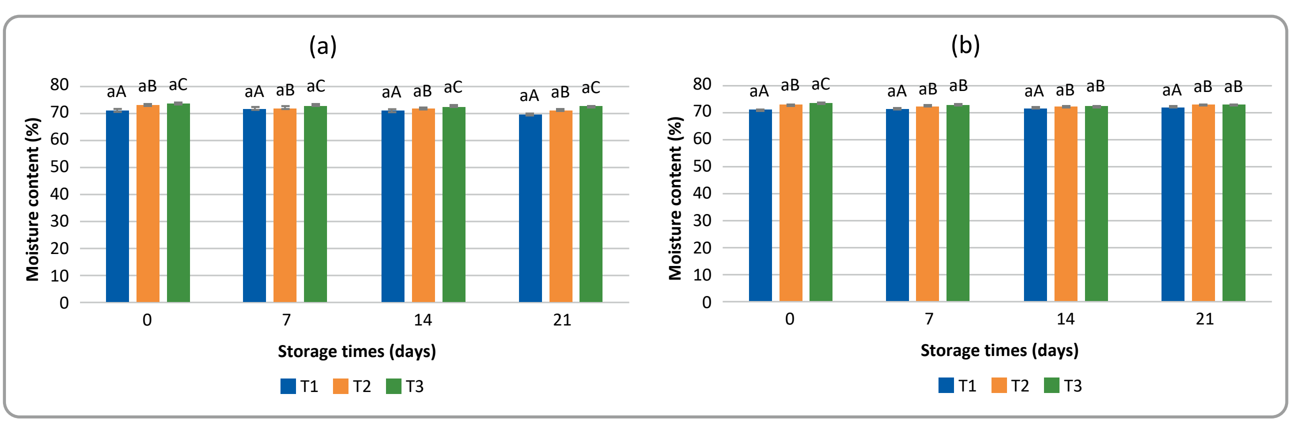

Figure 1. Moisture content (%) of sous-vide chicken breasts stored at (a) 4 °C and (b) 10 °C for up to 21 days, using T1 (60 °C/120 min), T2 (50 °C/40 min + 60 °C/80 min), and T3 (50 °C/60 min + 60 °C/60 min). With $p < 0.05$, lowercase letters (a, b, c) denote significant differences across storage days within the same treatment, while uppercase letters (A, B, C) denote significant differences among treatments within the same storage day.

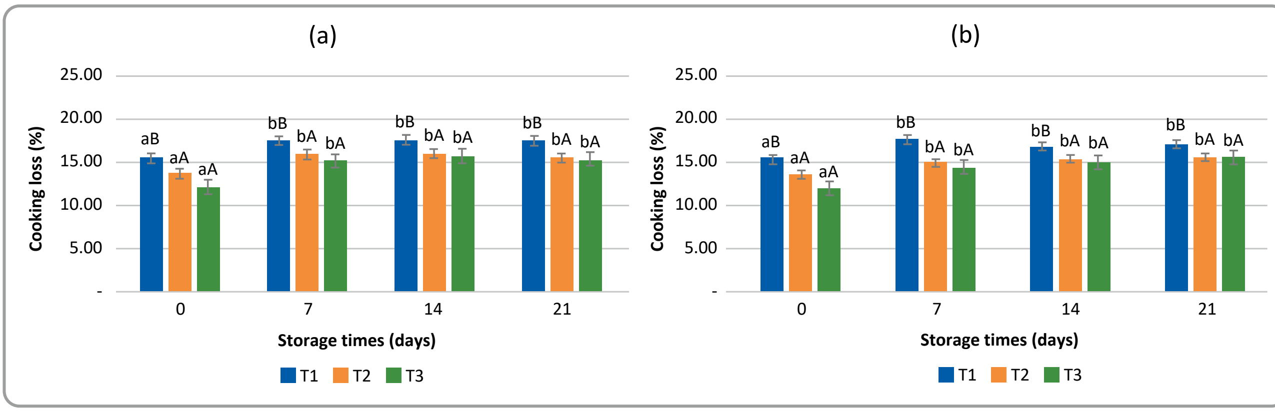

Figure 2. Cooking loss (%) of sous-vide chicken breasts stored at (a) 4 °C and (b) 10 °C for up to 21 days, using T1 (60 °C/120 min), T2 (50 °C/40 min + 60 °C/80 min), and T3 (50 °C/60 min + 60 °C/60 min). With $p < 0.05$, lowercase letters (a, b, c) denote significant differences across storage days within the same treatment, while uppercase letters (A, B, C) denote significant differences among treatments within the same storage day.

temperature increased, cooking loss rose while moisture content decreased (*Bıyıklı et al*., 2020; *Hasani et al*., 2022; *Hwang et al*., 2019). The moisture content of meat depends on the degree of thermal protein denaturation, as higher temperatures cause muscle fibres to shrink and expel water (*Offer et al*., 1984). Additionally, during cooking, collagen becomes soluble and forms a gel, increasing the meat's water content, which can lead to cooking loss when water and gelatinous material are expelled (*Zielbauer et al*., 2016). While moisture loss can concentrate nutrients, it may also result in the loss of heat-sensitive nutrients and liquids containing specific nutrients (*Ayub & Ahmad*, 2019). Moisture content plays a pivotal role in industries such as food processing, as it affects product quality, shelf life, and safety.

There was no significant difference in cooking loss (%) based on storage temperature ($p = 0.542$). However, a significant difference emerged in moisture content (%) ($p = 0.016$), with samples stored at 4 °C maintaining higher moisture content than those stored at 10 °C. While moisture content (%) did not differ significantly ($p > 0.05$) over the storage period, cooking loss (%) did ($p < 0.05$) at both 4 °C and 10 °C. The temperatures in both storage conditions varied notably between Day 0 and Days 7, 14, and 21. Previous work has shown that storage duration can influence chicken breast weight loss, with a significant increase observed after Day 9 (*Kaewthong et al*., 2019). During storage, meat can lose weight through evaporation — when water vapor escapes the surface — and through microbial activity, which may break down muscle fibres and cause moisture loss. Consequently, cooking loss can rise as the meat dries out. Storing meat at low temperatures (0–4 °C) can enhance water-holding capacity and minimize thawing-cooking loss (*Fernandes et al*., 2016). Furthermore, both storage temperature and duration — as well as microbial growth —c an affect the ability of meat myofibrils to retain water (*Zhang et al*., 2016).

3.2 Colour measurement

The colour properties of sous vide treated chicken breasts during chilled storage for 21 days are presented in Figure 3, 4, and 5.

Figure 3 shows the lightness (L*) values of the chicken breast samples. On Day 0, ANOVA with post hoc Tukey's test revealed significant differences ($p < 0.05$) among treatments, where single-step sous-vide (T1) exhibited higher L* values than the double-step methods (T2 and T3), likely due to myoglobin changes during denaturation at elevated temperatures (*Christensen et al.*, 2011). No significant differences ($p > 0.05$) were observed on Day 21 for samples stored at 4 °C after 14 days, nor from Day 7 to Day 21 for samples stored at 10 °C across all treatments (*Silva-Buzanello et al*., 2019). In terms of storage duration, significant differences ($p < 0.05$) began on Day 7 at 4 °C and Day 14 at 10 °C, with L* values decreasing over time, although storage temperature did not show a significant difference ($p = 0.054$) (*Pizato et al*., 2015). Additionally, there is a known correlation between cooking loss and lightness, suggesting multiple factors can affect the L* value of cooked chicken breast (*Saláková et al*., 2009).

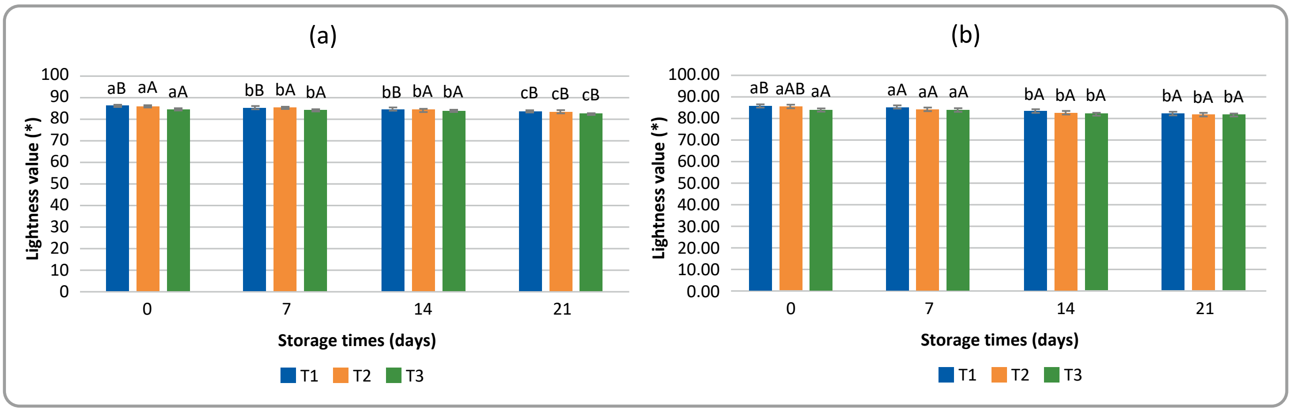

Figure 3. The lightness value (L*) of sous-vide chicken breasts stored at (a) 4 °C and (b) 10 °C for up to 21 days, using T1 (60 °C/120 min), T2 (50 °C/40 min + 60 °C/80 min), and T3 (50 °C/60 min + 60 °C/60 min). With $p < 0.05$, lowercase letters (a, b, c) denote significant differences across storage days within the same treatment, while uppercase letters (A, B, C) denote significant differences among treatments within the same storage day.

The redness (a*) measurements (Figure 4) indicate that on Day 0, T3 had a significantly higher redness value ($p < 0.05$) than T2 and T1, likely because T3 was cooked at 60 °C for a shorter time and 50 °C for a longer time (*Hunt et al*., 1999). Myoglobin, which influences redness, begins denaturing between 55 °C and 65 °C, and is fully denatured at 80 °C (*Geileskey et al*., 1998). These differences persisted until Day 14 at 4 °C and Day 7 at 10 °C, after which no significant differences ($p > 0.05$) were observed (*Hong et al*., 2015). Notably, pink colouration may concern consumers who view it as undercooked or unsafe, and a pink threshold of a* = 3.8 has been established, which all samples in this study remained below (*Kaewthong et al*., 2019). Significant differences ($p < 0.05$) in redness appeared during storage at 10 °C on Days 14 and 21, when the redness values declined (*Kaewthong et al*., 2019). In contrast, no significant changes ($p > 0.05$) were seen for samples stored at 4 °C. Storage temperature also significantly influenced redness ($p = 0.003$), with samples at 4 °C exhibiting higher values than those at 10 °C. Similar to lightness, the reduction in redness is attributed to microbial activity that alters meat colour (*Pizato et al*., 2015).

According to the ANOVA and Tukey's post-hoc test, a significant difference ($p < 0.05$) in yellowness (b*) was observed between the single-step sous-vide (T1) and double-step sous-vide (T2 and T3) treatments, with T2 and T3 recording higher b* values (*Hasani et al*., 2022). This outcome is attributed to the reduced exposure of meat to 60 °C in the two-step methods, potentially leading to increased metmyoglobin concentrations (*Ayub & Ahmad*, 2019). Regarding storage temperature, there was no significant difference ($p = 0.309$) between 4 °C and 10 °C. However, for storage duration, a significant difference (p <

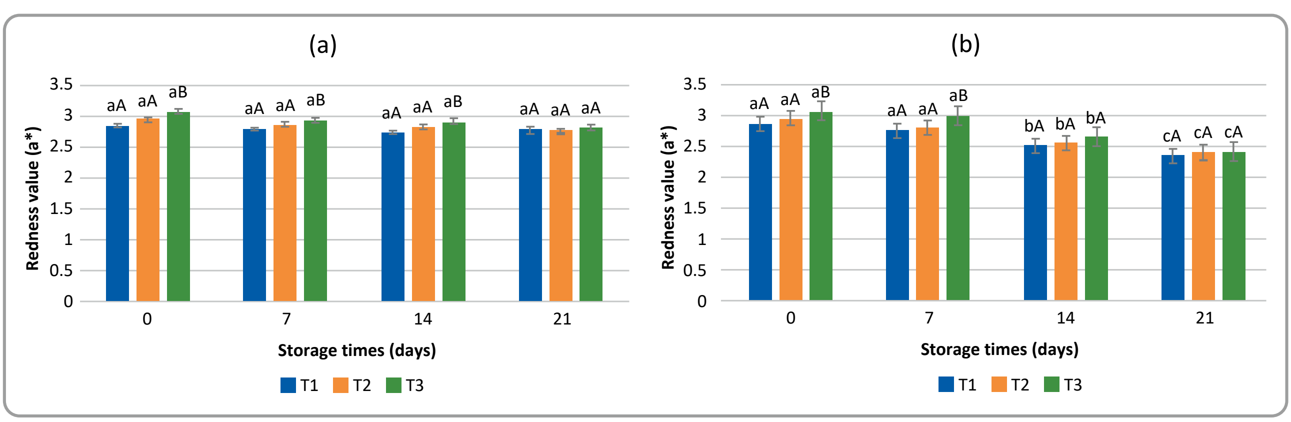

Figure 4. The redness value (a*) of sous-vide chicken breasts stored at (a) 4 °C and (b) 10 °C for up to 21 days, using T1 (60 °C/120 min), T2 (50 °C/40 min + 60 °C/80 min), and T3 (50 °C/60 min + 60 °C/60 min). With $p < 0.05$, lowercase letters (a, b, c) denote significant differences across storage days within the same treatment, while uppercase letters (A, B, C) denote significant differences among treatments within the same storage day.

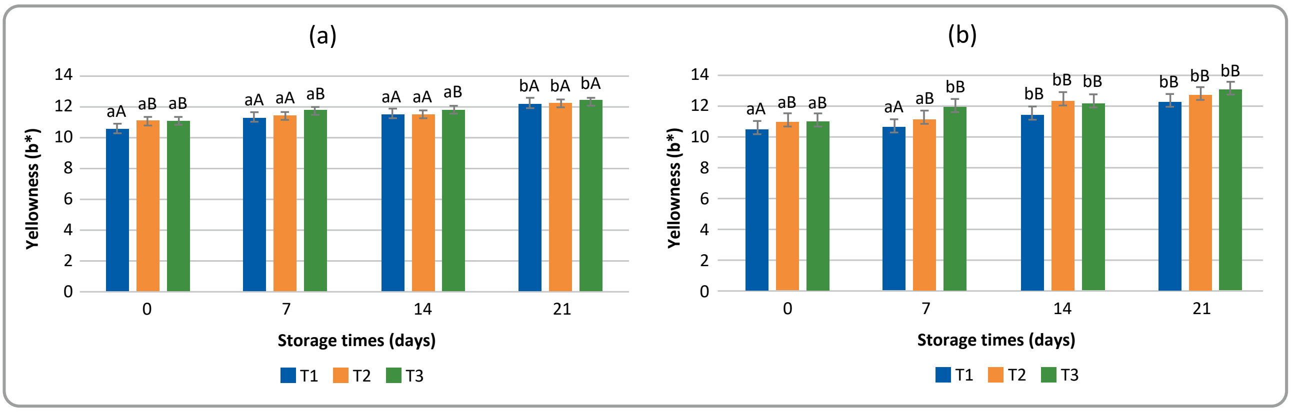

Figure 5. The yellowness value (b*) of sous-vide chicken breasts stored at (a) 4 °C and (b) 10 °C for up to 21 days, using T1 (60 °C/120 min), T2 (50 °C/40 min + 60 °C/80 min), and T3 (50 °C/60 min + 60 °C/60 min). With $p < 0.05$, lowercase letters (a, b, c) denote significant differences across storage days within the same treatment, while uppercase letters (A, B, C) denote significant differences among treatments within the same storage day.

0.05) emerged: yellowness began increasing on Day 21 at 4 °C and on Day 14 at 10 °C, which aligns with previous findings (*Pizato et al*., 2015). Discolouration during storage generally results from pigment oxidation in muscle tissue, the stability of which depends on species and muscle biochemistry (*Genot*, 2003).

Tables 2 and 3 show the total colour differences (ΔE) for chicken breasts stored at 4 °C and 10 °C. When E exceeds 3.5, a clear colour difference is perceived in meat products (*Tomasevic et al*., 2019). The comparison of storage temperatures reveals that category IV (indicating a clearly perceptible colour

Table 2. Total colour difference (ΔE) between chicken breasts cooked with different sous-vide treatments and stored for different durations at 4 °C.

Treatment		T1				T2				T3			
	Storage duration (days)	**0**	**7**	**14**	**21**	**0**	**7**	**14**	**21**	**0**	**7**	**14**	**21**
T1	0		I	II	III	I	II	III	III	II	III	III	IV
	7	0.99		I	II	I	I	II	III	I	II	II	III
	14	1.74	0.81		II	II	I	I	II	I	I	II	III
	21	3.01	2.05	1.27		III	II	I	I	II	I	I	II
T2	0	0.65	0.38	1.15	2.39		I	II	III	I	I	III	I
	7	1.17	0.20	0.68	1.89	0.53		II	III	I	II	II	III
	14	2.37	1.51	0.72	0.78	1.81	1.38		I	I	I	I	II
	21	3.18	2.23	1.44	0.19	2.57	2.07	0.90		II	I	I	I
T3	0	1.69	0.97	0.56	1.49	1.18	0.89	0.76	1.64		I	II	III
	7	2.29	1.37	0.60	0.74	1.69	1.22	0.32	0.90	0.77		I	II
	14	2.73	1.84	1.05	0.47	2.15	1.69	0.39	0.56	1.81	0.49		II
	21	3.95	3.03	2.23	1.02	3.36	2.88	1.59	0.83	2.32	1.67	1.22	

T1: 60 ◦C/120 min; T2: 50 ◦C /40 min and 60 ◦C/80 min; T3: 50 ◦C/60 min and 60 ◦C/60 min. The total colour difference (ΔE) categories using Roman numerals, where I ($0 < ΔE < 1$) indicates no difference, II ($1 < ΔE < 2$) indicates only experienced observers can detect a difference, III ($2 < ΔE < 3.5$) indicates inexperienced observers can detect a difference, and IV ($3.5 < ΔE < 5$) indicates a clear difference in colour is detectable.

Table 3. Total colour difference (ΔE) between chicken breasts cooked with different sous-vide treatments and stored for different durations at 10 °C.

Treatment		T1				T2				T3			
	Storage duration (days)	0	7	14	21	0	7	14	21	0	7	14	21
T1	0		I	III	IV	I	II	IV	IV	II	II	IV	IV
	7	0.78		II	III	I	I	II	IV	I	II	III	IV
	14	2.51	1.76		II	II	I	II	III	I	I	II	III
	21	4.12	3.38	1.62		IV	III	I	I	III	II	I	I
T2	0	0.65	0.54	1.98	3.56		II	III	IV	II	II	IV	IV
	7	1.60	0.87	0.93	2.54	1.06		III	III	I	I	III	III
	14	3.67	2.96	1.24	0.58	3.08	2.10		I	III	II	I	II
	21	4.60	3.88	2.12	0.54	4.02	3.02	0.94		III	III	I	I
T3	0	1.69	0.97	1.00	2.55	1.18	0.33	2.13	3.03		II	III	III
	7	2.48	1.84	0.73	1.82	1.86	0.99	1.29	2.22	1.03		II	III
	14	4.21	3.47	1.73	0.35	3.65	2.62	0.72	0.58	2.93	1.88		I
	21	4.93	4.22	2.48	0.92	4.34	3.36	1.26	0.39	3.37	2.52	0.93	

T1: 60 ◦C/120 min; T2: 50 ◦C /40 min and 60 ◦C/80 min; T3: 50 ◦C/60 min and 60 ◦C/60 min. The total colour difference (ΔE) categories using Roman numerals, where I ($0 < \Delta E < 1$) indicates no difference, II ($1 < \Delta E < 2$) indicates only experienced observers can detect a difference, III ($2 < \Delta E < 3.5$) indicates inexperienced observers can detect a difference, and IV ($3.5 < \Delta E < 5$) indicates a clear difference in colour is detectable.

difference) was observed more strongly at 4 °C than at 10 °C. The most pronounced colour difference was noted between Day 0 and Day 21 of storage. These results indicate that both storage temperature and duration influenced the colour characteristics of the sous-vide treatments.

3.3 Lipid Oxidation

Figure 6 present the findings of the TBARS analysis, used to assess lipid oxidation in sous-vide chicken breast, by measuring the concentration of secondary oxidation compounds.

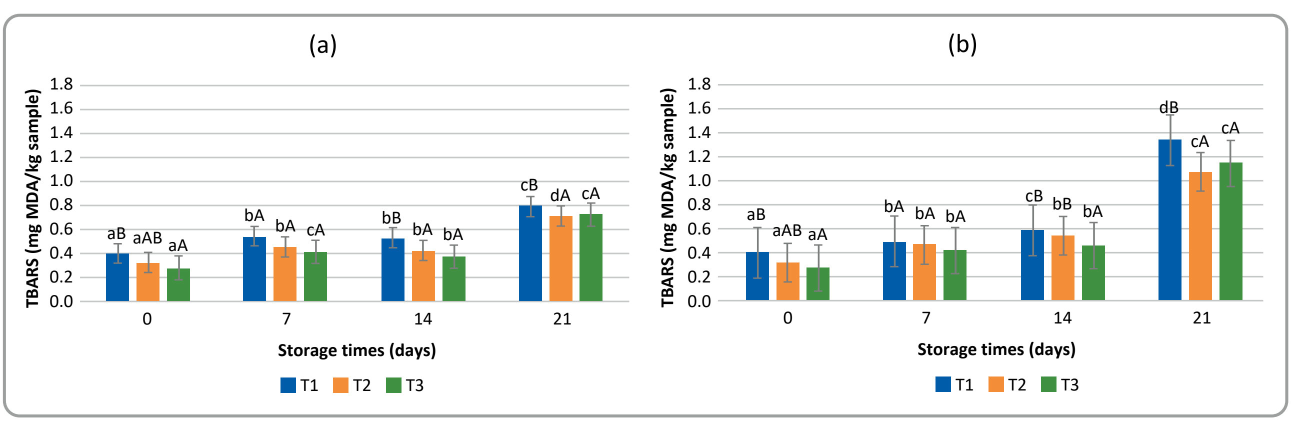

Figure 6. TBARS (mg MDA/kg sample) of sous-vide chicken breasts stored at (a) 4 °C and (b) 10 °C for up to 21 days, using T1 (60 °C/120 min), T2 (50 °C/40 min + 60 °C/80 min), and T3 (50 °C/60 min + 60 °C/60 min). With $p < 0.05$, lowercase letters (a, b, c) denote significant differences across storage days within the same treatment, while uppercase letters (A, B, C) denote significant differences among treatments within the same storage day.

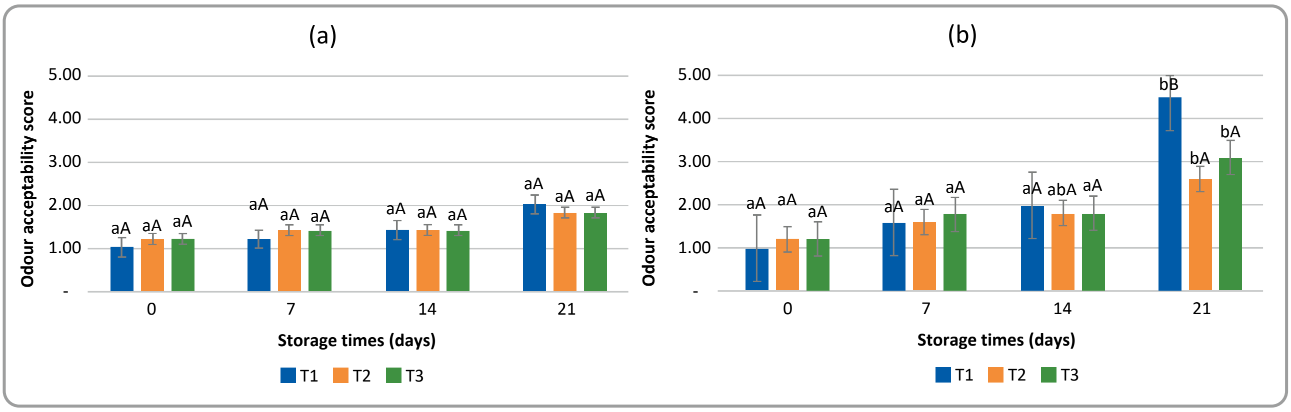

Figure 7. Odour acceptability score of sous-vide chicken breasts stored at (a) 4 °C and (b) 10 °C for up to 21 days, using T1 (60 °C/120 min), T2 (50 °C/40 min + 60 °C/80 min), and T3 (50 °C/60 min + 60 °C/60 min). With $p < 0.05$, lowercase letters (a, b, c) denote significant differences across storage days within the same treatment, while uppercase letters (A, B, C) denote significant differences among treatments within the same storage day.

ANOVA and post-hoc Tukey's analysis showed that on Day 0, the single-step treatment (T1) differed significantly ($p < 0.05$) from the double-step treatments (T2 and T3), with the double-step treatments exhibiting lower values (*Hasani et al*., 2022; *Karpińska-Tymoszczyk et al*., 2020). This difference may be attributed to higher cooking temperatures causing increased protein denaturation and the release of iron ions, which have potent pro-oxidant effects (*Ganhão et al*., 2011). Additionally, cooking meat can accelerate lipid oxidation while deactivating antioxidant compounds or enzymes (*Hong et al*., 2015). Regarding storage temperature, there was a significant difference ($p = 0.044$) between 4 °C and 10 °C, with higher values observed at 10 °C. Lipid oxidation also rose significantly over time at both temperatures ($p < 0.05$), possibly because early oxidation forms hydroperoxides that convert into secondary products, like ketones and aldehydes. Changes in fatty acid and amino acid compositions persisted until the fourth week, underscoring the influence of storage temperature and duration on lipid oxidation (Liu et al., 2019). TBARS values quantify specifically malonaldehyde, which significantly contributes to aroma degradation in stored meat products.

3.4 Odour Acceptability

The results of odour acceptability scoring are shown in Figures 7. This standardized assessment facilitated an objective evaluation of the chicken's odour, enabling conclusions about the product's sensory characteristics and potential consumer appeal.

According to the ANOVA and post-hoc Tukey's test, no significant differences ($p > 0.05$) were observed among the three treatments (T1, T2, and T3), and all remained acceptable until Day 14 of storage. However, on Day 21 at 10 °C, an unpleasant odour was detected ($p < 0.05$), possibly resulting from the formation of secondary lipid oxidation products exceeding the sensory threshold limit of 1 mg MDA/kg sample (*Akoğlu et al*., 2018).

4. Conclusion

This study highlights the effectiveness of both single-step (60 °C/120 min) and double-step (50 °C/60 °C) sous-vide cooking methods in producing high-quality chicken breast, with the two-step treatments exhibiting notably lower cooking loss and higher moisture content. Over a 21-day storage period, the product's colour, lipid oxidation, and odour acceptability were influenced by storage temperature (4 °C vs. 10 °C) and duration. While lipid oxidation and discolouration increased at the higher storage temperature, 4 °C generally helped maintain better sensory attributes. Nevertheless, by Day 21 at 10 °C, even the double-step treatments showed diminished odour acceptability, likely due to secondary lipid oxidation exceeding sensorial thresholds. Overall, the findings underscore the potential benefits of double-step sous-vide processing and emphasize the importance of controlling storage temperature and duration to preserve product quality and extend shelf life.

Nova dvostepena sous-vide tehnika: Inovativna strategija za očuvanje kvaliteta i svežine pilećih grudi

Endrit Hasani, Masagus Haidir Tamimi, István Dalmadi i György Kenesei

INFORMACIJE O RADU

Ključne reči:
Pileće grudi
Dvostepeni sous-vide postupak
Rok trajanja
Smanjenje otpada hrane
Održiva prerada živinskog mesa

APSTRAKT

Ova studija ispitivala je efekte jednostepenog i dvostepenog sous-vide tretmana na kvalitet pilećih grudi tokom različitih perioda skladištenja (0, 7, 14 i 21 dan) i pri različitim temperaturama skladištenja (4 °C i 10 °C). Mišići pectoralis major pilića vakuumski su pakovani i termički obrađeni ili na 60 °C tokom 120 minuta (jednostepeni postupak) ili primenom dvostepenog temperaturnog profila (50 °C, zatim 60 °C) uz jednako ukupno vreme termičke obrade. Analizirani su parametri kvaliteta uključujući sadržaj vlage, gubitak mase tokom kuvanja, boju (CIELAB), lipidnu oksidaciju (supstance reaktivne na tiobarbiturnu kiselinu; TBARS) i prihvatljivost mirisa. Dvostepeni postupak pokazao je značajno bolje zadržavanje vlage i manji gubitak mase tokom kuvanja u poređenju sa jednostepenim postupkom, verovatno usled manjeg skupljanja mišićnih vlakana i bolje rastvorljivosti proteina. Skladištenje na 4 °C omogućilo je bolju stabilnost boje, niži nivo lipidne oksidacije i bolje ocene mirisa u poređenju sa skladištenjem na 10 °C. Do 21. dana skladištenja na 10 °C, vrednosti TBARS-a premašile su senzorni prag, što je dovelo do pojave neprijatnih mirisa i smanjene prihvatljivosti proizvoda. Sa aspekta održivosti, dvostepeni sous-vide pristup može doprineti smanjenju otpada hrane produženjem roka trajanja i očuvanjem kvaliteta proizvoda tokom dužeg perioda distribucije. Ovakav kontrolisani temperaturni profil sous-vide obrade može takođe poboljšati energetsku efikasnost u poređenju sa produženim jednostepenim kuvanjem na visokoj temperaturi. Usklađivanje naprednih metoda termičke obrade sa optimalnim uslovima skladištenja na taj način podržava održiviju proizvodnju živinskog mesa.

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