ISSN Print: 2664-6064
ISSN Online: 2664-6072
IJAN 2024; 6(2): 13-20
www.agriculturejournal.net
Received: 16-05-2024
Accepted: 21-06-2024

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Impact of storage temperature on quality changes in mashed potatoes

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DOI: https://doi.org/10.33545/26646064.2024.v6.i2a.173

Abstract
This study investigates the impact of storage temperature on the quality changes of instant mashed potatoes over a 40-day period. Instant mashed potato samples were stored at three different temperatures: 2 °C, 5 °C, and 8 °C. Various quality parameters, including pH, total acids, reducing sugars, starch, protein, and lipid contents, as well as microbiological indicators such as Coliform, total yeast, and mold counts, were monitored. Results indicated minimal fluctuations in pH levels, with values ranging from 5.12 to 5.24 across all temperatures. Total acid content increased slightly over time, with higher levels at warmer temperatures. Reducing sugars and starch decreased significantly, with the smallest reduction observed at 2 °C. Protein and lipid contents also decreased but to a lesser extent. Microbiological analysis showed that while Coliform and yeast and mold counts were below permissible limits initially, significant growth occurred, especially at 8 °C. By the 40th day, Coliform counts exceeded allowable limits at 8 °C, indicating spoilage, while 2 °C and 5 °C maintained acceptable microbial levels. Overall, storage at 2 °C proved to be the most effective in preserving quality. These findings suggest that lower storage temperatures can better maintain the quality and safety of instant mashed potatoes.

Keywords: Storage temperature, quality changes, mashed potatoes, nutritional content, microbial growth

Introduction
Instant mashed potatoes are a convenient and popular food product known for their ease of preparation and versatility. The quality and shelf life of this product are influenced by various factors during storage, including temperature. Understanding how different storage conditions affect the product's quality is crucial for optimizing storage practices and ensuring product safety.

This study aims to evaluate the impact of different storage temperatures on the quality of instant mashed potatoes. Specifically, we focus on several key quality parameters: pH, total acids, reducing sugars, and starch, protein, and lipid contents. Additionally, microbiological parameters such as Coliform counts and yeast and mold presence are assessed to determine the safety of the product over time.

Previous research has shown that storage temperature can significantly affect the physicochemical and microbiological properties of food products. For instance, temperature variations can influence microbial growth, enzymatic activities, and chemical reactions, leading to changes in taste, texture, and nutritional value. In the context of instant mashed potatoes, which are often subjected to varying storage conditions during distribution and retail, it is essential to understand these effects to ensure product quality and safety.

This research investigates these effects by storing instant mashed potatoes at 2 °C, 5 °C, and 8 °C and monitoring the changes in quality indicators over a 40-day period. The outcomes of this study provide valuable insights into the optimal storage conditions for maintaining the quality and safety of instant mashed potatoes, offering practical guidance for manufacturers, distributors, and consumers.

Content and Research Methods

Research content

This study investigates the impact of storage temperature on quality changes (pH, total acidity, starch content, reducing sugars, protein, lipids, and certain microbiological indicators) in mashed potato products.

Research methods

Experimental processing

- **Materials:** Solana potato variety
- **Preparation:** Select potatoes with uniform size, shape, and color. Potatoes that are spoiled or damaged are discarded. Peel the potatoes and cut them into small pieces. Blanch the potatoes in boiling water with a salt concentration of 0.75% for 5 minutes to inhibit browning, reduce off-flavors, and enhance the sensory quality of the final product.
- **Cooking:** Steam the potatoes for 15 minutes. Steaming helps retain the color and nutritional value of the potatoes.
- **Mashing and Mixing:** After steaming, mash the potatoes thoroughly. Mix the mashed potatoes with other ingredients and additives according to the formula shown in Table 1.

Table 1: Formulation of mashed potatoes in the experiment

Ingredients	Percentage (%)	Ingredients	Percentage (%)
Potatoes	100	Coloring agent (E450)	0, 2
Water	50	Acidity regulator (E330)	0, 1
Bone powder	0,625	Sorbic acid (E200)	0,03
Salt	0,35	Sodium benzoate (E211)	0,03
Cooking oil	1,5	Emulsifier (E471)	0,075

Note: Potatoes are the main ingredient, and other components are calculated as a percentage of the potato weight

Packaging and sterilization: After mixing, the product is packed in aluminum foil bags measuring 13 x 18 cm and then sterilized at 92 °C (product core temperature) with a heating time of 25-30 minutes, followed by a holding time of 15 minutes, and then cooled to room temperature. The product is subsequently subjected to sensory evaluation and nutritional assessment.

Assessment of quality changes during cold storage

The experiment includes 3 treatments (T), replicated 3 times, each with 600g of product at a specific temperature:
T_1: 2 °C±0.5
T_2: 5 °C±0.5
T_3: 8 °C±0.5

Product quality is monitored over a period of 40 days with observations every 10 days. The parameters monitored include:
pH measurement: According to National Standard (TCVN 12348:2018).
Total acidity determination: According to National Standard (TCVN 4589-88).
Reducing sugars determination: According to National Standard (TCVN 6960:2023).
Starch content determination: According to National Standard (TCVN 9935:2013)
Protein determination: According to National Standard (TCVN 9936:2013).
Lipid determination: According to National Standard (TCVN 4592:1988).
Coliform determination: According to National Standard (TCVN 6848:2007).
Total aerobic microorganisms determination: According to National Standard (TCVN 9977:2013).

Data processing methods

Experimental data were processed using Excel and SAS 9.1 software. Differences in mean values between formulations were assessed using ANOVA analysis in SAS 9.1 software.

Results and Discussion

Table 2 shows that the product contains starch, protein, and lipid amounts of 13.9 g, 0.99 g, and 1.4 g per 100 g of the product, respectively. Compared to other products such as noodles and pho, mashed potatoes are lower in starch (noodles: 25.7 g/100 g; pho: 31.7 g/100 g - Nguyen Cong Khan & Ha Thi Anh Dao, 2007), slightly lower in protein content compared to noodles (1.7 g/100 g), but higher in fat content (due to the inclusion of cooking oil in the product formula).

Table 2: Average nutritional values per 100 g of mashed potato product

Nutritional component	Content (g)
Starch	13,87±0,1
Reducing sugars	1,80±0,016
Protein	0,99±0,014
Lipid	1,38±0,003

Instant mashed potatoes are a sterilized product where microbial quality is crucial, closely related to product safety. In this study, we used a composite aluminum foil packaging (3-layer Couche/MPET/BOPP) with good heat resistance, odor barrier properties, and a sealed seam to limit microbial contamination. The results of evaluating certain microbiological indicators in the instant mashed potato samples after processing are as follows:
Coliform: < 1×10^1 CFU/g of product.
Total aerobic microorganisms: 4.33×10^2 CFU/g of product.
Total yeast and mould: < 1×10^1 CFU/g of product.

Comparing the microbiological results with the standards set forth in Decision 46/2007/QD-BYT, it can be concluded that the instant mashed potato product meets the safety criteria for microbial indicators.

Evaluation of pH fluctuations in instant mashed potato products during cold storage

pH is one of the key indicators in assessing product quality. It is closely related to the activity of microorganisms as well as the chemical reactions that occur during food storage. By monitoring the fluctuations of this indicator, we obtained the following results:

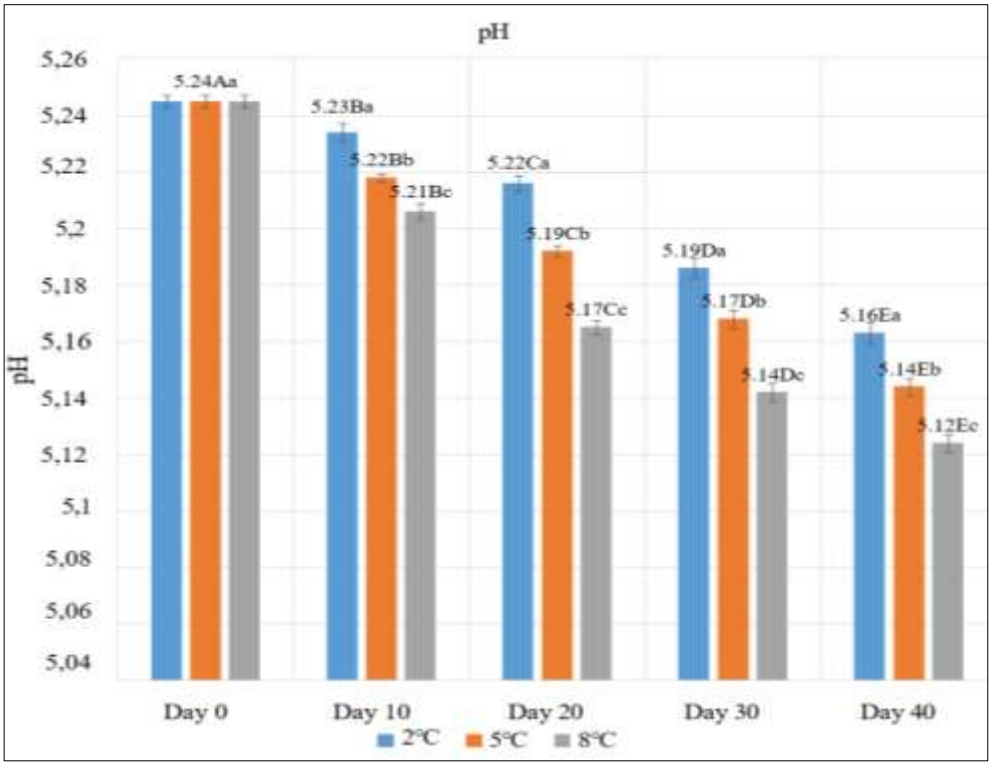


Fig 1: The effect of temperature on pH values during cold storage

A, B, C, D, E represent differences between storage days.
a, b, c, d represent differences between formulations on the same day.
The results indicate that although pH levels showed some differences within the first 10 days of storage, with a slight decline in the following days, the fluctuations were minimal. Additionally, the differences in pH between the formulations were not significant. A more pronounced decrease in pH was observed on the 20th day of storage. Overall, pH values ranged from 5.12 to 5.24 throughout the monitoring period across all tested storage temperatures. This may be related to the stability of product quality under our experimental conditions, which warrants further investigation

Evaluation of total acid content fluctuations in mashed potato products during cold storage

Total acid content is closely related to the chemical/biochemical reactions occurring in food during storage. Figure 2 presents the analysis results of this indicator over the monitoring days.

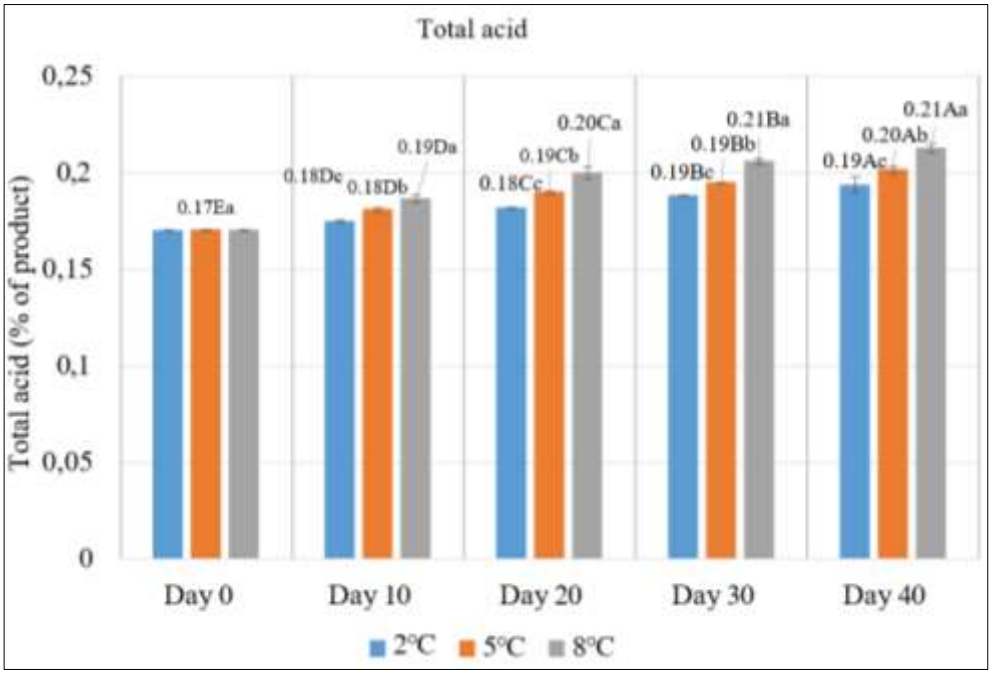


Fig 2: The effect of temperature on total acid content during cold storage

A, B, C, D, E represent differences between storage days.
a, b, c, d represent differences between formulations on the same day.

We observed that this indicator showed minimal fluctuations over the 40 days of storage. The total acid content tended to increase, with differences observed between the experimental formulations on the 20th day of storage. This indicator ranged from 0.17-0.19% at a storage temperature of 2°C, 0.17-0.20% at 5°C, and 0.17-0.21% when the product was stored at 8°C. This increase may be attributed to the production of acids by microorganisms during storage. These results align with the pH values we obtained earlier.

Evaluation of reducing sugar content fluctuations in mashed potato products during cold storage

Reducing sugar content is a significant component in potatoes. High levels of reducing sugars are often associated with changes in color during processing and storage. Analysis results shown in Figure 3 indicate that reducing sugar content tends to decrease across all three tested storage temperatures, particularly after the 30th day. The temperature of 2°C resulted in the smallest reduction compared to the other two temperatures. Specifically, at 8°C, reducing sugars decreased by nearly half from the initial level, approximately 40% at 5°C, and about 30% at 2°C. However, during the monitoring period, the differences in this indicator between the experimental formulations and between storage days were relatively minor. The results may be attributed to the reduction or utilization of reducing sugars by microorganisms toward the end of the storage period.

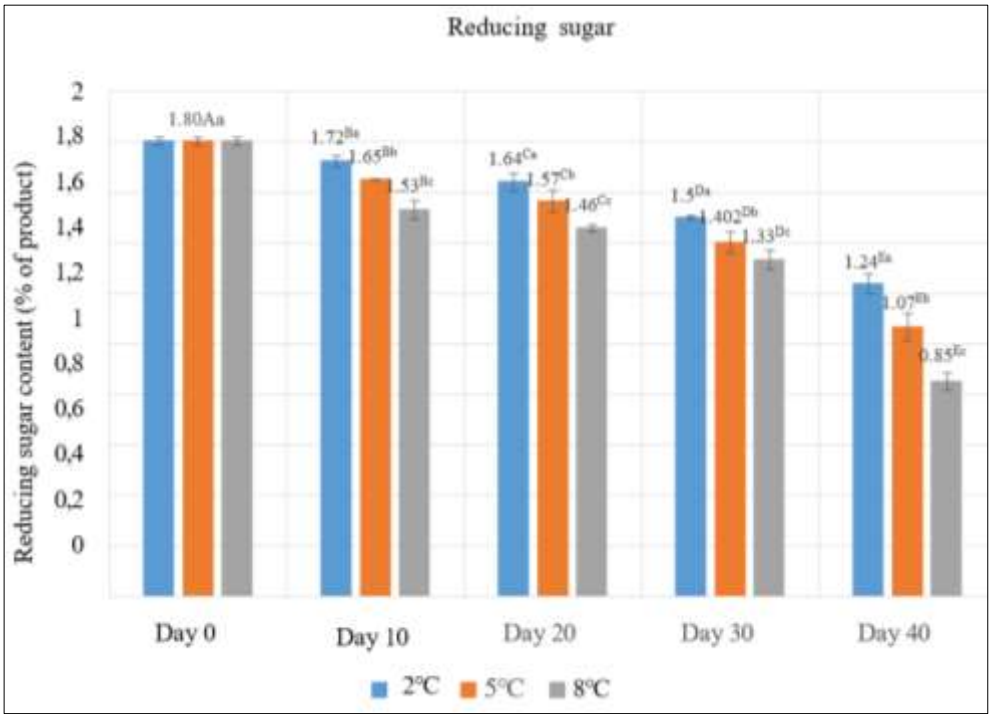


Fig 3: The effect of temperature on reducing sugar content changes during cold storage

A, B, C, D, E represent differences between storage days.
a, b, c, d represent differences between formulations on the same day.

Evaluation of starch content fluctuations in mashed potato products during cold storage

Starch is the primary energy source in potatoes. The research results, shown in Figure 4, indicate that starch content tends to decrease significantly at all three tested storage temperatures, especially by the 30th day of storage. Among the experimental conditions, 2°C remains the most effective storage temperature, with a slower reduction in starch content. Specifically, starch content decreased to 7.68% after 40 days of storage at 5°C, 7.28% at 8°C, but remained at 9.01% in the sample stored at 2°C. The reduction in starch content may be attributed to its utilization as a nutrient by microorganisms and its involvement in chemical changes such as hydrolysis and oxidation reactions

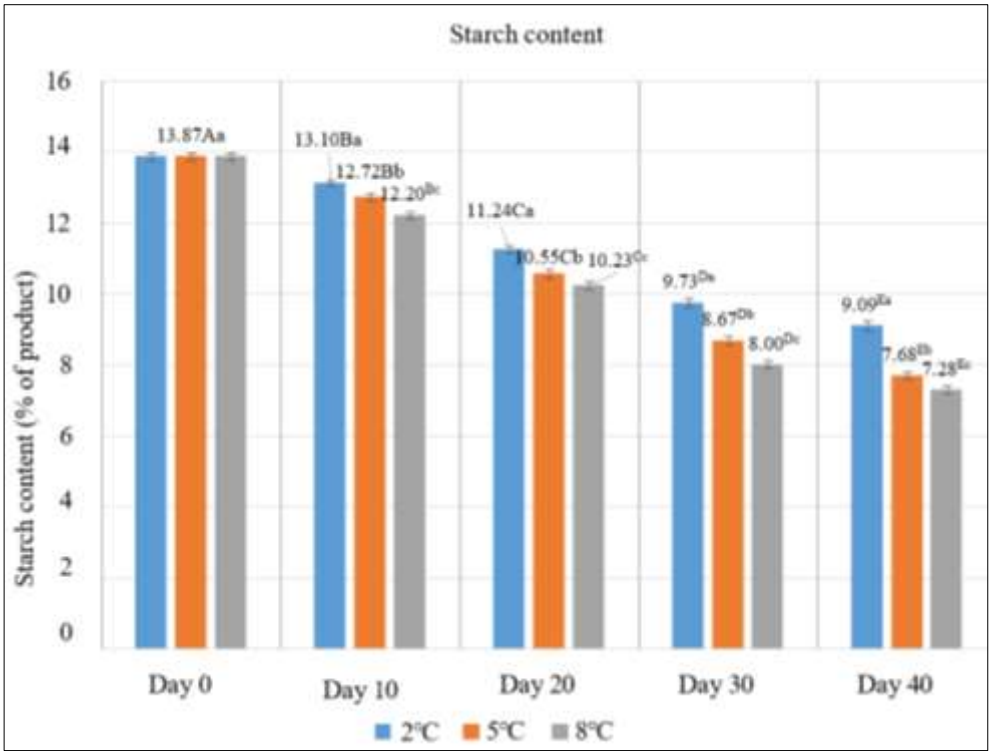


Fig 4: The effect of temperature on starch content changes during cold storage

A, B, C, D, E represent differences between storage days.
a, b, c, d represent differences between formulations on the same day.

Evaluation of protein content fluctuations in mashed potato products during cold storage

Proteins play a crucial role in all biological processes and are also an important source of nutrition in food. The study of this indicator is shown in Figure 5. We observed that at all three temperatures (2°C, 5°C, and 8°C), protein content tended to decrease over the storage period. However, the differences between the experimental formulations were not significant. After 40 days of storage, the protein content remained approximately 65-77% of the initial level at day 0.

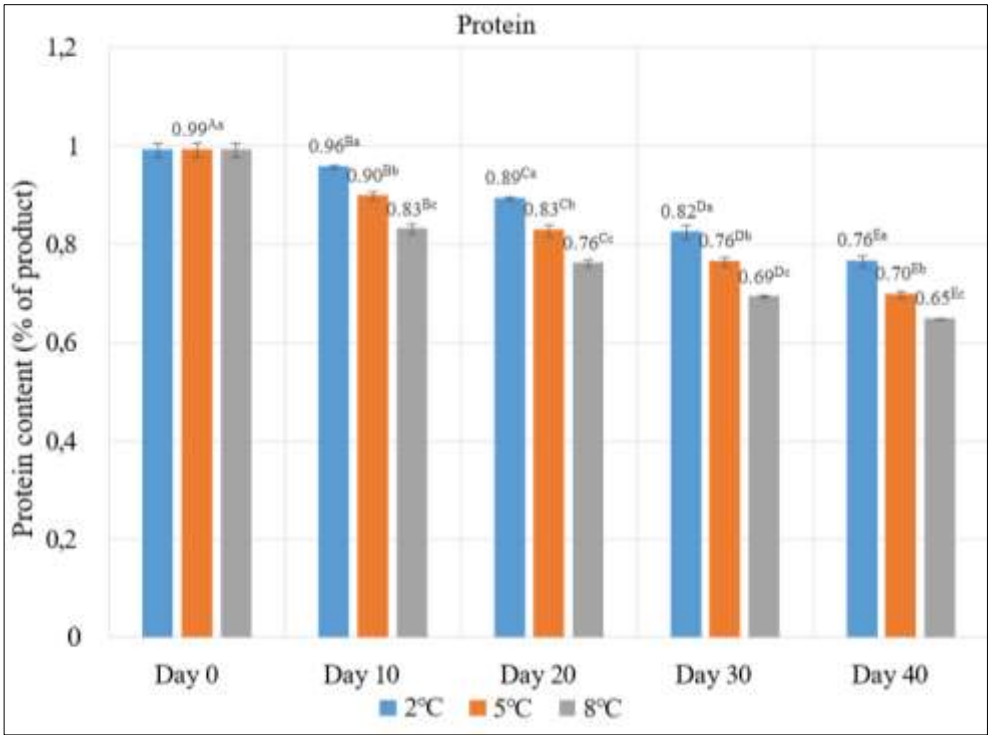


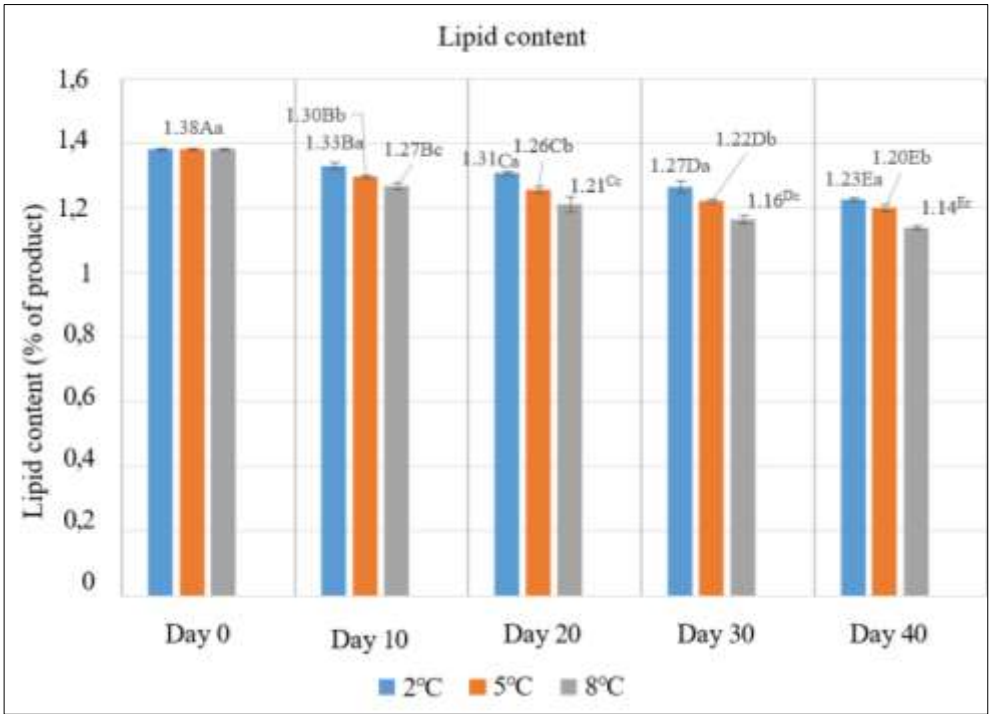
Fig 5: The effect of temperature on protein content changes during cold storage.

A, B, C, D, E represent differences between storage days.
a, b, c, d represent differences between formulations on the same day.

Evaluation of lipid content fluctuations in mashed potato products during cold storage

Fats are not only a source of energy but also significantly influence sensory properties such as texture (smoothness, gloss) and odor in instant mashed potato products. However, during storage, changes in this component often lead to undesirable smells and tastes (rancid, burnt, etc.). The results indicate that although there is a decreasing trend over the storage period, the fluctuations in lipid content are not substantial. The results for lipids are similar to those for proteins, with content decreasing across the temperatures of 2 °C, 5 °C, and 8 °C, though the reduction is not significant throughout the 40-day storage period (approximately 0.15%-0.24%).

Thus, all nutritional components tend to decrease from the 10th day of storage, except for total acids, with the extent of decline varying by indicator. Among the three tested temperatures, the effectiveness of storage is generally in the order of 2 °C > 5 °C > 8 °C.



A, B, C, D, E represent differences between storage days.
a, b, c, d represent differences between formulations on the same day.

Fig 6: The effect of temperature on lipid content changes during cold storage

Evaluation of microbiological parameters in mashed potato products during cold storage

Microbiological parameters are among the factors that directly determine the product's shelf life. Monitoring these parameters during storage, we obtained results shown in Tables 3, 4, and 5

Table 3: Coliform levels during cold storage

Monitoring day	Coliform (CFU/g)		
	2 °C	5 °C	8 °C
0	$< 1\times10^1$	$< 1\times10^1$	$< 1\times10^1$
10	1×10^2	$1,7\times10^2$	$2,6\times10^2$
20	$1,8\times10^2$	$2,4\times10^2$	$3,5\times10^2$
30	$3,6\times10^2$	$4,7\times10^2$	$5,9\times10^2$
40	$6,9\times10^2$	9×10^2	$1,1\times10^3$

Table 4: Total aerobic microorganism counts during cold storage

Monitoring day	Total aerobic microorganisms (CFU/g)		
	2 °C	5 °C	8 °C
0	$4,3\times10^2$	$4,3\times10^2$	$4,3\times10^2$
10	$1,5\times10^3$	$2,7\times10^3$	$4,7\times10^3$
20	$4,1\times10^3$	$6,4\times10^3$	$8,2\times10^3$
30	$8,1\times10^3$	$9,4\times10^3$	$1,7\times10^4$
40	$2,5\times10^4$	$3,3\times10^4$	$4,6\times10^4$

Table 5: Total yeast and mold counts during cold storage

Monitoring day	Yeast and mold (CFU/g)		
	2 °C	5 °C	8 °C
0	< 1×10^1	< 1×10^1	< 1×10^1
10	$6{,}7\times10^1$	$1{,}3\times10^2$	$2{,}2\times10^2$
20	$1{,}3\times10^2$	$2{,}2\times10^2$	$3{,}2\times10^2$
30	$2{,}3\times10^2$	$3{,}3\times10^2$	5×10^2
40	$3{,}8\times10^2$	$6{,}3\times10^2$	$7{,}7\times10^2$

The instant mashed potato product was supplemented with additives E200 and E211, which have antifungal and antibacterial effects, and combined with a pasteurization process at 92 °C. Therefore, the results indicate that microbiological parameters such as Coliform and total yeast and mold counts were all < 1×10^1 CFU/g of product on the initial day, which is entirely reasonable. After 10 days of storage, these microorganisms began to appear, except for the total aerobic microorganisms, which were present from the first day at 4.3×10^2 CFU/g of product.

On day 40, at a temperature of 8 °C, the Coliform count reached 1.1×10^3 CFU/g, the highest among the three storage temperatures. Similarly, for total aerobic microorganisms and total yeast and mold counts at this temperature, results were higher compared to the other two temperatures, at 4.6×10^4 and 7.7×10^2 CFU/g of product, respectively. In contrast, the temperature of 2 °C showed the lowest microbial growth, with total aerobic microorganisms and total yeast and mold counts being only about half of those at 8 °C.

According to Decision 46/2007/QD-BYT on permissible limits for biological contamination in processed foods made from cereals, tubers, and legumes that have undergone thermal treatment, the microbiological parameters of the product remain within permissible limits after 30 days of storage. By day 40, only at temperatures of 2 °C and 5 °C were the microbial counts within the allowable range, whereas at 8 °C, the Coliform count exceeded the regulated limits and was considered to indicate spoilage.

Conclusion

The instant mashed potato product developed during the experiment has an attractive sensory quality, is positively rated, and is considered of good quality. The starch, protein, and lipid contents are 13.9 g, 0.99 g, and 1.4 g per 100 g of product, respectively.

At a cold storage condition of 2 °C±0, the product quality remains virtually unchanged over the first 20 days regarding physical-chemical, nutritional, sensory, and microbiological parameters. These parameters show slight variations, and sensory quality remains good by the 30th day of storage.

At a storage condition of 5 °C±0.5, the quality remains almost unchanged over the first 10 days. The overall sensory score decreases slightly but remains good, and the product remains microbiologically safe by the 20th day.

At a storage condition of 8 °C±0.5, the product shows slight changes in physical-chemical, nutritional, sensory, and microbiological parameters over the first 10 days. These parameters exhibit more significant fluctuations from the 10th to the 40th day of storage, particularly in sensory and microbiological quality. Thus, depending on the quality objectives and actual consumption, storage can be maintained at temperatures between 2 and 5 °C

References

1. Fernández C, Canet W, Álvarez MD. The effect of long-term frozen storage on the quality of frozen and thawed mashed potatoes with added cryoprotectant mixtures. Int J Food Sci Technol. 2009;44(7):1373–87. doi: 10.1111/j.1365-2621.2007.01725.x.
2. Álvarez MD, Fernández C, Canet W. Effect of freezing/thawing conditions and long-term frozen storage on the quality of mashed potatoes. J Sci Food Agric. 2005;85(14):2327–40. doi: 10.1002/jsfa.2240.
3. Nourian F, Ramaswamy HS, Kushalappa AC. Kinetics of quality change associated with potatoes stored at different temperatures. LWT Food Sci Technol. 2003;36(1):49–65. doi: 10.1016/S0023-6438(02)00202-8.
4. Canet W, Fernández C, Álvarez MD, Raimundo A, Cambero MI. The effect of sample temperature on instrumental and sensory properties of mashed potato products. Int J Food Sci Technol. 2005;40(5):481–93. doi: 10.1111/j.1365-2621.2005.00950.x.
5. Baardseth P. Effect of selected antioxidants on the stability of dehydrated mashed potatoes. Food Addit Contam. 1989;6(2):201–7. doi: 10.1080/02652038909373778.
6. Patel J, Armstrong L, Song J, Tang J, Barbosa-Cánovas GV. Storage stability of vitamin C fortified purple mashed potatoes processed with microwave-assisted thermal sterilization system. Food Innov Adv. 2023;2(2):106–14. doi: 10.1002/fia2.12015.
7. Fernández C, Canet W, Álvarez MD. Quality of mashed potatoes: effect of adding blends of kappa-carrageenan and xanthan gum. Eur Food Res Technol. 2009;229(2):205–22. doi: 10.1007/s00217-009-1044-8.
8. Kaaber L, Nielsen S, Thybo AK. The effect of storage conditions on chemical content of raw potatoes and texture of cooked potatoes. Potato Res. 2001;44(2):153–63. doi: 10.1007/BF02410096.
9. Sonar CR, Ahmed J, Al-Attabi ZH, Raman S. Investigating thermal and storage stability of vitamins in pasteurized mashed potatoes packed in barrier packaging films. Food Packag Shelf Life. 2020;24:100486. doi: 10.1016/j.fpsl.2020.100486.
10. Zhang H, Tang J, Kong F, Wang Y. Effects of oxygen and water vapor transmission rates of polymeric pouches on oxidative changes of microwave-sterilized mashed potato. Food Bioprocess Technol. 2016;9(2):341–51. doi: 10.1007/s11947-015-1628-3.
11. Miao W, Fan Z, Yi J, Zhang L, Shi Z. Rheological, sensory, and microstructural properties of fresh and frozen/thawed mashed potatoes enriched with different proteins. CyTA J Food. 2018;16(1):113–21. doi: 10.1080/19476337.2017.1355063.
12. Chen J, Tang J, Liu F, Wang Y, Song J. Temperature-dependent dielectric and thermal properties of whey protein gel and mashed potato. Trans ASABE. 2013;56(6):1457–67. doi: 10.13031/trans.56.10176.
13. Park HW, Yoon WB. Effect of drying and grinding characteristics of colored potato (Solanum tuberosum

L.) on tribology of mashed colored potato paste. CyTA J Food. 2018;16(1):135–45. doi: 10.1080/19476337.2017.1358710.
14. Álvarez MD, Canet W, Fernández C, Barber CB, Frías JM. Viscoelasticity and microstructure of inulin-enriched mashed potatoes: Influence of freezing and cryoprotectants. J Food Eng. 2011;102(1):66–76. doi: 10.1016/j.jfoodeng.2010.08.016.
15. Chiavaro E, Mazzeo T, Visconti A, Manzi C, Fogliano V, Pellegrini N. The effect of different cooking methods on the instrumental quality of potatoes (cv. Agata). J Food Eng. 2006;77(1):169–78. doi: 10.1016/j.jfoodeng.2005.06.020.
16. Fernández C, Álvarez MD, Canet W. Steady shear and yield stress data of fresh and frozen/thawed mashed potatoes: Effect of biopolymers addition. Food Hydrocoll. 2008;22(7):1381–95. doi: 10.1016/j.foodhyd.2007.06.002.