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Effect of Calcium Chloride and Calcium Lactate on the Characteristics of Sweet Potato

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Abstract: Sweet potatoes have gained popularity as a result of their adaptability to a wide variety of food production methods. However, due to the perishable nature of its properties, it was determined that sweet potato could be treated with calcium chloride and calcium lactate to circumvent this limitation. Hence, the effect of calcium salts on the sweet potato was investigated on the water activity, moisture content, colour measurement, texture analysis, sensory acceptance, and microbial growth. Three sweet potato samples were evaluated: untreated sweet potato (SP), sweet potato treated with calcium chloride (SP-CC), and sweet potato treated with calcium lactate (SP-CL). The samples of SP-CC and SP-CL had slightly lower water activity and moisture content mean values. Besides, both treated samples had a firmer texture than SP. Sensory analysis revealed that SP-CC and SP-CL possessed a stronger aroma, a saltier and bitterer flavour, but were less sweet than SP. No significant differences in colour measurement between the treated and control sweet potatoes were observed. Additionally, a microbial growth analysis revealed that the SP-CC and SP-CL had a longer shelf life of approximately 2-5 weeks than SP, which has a shelf life of only one week. As summarised, the calcium chloride and calcium lactate treatment affected the characteristics of sweet potatoes.

Keywords: Sweet Potato, Calcium Chloride, Calcium Lactate

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1. Introduction

Sweet potato is a tuberous root plant that grows throughout the world's tropical, subtropical, and warm temperature regions [1]. Sweet potatoes are high in dietary fibre, minerals, vitamins, and phytochemicals. Although sweet potato is extremely popular in the food industry, it has a high moisture content due to its susceptibility to spoilage microorganisms, which contributes to its shelf life after harvest. Numerous methods, such as drying and chemical methods [2], have been studied to keep it from spoiling rapidly. The methods, however, continue to affect flavour and texture. For instance, when the sweet potato is subjected to thermal processing such as oven drying, hot air, boiling, or blanching, the texture of the sweet potato will change [3]. The characteristics of sweet potatoes is crucial to ensure the made-up products have a long shelf life and good sensory acceptance. Therefore, many alternative techniques for post-harvest food treatment are studied to ensure the preservation of texture and shelf-life [4].

Several studies have been conducted on the application of calcium salts to soil products, which are used primarily for protection or possibly to increase the product's firmness [5-7]. In addition, calcium salts help to extend the useful life of soil products by preventing them from scorching and providing immovability to their structure. It affects tissue immobility because it can reinforce the cell divider by preventing the free carboxylic gathering of gelatine chains framing cross-connections or spans while also preserving the underlying and useful respectability of films [8]. Recent research conducted by Yu et al. (2018) [9] studied the application of high-pressure processing and soaking in calcium salts for fresh-cut carrots which resulted in a 9-day storage period for fresh-cut carrots treated with calcium chloride. Liu et al. (2020) [10] had discussed calcium chloride and calcium lactate can enhance the hardness of potato slices after boiling. These researches indicated the potential of calcium salts with different techniques for different fruit and vegetables.

In this study, the effect of sweet potatoes treated with calcium salts which are calcium chloride and calcium lactate was explored. The water activity, moisture content, colour measurement, texture analysis, sensory acceptance, and microbial growth of the samples were investigated to assess the quality of sweet potatoes treated with both calcium salts. Three samples were prepared included untreated sweet potato (SP) as a control sample, sweet potato treated with calcium chloride (SP-CC), and sweet potato treated with calcium lactate (SP-CL) for this study.

2. Materials and Methods

2.1 Materials

Sweet potatoes, calcium chloride and calcium lactate (both calcium salts are food grade) are materials that were used in this study. Several instruments included water activity meter (AquaLab LITE-Decagon, USA), moisture analyzer (MX-50 A&D, Japan), texture analyzer (CT3, Brookfield, MA, USA), and colour flex (Miniscan EZ, Hunter Lab, USA) were utilised in this study.

2.2 Sample preparation

The sweet potatoes were purchased and stored at 4 ºC before utilising them. In the preparation, the sweet potato samples were cleaned with tap water. Then, cut it in a round shape that has a thickness of ±0.5 cm and a length of about ± 5 cm as shown in Figure 1. After that, the sweet potato has undergone treatment with calcium salts. Three categories of samples were prepared which are untreated sweet potato (SP) as a control sample, sweet potato treated with calcium chloride (SP-CC), and sweet potato treated with calcium lactate (SP-CL). SP-CC and SP-CL were soaked identically in each calcium salt solution for 1 hour at ambient temperature. Then, the sweet potato samples were undergone a boiling process which is a thermal treatment process chosen. Finally, the quality assessment for sweet potatoes was conducted and observed [10].

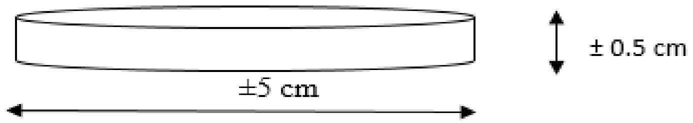

Figure 1: Illustration shape of treated sweet potato

2.3 Water activity

A fast water activity meter was used to determine the water activity of samples. To begin, a calibration of the water activity meter was required prior to testing. A slice of sweet potato was put in a small plastic cup, not more than halfway full, then placed in the base of an airtight test chamber. Following that, the samples were sealed with the measuring head and then with the base to create an airtight seal. Three replicates of each sample were determined and water activity values for each sample were recorded.

2.4 Moisture content

A moisture analyser was used to determine the moisture content. 5 g of each sample was located in a moisture analyser at the temperature of 70 °C. The steps were repeated in triplicate for each sample.

2.5 Texture analysis

The texture analysis was evaluated by using a texture analyser. The cylindrical sweet potato slice was pressed with a cylindrical aluminium plate at a constant crosshead speed of 2 mm/s. The texture was expressed as the firmness of its original thickness. Three replicates of each sample were determined.

2.6 Sensory analysis

The sensory assessment of the sliced sweet potatoes samples was analysed using a descriptive test. The descriptive test can be performed by 6 trained panellists. The quantitative descriptive analysis (QDA) was used for measuring the significant differences between sensory descriptors and attributes flavour and textural components of sweet potato. Aroma, mouthfeel, sweet, salty, bitter, colour, after taste, and overall acceptability were evaluated.

2.7 Colour measurement

The colour measurement of samples was identified by using HunterLab with the CIELab system at room temperature. All colour measurements of samples were carried out in triplicate, with L^* (lightness), a^* (redness) and b^* (yellowness) mean values.

2.8 Microbiological analysis

The microbiological analysis was tested by making the sample preparation, spread plates, and then put onto the medium preparation. 10 g of samples were diluted with 500 mL of 2 % peptone water for 2 min under sterile conditions. A series of dilutions were prepared according to the standard method agar (SMA) which were 10^{-3} until 10^{-5}. For each dilution, 1 mL aliquot was taken using aseptically pipetted onto a duplicate petri dish. A spreader was utilised to make the samples distribute evenly on the petri dish. To examine the total plate count (TPC), standard method agar was used. Then, this agar would undergo incubation. The incubation condition for TPC was 37 °C for 48 hours. The observations were carried out in Weeks 1, 2, and 5 [11].

2.9 Statistical analysis

The triplicates of experimental results were expressed as the means ± standard deviation to show variations in the various experimental. The averages and standard deviation of the means were calculated using Microsoft Excel 2013 (Vista Edition, Microsoft Corporation, USA).

3. Results and Discussion

3.1 Water activity and moisture content

There is slightly different water activity and moisture content mean values between the control sample (SP) with treated sweet potatoes samples (SP-CC and SP-CL) (Table 1). The SP sample has a water activity mean value of 0.913 ± 0.003 while the treated sweet potatoes samples; SP-CC and SP-CL samples have water activity mean values of 0.909 ± 0.008 and 0.916 ± 0.005, respectively. For moisture content, the SP, SP-CC and SP-CL samples have mean values of 84.32 ±0.236, 82.00 ±1.593, and 83.11 ± 0.751, respectively. The treated sweet potatoes samples have slightly lower water activity (a_w) and moisture content (%) than untreated sweet potatoes. It is because the addition of calcium salts into the samples will increase water loss due to osmotic pressure occur that is strongly related to the cell wall effects [12-14].

Table 1: Water activity and moisture content of sweet potatoes

Samples	Water activity (a_w) Mean ± SD	Moisture content (%) Mean ± SD
SP (control)	0.913 ± 0.003	84.32 ± 0.236
SP-CC	0.909 ± 0.008	82.00 ±1.593
SP-CL	0.916 ± 0.005	83.11 ± 0.751

3.2 Texture Analysis

Table 2 indicated the control sample (SP) has a texture mean value of 2631.408 ± 296.5397. While sweet potatoes treated with calcium chloride (SP-CC) and calcium lactate (SP-CL) have mean values of 10715.39 ± 1198.446 and 9289.083 ± 951.0749, respectively. This result indicates that the SP-CC and SP-CL samples require more force to rupture than the SP sample, owing to the fact that negatively charged galacturonic acid residues in pectin form ionic bonds in the presence of calcium. This results in the formation of a calcium-pectate structure, which strengthens cell walls. Calcium was likely to act as a protector, preventing pectin loss from the cell wall [15]. According to Pereira et al. (2007) [12], the firming effect is caused by calcium ions being bound to the cell wall and middle lamella pectin. Also, the calcium absorption by the tissue could provide increased resistance to friction, thereby avoiding rupture and mass loss [16].

Calcium ions and pectin linkages in the cell wall appear to obstruct water evaporation from the structured cells, thus making the cell wall rigid, resulting in cytoplasm shrinkage but with no alteration in the total water content of the fruit or vegetables. In addition, the texture mean value of SP-CC is higher than SP-CL indicated different calcium ions performance between calcium chloride and calcium lactate solution. The calcium chloride formed by the reaction of a strong acid with a strong base, while the calcium lactate is a salt formed by the reaction of a weak acid with a strong base. Since that, all the calcium ions are dissociated in calcium chloride solution but only some of these ions are available in calcium lactate solution, resulting in a higher amount of free calcium ion available for pectin linkage in SP-CC sample rather than SP-CL [17].

Table 2: Texture of sweet potatoes

Samples	Mean of force to puncture ± SD
SP	2631.408 ± 296.5397
SP-CC	10715.39 ± 1198.446
SP-CL	9289.083 ± 951.0749

3.3 Sensory analysis

In this study, the sensory testing was done by using the descriptive method. Three studied sweet potatoes were coded as 453, 128, and 143 during experimental analysis represented for SP, SP-CC, and SP-CL samples, respectively. As shown in Figure 2, the calcium salts influenced the sensory evaluation of sweet potatoes. The treated sweet potatoes are less sweet than the control sweet potato. Additionally, calcium salts impart a pleasant aroma to sweet potatoes, where the SP-CL sample produces the strongest aroma, followed by the SP-CC and SP control samples. Furthermore, these calcium salts impart bitterness to the sweet potatoes that are not present in the controlled sweet potato. In terms of after-taste observation, the bitterness of treated sweet potatoes is still can be tasted in the mouth. The overall acceptability result summarised treated sweet potatoes to be the least acceptable. However, the sensory evaluation can be altered during the manufacturing process of food products by adding sweeteners such as honey or sugar or by adding water to dilute the bitter taste [18].

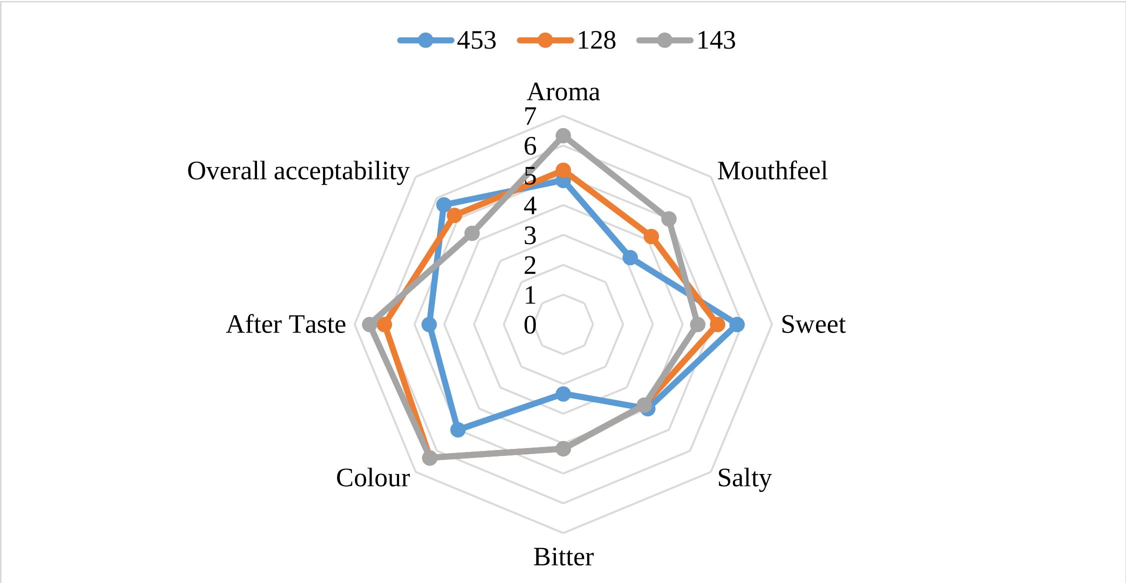

Figure 2: Sensory evaluation of sweet potatoes; the 453, 128, and 143 codes correspond to SP (control) samples, SP-CC samples, and SP-CL samples, respectively.

3.4 Colour measurement

The colour measurement analysis (Table 3) tabulated the value of L^*, a^* and b^* for the SP-CC (L^* = 49.20 ± 1.59, a^* = 22.99 ± 1.89, and b^* = 32.98 ± 1.38) and SP-LC (L^* = 49.30 ± 1.08, a^* = 22.87 ± 0.84, and b^* = 33.73 ± 0.41) samples are slightly similar to the SP sample (L^* = 49.29 ± 1.73, a^* = 23.63

± 1.03, b^* = 33.99 ± 0.78). It is because, during calcium impregnation, the colour purity and brightness of fresh fruits and vegetables remained unaltered [16].

Table 3: Colour measurement analysis of the sweet potatoes

Colour Scales	Samples	Mean ± SD
L*	SP	49.29 ± 1.73
	SP-CC	49.20 ± 1.59
	SP-CL	49.30 ± 1.08
a*	SP	23.63 ± 1.03
	SP-CC	22.99 ± 1.89
	SP-CL	22.87 ± 0.84
b*	SP	33.99 ± 0.78
	SP-CC	32.98 ± 1.38
	SP-CL	33.73 ± 0.41

3.5 Microbiological analysis

To determine the shelf life of sweet potatoes treated with calcium salts, the total mould count was evaluated. The total yeast and mould count of the sweet potatoes is shown in Table 4. During the first week, a mould was detected on the SP sample (2.0 x 10^{-3} ± 1.41), but not on the SP-CC and SP-CL treated sweet potatoes. However, mould growth was started appearing in Week 2 on the SP-CC sample (4.0 x 10^{-3} ± 28.28) in Week 2, while on the SP-CL sample (3.0 x 10^{-3} ± 2.83) in Week 3. This resulted from the effects of moisture content and water activity. The calcium reduces the moisture content and water activity of the sweet potatoes that have been treated. This result indicates that sweet potatoes treated with calcium salts have a survival rate of approximately 2-5 weeks, compared to untreated sweet potatoes, which have a survival rate of only one week. As known, when the moisture content and water activity of food products are low, microbial growth is inhibited, thereby extending the shelf life of the product [19].

Table 4: Total yeast and mould colony of sweet potatoes

Samples	Colony-forming unit per millitre (cfu/ml) (Mean ± SD)		
	Week 1	Week 2	Week 5
SP (control)	2.0 x 10^3 ± 1.41	3.4 x 10^2 ± 42.43	6.4 x 10^2 ± 33.94
SP-CC	-	4.0 x 10^3 ± 28.28	6.0 x 10^2 ± 19.80
SP-CL	-	-	3.0 x 10^3 ± 2.83

4. Conclusion

This study examined the calcium chloride and calcium lactate effect on the characteristics of sweet potatoes. From the results, no changes occurred in the physical characteristics and colour changes of the sweet potatoes. Additionally, the treatment of calcium salts improved the tissue firmness of sweet potatoes. Due to the antimicrobial effect, the treated sweet potatoes had a shelf life of approximately 2-5 weeks longer than the untreated sweet potato. It can be concluded that the calcium salt chloride and calcium lactate treatment can preserve the character and extend the shelf life of fresh sweet potatoes.

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References

[1] G. G., Ainsworth, A. S. Sussman , "The fungi an advanced treatise: the fungal cell.," New York: Academic Press., 1965.

[2] N. Shaari, R. Shamsudin, M. Z. M. Nor, and N. Hashim, “Quality attributes of Malaysia purple-fleshed sweet potato at different peel condition,” *Agronomy*, vol. 11, no. 5, pp. 1–14, 2021, doi: 10.3390/agronomy11050872.

[3] M. O. Oke and T. S. Workneh, “A review on sweet potato postharvest processing and preservation technology,” *African J. Agric. Res.*, vol. 8, no. 40, pp. 4990–5003, 2013, doi: 10.5897/AJAR2013.6841.

[4] M. Schmidt, E. Zannini, and E. K. Arendt, “Recent advances in physical post-harvest treatments for shelf-life extension of cereal crops,” *Foods*, vol. 7, no. 4, pp. 1–22, 2018, doi: 10.3390/foods7040045.

[5] S. M. Alzamora, D. Salvatori, M. S. Tapia, A. López-Malo, J. Welti-Chanes, and P. Fito, “Novel functional foods from vegetable matrices impregnated with biologically active compounds,” *J. Food Eng.*, vol. 67, no. 1–2, pp. 205–214, 2005, doi: 10.1016/j.jfoodeng.2004.05.067.

[6] I. Luna-Guzmán and D. M. Barrett, “Comparison of calcium chloride and calcium lactate effectiveness in maintaining shelf stability and quality of fresh-cut cantaloupes,” *Postharvest Biol. Technol.*, vol. 19, no. 1, pp. 61–72, 2000, doi: 10.1016/S0925-5214(00)00079-X.

[7] G. A. Manganaris, M. Vasilakakis, G. Diamantidis, and I. Mignani, “Effect of calcium additives on physicochemical aspects of cell wall pectin and sensory attributes of canned peach (Prunus persica (L) Batsch cv Andross),” *J. Sci. Food Agric.*, vol. 85, no. 10, pp. 1773–1778, 2005, doi: 10.1002/jsfa.2182.

[8] S. Tappi *et al.*, “Optimization of Vacuum Impregnation with Calcium Lactate of Minimally Processed Melon and Shelf-Life Study in Real Storage Conditions,” *J. Food Sci.*, vol. 81, no. 11, pp. E2734–E2742, 2016, doi: 10.1111/1750-3841.13513.

[9] Y. Yu, X. Jiang, H. S. Ramaswamy, S. Zhu, and H. Li, “High Pressure Processing Treatment of Fresh-Cut Carrots: Effect of Presoaking in Calcium Salts on Quality Parameters,” *J. Food Qual.*, vol. 2018, 2018, doi: 10.1155/2018/7863670.

[10] J. Liu *et al.*, “Enhancing the hardness of potato slices after boiling by combined treatment with lactic acid and calcium chloride: Mechanism and optimization,” *Food Chem.*, vol. 308, 2020, doi: 10.1016/j.foodchem.2019.05.106.

[11] I. Sugri, B. K. Maalekuu, F. Kusi, and E. Gaveh, “Quality and Shelf-life of Sweet Potato as Influenced by Storage and Postharvest Treatments,” *Trends Hortic. Res.*, vol. 7, no. 1, pp. 1–10, 2017, doi: 10.3923/thr.2017.1.10.

[12] L. M. Pereira, C. C. Ferrari, S. D. S. Mastrantonio, A. C. C. Rodrigues, and M. D. Hubinger, “Kinetic aspects, texture, and color evaluation of some tropical fruits during osmotic dehydration,” *Dry. Technol.*, vol. 24, no. 4, pp. 475–484, 2006, doi: 10.1080/07373930600611968.

[13] C. C. Ferrari, S. M. Carmello-Guerreiro, H. M. A. Bolini, and M. D. Hubinger, “Structural changes, mechanical properties and sensory preference of osmodehydrated melon pieces with sucrose and calcium lactate solutions,” *Int. J. Food Prop.*, vol. 13, no. 1, pp. 112–130, 2010, doi: 10.1080/10942910802227934.

[14] N. E. Mavroudis, M. J. Gidley, and I. Sjöholm, “Osmotic processing: Effects of osmotic medium composition on the kinetics and texture of apple tissue,” *Food Res. Int.*, vol. 48, no. 2, pp. 839–847, 2012, doi: 10.1016/j.foodres.2012.06.034.

[15] D. Rico, A. B. Martín-Diana, J. M. Frías, J. M. Barat, G. T. M. Henehan, and C. Barry-Ryan, “Improvement in texture using calcium lactate and heat-shock treatments for stored ready-to-eat carrots,” *J. Food Eng.*, vol. 79, no. 4, pp. 1196–1206, 2007, doi: 10.1016/j.jfoodeng.2006.04.032.

[16] D. W. Newton, “Drug incompatibility chemistry,” *Am. J. Heal. Pharm.*, vol. 66, no. 4, pp. 348–357, 2009, doi: 10.2146/ajhp080059.

[17] N. Lovera, L. Ramallo, and V. Salvadori, "Effect of processing conditions on calcium content,firmness, and color of papaya in syrup.," Journal of Food Processing. , 2014. LOVERA

[18] R. P. Aidoo, F. Depypere, E. O. Afoakwa, and K. Dewettinck, “Industrial manufacture of sugar-free chocolates - Applicability of alternative sweeteners and carbohydrate polymers as raw materials in product development,” *Trends Food Sci. Technol.*, vol. 32, no. 2, pp. 84–96, 2013, doi: 10.1016/j.tifs.2013.05.008.

[19] C. Krishna, “Solid-state fermentation systems - An overview,” *Crit. Rev. Biotechnol.*, vol. 25, no. 1–2, pp. 1–30, 2005, doi: 10.1080/07388550590925383.