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The study on SFLAB GanedenBC³⁰ viability on baking products during storage

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Abstract

For understanding *Bacillus coagulans*, GanedenBC³⁰ was used in different ways to added in raw dough and examine their viability after baking. Eight different baking products: (1) chrysanthemum cookies, (2) egg pastry cakes, (3) mooncakes, (4) muffins, (5) polo breads, (6) soda cookies, (7) sponge cakes, and (8) toasts were made from 0.5% GanedenBC³⁰ added to their dough in two ways: (a) flour powder or (b) egg yolk. Then the (a) pH value, (b) titratable acidity, (c) GanedenBC³⁰ counts, and (d) viability GanedenBC³⁰ of eight different baking products were determined after storing at 4°C for 0, 3, 6, 9, 12, 15 days, or 25°C for 0, 3, 6 days. The eight types of raw dough had relatively lower pH values and rise after baking. The titratable acidity of the eight types of dough was relatively higher, and declined after baking. However, the pH value and titratable acidity of the eight baking products remained the same after 9 days at 4°C. On the other hand, the GanedenBC³⁰ counts in the eight baking products were less than their raw dough GanedenBC³⁰ levels. For storage at both 4 and 25°C, the results show the GanedenBC³⁰ viability of baking products decreased with storage days. The dough made by flour powder and baking showed higher GanedenBC³⁰ viability than by egg yolk. GanedenBC³⁰ are good candidates for baking product use, both in lactic acid production and probiotic preparations.

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Keywords: *Bacillus coagulans*; GanedenBC³⁰; baking; viability;

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1. Introduction

Probiotics are live bacteria showing documented beneficial effects [1]. Probiotics have various effects: they may be used to prevent and treat antibiotic-associated diarrhoea and acute infectious diarrhoea; they also may be effective in relieving symptoms of irritable bowel syndrome, inflammatory bowel disease, and in treating atopic dermatitis in children. Other documented effects include such overlapping mechanisms as regulating intestinal microbial homeostasis, the stimulation of local and systemic immune responses, prevention of pathogens infecting the mucosa, stabilization or maintenance of the gastrointestinal barrier function, inhibition of procarcinogenic enzymatic activity, and the competition for limited nutrients [2, 3]. However, probiotic effects appear to be strain specific [4]. Regardless of the strain and its potential effect, probiotics intended for the gastro-intestinal tract must survive gastric and bile acids [4] to reach the intestinal tract, colonize the host epithelium, and have a beneficial effect [5]. The aim of the study was to determine the survival and viability of a particular strain of *B. coagulans* known as GanedenBC³⁰, a commercial product, in eight different baking products stored under refrigeration or at room temperature.

2.1 Materials & Methods

2.1 Test Strains

GanedenBC³⁰ was provided by Ganeden Biotech (Mayfield Heights, OH, USA). This *B. coagulans* containing product had 7.3×10^8 colony forming units per gram of powder (CFU/g).

2.2 Storage experiment

When the different baking products were finished, they were stored in a refrigerator (GR-B500A, LG, Seoul, Korea) at 4°C for 0, 3, 6, 9, 12, 15 days, or stored in microwave box at 25°C for 0, 3, 6 days (According to Wu *et al.*, 2005). The duration of the storage period of pH value, titratable acidity (TA), GanedenBC³⁰, and viability of baking product were determined as below.

3. Results & Discussion

The results show the pH values and TA of (1) chrysanthemum cookies, (2) egg pastry cakes, (3) mooncakes, (4) muffins, (5) polo breads, (6) soda cookies, (7) sponge cakes, and (8) toasts made from GanedenBC³⁰ added to flour powder or egg yolk as shown in table 1-8. The pH values and TA of chrysanthemum cookies, egg pastry cakes, mooncakes, muffins, polo breads, sponge cakes, and toasts were constant with the storage days, both at refrigeration temperature or room temperature. And the results show the pH value of the soda cookies made from GanedenBC³⁰ added in flour powder or egg yolk all decreased for storage 0-3 days, both at refrigeration temperature or room temperature, as shown in table 6. And the TA of the soda cookies made from GanedenBC³⁰ added to flour powder or egg yolk all increased in the initial stage storage days, and remained stable until the end of storage, both at refrigeration temperature or room temperature.

The GanedenBC³⁰ counts and GanedenBC³⁰ viability of the chrysanthemum cookies, egg pastry cakes, muffins, soda cookies, sponge cakes, and toasts made from GanedenBC³⁰ added to flour powder or egg yolk all decreased with the storage days, both at refrigeration temperature or room temperature. And the chrysanthemum cookies that made from GanedenBC³⁰ added in flour powder appear high viability than in egg yolk. And the GanedenBC³⁰ counts and GanedenBC³⁰ viability of the moon cakes and polo breads made from GanedenBC³⁰ added to flour powder or egg yolk all decreased with the storage days, both at

refrigeration temperature or room temperature. And the mooncakes that made from GanedenBC³⁰ added in egg yolk appear high viability than in flour powder.

In decreasing pH values, the baking products were all decreasing with little change, especially at storage of 9-15 days under a constant 4°C. Further comparison with the TA of all baking products confirmed this outcome. Since GanedenBC³⁰ produced organic acid, L(+)-lactic acid and the temperature germination was 30°C [6]. Therefore, this situation showed nutrient in baking products no more employ by GanedenBC³⁰ that indicate low temperature were unfavorable for GanedenBC³⁰. So, we recommended baking products containing GanedenBC³⁰ be stored under refrigeration temperature rather than at room temperature. The baking products containing GanedenBC³⁰ in the flour powder had higher pH values and lower TA for chrysanthemum cookie, egg pastry cake, muffin, soda cookie, sponge cake, and toast compared to GanedenBC³⁰ in egg yolk. These baking products contain less organic acid than moon cake and polo bread.

Table 1. pH values, titratable acidities (TA), GanedenBC³⁰ counts (log CFU/mL), and viability of the chrysanthemum cookies containing GanedenBC³⁰ during storage under refrigeration temperature or at room temperature

		GanedenBC ³⁰ in Powder				GanedenBC ³⁰ in Egg Yolk			
		pH value	TA	log CFU/g	Viability (%)	pH value	TA	log CFU/g	Viability (%)
Raw Dough	Day	5.52 ± 0.01 ^e	0.17 ± 0.02 ^a	7.12 ± 0.03 ^a	100.0	5.44 ± 0.01 ^d	0.19 ± 0.02 ^a	7.46 ± 0.19 ^a	100.0
	0	5.87 ± 0.01 ^{bc}	0.11 ± 0.02 ^b	6.96 ± 0.01 ^b	68.9	5.61 ± 0.01 ^c	0.13 ± 0.01 ^b	6.74 ± 0.01 ^b	18.3
Refrigeration Temperature	3	5.85 ± 0.02 ^{cd}	0.12 ± 0.02 ^b	6.94 ± 0.02 ^{bc}	65.9	5.65 ± 0.02 ^{ab}	0.12 ± 0.01 ^b	6.63 ± 0.10 ^{bc}	14.3
	6	5.84 ± 0.02 ^d	0.11 ± 0.02 ^b	6.90 ± 0.01 ^{cd}	59.8	5.64 ± 0.01 ^b	0.11 ± 0.02 ^b	6.60 ± 0.03 ^{bc}	13.3
	9	5.89 ± 0.02 ^b	0.10 ± 0.02 ^b	6.89 ± 0.01 ^d	58.3	5.65 ± 0.01 ^{ab}	0.11 ± 0.02 ^b	6.56 ± 0.03 ^{bc}	12.0
	12	5.88 ± 0.02 ^{bc}	0.11 ± 0.02 ^b	6.86 ± 0.02 ^{ef}	54.5	5.65 ± 0.02 ^{ab}	0.12 ± 0.01 ^b	6.50 ± 0.04 ^{bc}	10.7
	15	5.87 ± 0.02 ^{bc}	0.11 ± 0.02 ^b	6.84 ± 0.03 ^{ef}	52.3	5.65 ± 0.02 ^{ab}	0.12 ± 0.01 ^b	6.46 ± 0.17 ^{cd}	10.0
Room Temperature	0	5.86 ± 0.01 ^{cd}	0.11 ± 0.02 ^b	6.90 ± 0.01 ^{cd}	59.8	5.67 ± 0.01 ^a	0.11 ± 0.02 ^b	6.47 ± 0.12 ^{cd}	10.0
	3	5.87 ± 0.02 ^{bc}	0.12 ± 0.02 ^b	6.87 ± 0.03 ^{de}	56.1	5.67 ± 0.02 ^a	0.12 ± 0.01 ^b	6.25 ± 0.07 ^d	6.0
	6	5.94 ± 0.02 ^a	0.12 ± 0.02 ^b	6.82 ± 0.02 ^f	50.0	5.64 ± 0.02 ^b	0.12 ± 0.01 ^b	5.75 ± 0.07 ^e	1.9

Different letter in the same row indicate significant differences ($p < 0.05$).

In this study, the baking products have complex components, such as protein and carbohydrates, that can switch on germination of GanedenBC³⁰. Maathuis *et al.*, (2010) indicated lactose and fructose digestion were measured by analyzing the production of lactate, produced after fermentation of the sugars by GanedenBC³⁰ *B. coagulans*. Lactate is only produced by vegetative cells, and is thus a measure of germination. The TA of the baking products remained constant at under 4°C during days 9-15, meaning the germination of GanedenBC³⁰ had stopped and keep spore mode. We attempted to add probiotics

GanedenBC³⁰ into different baking products as new functional foods for human gastrointestinal benefits. Clearly, the storage room temperature show more decreasing viability percentage than refrigeration temperature, indicating GanedenBC³⁰ germination at room temperature that conform to the GanedenBC³⁰ germination temperature. However, the mix form of baking products containing GanedenBC³⁰ in the flour powder seem to have good viability for chrysanthemum cookie, egg pastry cake, muffin, soda cookie, sponge cake, and toast. This method was better than egg yolk, and in concert with the same trend of pH values and TA. This effect shows egg yolk contains more nutrients, such as protein, than flour powder. Therefore, when the raw dough of baking products is created for baking, the GanedenBC³⁰ having access to the nutritional environment begin to germinate into replicative bacteria, and next stage could losing the protection cause GanedenBC³⁰ died due to heating in the baking process. Another reason, fermentation time of raw dough of baking products before baking, the more fermentation time that lead to GanedenBC³⁰ germination number increasing, and next stage could losing the protection cause GanedenBC³⁰ died due to heating in the baking process. Therefore, this fermentation stage must be kept at low temperature and a shortened time to avoid excessive GanedenBC³⁰ germination.

Table 2. pH values, titratable acidities (TA), GanedenBC³⁰ counts (log CFU/mL), and viability of the egg pastry cakes containing GanedenBC³⁰ during storage under refrigeration temperature or at room temperature

		GanedenBC ³⁰ in Powder				GanedenBC ³⁰ in Egg Yolk			
		pH value	TA	log CFU/g	Viability (%)	pH value	TA	log CFU/g	Viability (%)
Raw Dough	Day	5.38 ± 0.02 ^g	0.19 ± 0.01 ^a	7.00 ± 0.01 ^a	100.0	5.21 ± 0.02 ^d	0.21 ± 0.02 ^a	8.32 ± 0.09 ^a	100.0
	0	5.68 ± 0.01 ^a	0.13 ± 0.03 ^{bc}	6.88 ± 0.01 ^b	75.0	5.45 ± 0.02 ^c	0.17 ± 0.01 ^b	7.83 ± 0.02 ^b	32.4
Refrigeration Temperature	3	5.63 ± 0.01 ^{cd}	0.13 ± 0.01 ^{bc}	6.83 ± 0.05 ^b	68.0	5.49 ± 0.02 ^a	0.16 ± 0.02 ^{bc}	7.73 ± 0.02 ^{bc}	25.7
	6	5.66 ± 0.01 ^{ab}	0.14 ± 0.02 ^{bc}	6.73 ± 0.02 ^c	54.0	5.48 ± 0.01 ^{ab}	0.17 ± 0.02 ^{bc}	7.64 ± 0.08 ^c	21.0
	9	5.64 ± 0.01 ^f	0.15 ± 0.01 ^b	6.63 ± 0.01 ^d	43.0	5.44 ± 0.01 ^c	0.16 ± 0.02 ^{bc}	7.50 ± 0.04 ^d	15.2
	12	5.63 ± 0.02 ^{cd}	0.13 ± 0.01 ^{bc}	6.50 ± 0.08 ^e	32.0	5.45 ± 0.02 ^{bc}	0.16 ± 0.01 ^{bc}	7.29 ± 0.12 ^e	9.5
	15	5.65 ± 0.03 ^{bc}	0.12 ± 0.01 ^c	6.37 ± 0.02 ^f	23.6	5.44 ± 0.01 ^c	0.16 ± 0.02 ^{bc}	7.18 ± 0.04 ^e	7.1
Room Temperature	0	5.61 ± 0.01 ^{de}	0.06 ± 0.01 ^d	6.86 ± 0.02 ^b	72.0	5.45 ± 0.02 ^{bc}	0.15 ± 0.01 ^{bc}	7.71 ± 0.01 ^{bc}	24.3
	3	5.60 ± 0.01 ^e	0.08 ± 0.01 ^d	6.67 ± 0.01 ^{cd}	47.0	5.45 ± 0.02 ^c	0.14 ± 0.02 ^{bc}	6.84 ± 0.02 ^f	3.3
	6	5.62 ± 0.01 ^{de}	0.08 ± 0.01 ^d	6.49 ± 0.06 ^e	31.0	5.46 ± 0.01 ^{bc}	0.14 ± 0.02 ^c	6.71 ± 0.01 ^g	2.4

Different letter in the same row indicate significant differences (p < 0.05).

Table 3. pH values, titratable acidities (TA), GanedenBC³⁰ counts (log CFU/mL), and viability of the mooncakes containing GanedenBC³⁰ during storage under refrigeration temperature or at room temperature

		GanedenBC ³⁰ in Powder				GanedenBC ³⁰ in Egg Yolk			
		pH value	TA	log CFU/g	Viability (%)	pH value	TA	log CFU/g	Viability (%)
Raw Dough	Day	5.16 ± 0.02 ^f	0.12 ± 0.02 ^a	7.71 ± 0.04 ^a	100.0	5.47 ± 0.02 ^e	0.14 ± 0.02 ^a	6.97 ± 0.04 ^a	100.0
Refrigeration Temperature	0	5.71 ± 0.02 ^{cd}	0.11 ± 0.02 ^{ab}	6.84 ± 0.03 ^b	13.5	5.96 ± 0.01 ^{cd}	0.09 ± 0.02 ^b	6.50 ± 0.08 ^b	34.4
	3	5.76 ± 0.02 ^a	0.09 ± 0.01 ^{bc}	6.81 ± 0.04 ^c	12.5	5.97 ± 0.01 ^{cd}	0.07 ± 0.02 ^b	6.47 ± 0.08 ^b	32.3
	6	5.75 ± 0.02 ^{ab}	0.09 ± 0.01 ^{bc}	6.78 ± 0.02 ^c	11.8	5.96 ± 0.01 ^{cd}	0.07 ± 0.02 ^b	6.46 ± 0.02 ^b	31.0
	9	5.71 ± 0.02 ^{cd}	0.09 ± 0.01 ^{bc}	6.68 ± 0.03 ^d	9.4	5.96 ± 0.01 ^{cd}	0.07 ± 0.02 ^b	6.46 ± 0.02 ^b	31.2
	12	5.73 ± 0.01 ^{bc}	0.09 ± 0.01 ^{bc}	6.65 ± 0.04 ^{de}	8.8	5.96 ± 0.01 ^{cd}	0.07 ± 0.02 ^b	6.45 ± 0.04 ^b	30.1
	15	5.73 ± 0.01 ^{bc}	0.09 ± 0.01 ^{bc}	6.63 ± 0.01 ^e	8.4	5.98 ± 0.01 ^c	0.07 ± 0.02 ^b	6.43 ± 0.02 ^b	29.0
	0	5.68 ± 0.02 ^e	0.09 ± 0.01 ^{bc}	6.81 ± 0.02 ^c	12.5	5.95 ± 0.02 ^d	0.07 ± 0.02 ^b	6.24 ± 0.14 ^c	19.4
Room Temperature	3	5.71 ± 0.02 ^{cd}	0.08 ± 0.01 ^{bc}	6.77 ± 0.01 ^c	11.6	6.05 ± 0.03 ^b	0.08 ± 0.01 ^b	6.18 ± 0.04 ^c	16.1
	6	5.69 ± 0.02 ^{de}	0.08 ± 0.01 ^c	6.67 ± 0.01 ^d	9.2	6.10 ± 0.01 ^a	0.07 ± 0.02 ^b	6.11 ± 0.05 ^c	14.0

Different letter in the same row indicate significant differences ($p < 0.05$).

Table 4. pH values, titratable acidities (TA), GanedenBC³⁰ counts (log CFU/mL), and viability of the muffins containing GanedenBC³⁰ during storage under refrigeration temperature or at room temperature

		GanedenBC ³⁰ in Powder				GanedenBC ³⁰ in Egg Yolk			
		pH value	TA	log CFU/g	Viability (%)	pH value	TA	log CFU/g	Viability (%)
Raw Dough	Day	6.98 ± 0.02 ^d	0.12 ± 0.02 ^a	6.68 ± 0.03 ^a	100.0	6.19 ± 0.02 ^e	0.16 ± 0.02 ^a	7.76 ± 0.01 ^a	100.0
Refrigeration Temperature	0	7.86 ± 0.02 ^a	0.07 ± 0.02 ^{bc}	6.63 ± 0.01 ^{ab}	89.6	7.00 ± 0.03 ^b	0.13 ± 0.02 ^{ab}	7.04 ± 0.02 ^b	19.3
	3	7.84 ± 0.01 ^a	0.07 ± 0.02 ^{bc}	6.61 ± 0.01 ^{abcd}	85.4	7.11 ± 0.01 ^d	0.12 ± 0.02 ^{bc}	6.97 ± 0.01 ^{bc}	16.3
	6	7.87 ± 0.01 ^a	0.06 ± 0.01 ^{bc}	6.60 ± 0.03 ^{abcd}	83.3	7.13 ± 0.01 ^{ab}	0.11 ± 0.02 ^{bc}	6.92 ± 0.01 ^{cd}	14.6
	9	7.86 ± 0.01 ^a	0.05 ± 0.02 ^c	6.59 ± 0.02 ^{abcd}	81.3	7.12 ± 0.01 ^b	0.09 ± 0.02 ^{bc}	6.88 ± 0.02 ^{cd}	13.3
	12	7.85 ± 0.01 ^a	0.06 ± 0.01 ^{bc}	6.56 ± 0.08 ^{abcd}	77.1	7.12 ± 0.02 ^b	0.09 ± 0.02 ^{bc}	6.76 ± 0.01 ^{ef}	10.0

	15	7.84 ± 0.04 ^a	0.06 ± 0.01 ^{bc}	6.52 ± 0.02 ^{de}	68.8	7.11 ± 0.01 ^b	0.09 ± 0.02 ^{bc}	6.72 ± 0.01 ^f	9.3
Room Temperature	0	7.72 ± 0.01 ^b	0.07 ± 0.02 ^{bc}	6.64 ± 0.03 ^{abc}	91.7	7.07 ± 0.02 ^c	0.11 ± 0.02 ^{bc}	7.04 ± 0.02 ^{bc}	19.1
	3	7.65 ± 0.01 ^c	0.08 ± 0.01 ^b	6.53 ± 0.07 ^{cde}	70.8	7.12 ± 0.02 ^b	0.09 ± 0.02 ^c	6.97 ± 0.03 ^{bcd}	16.3
	6	7.67 ± 0.02 ^c	0.08 ± 0.01 ^{bc}	6.46 ± 0.02 ^e	60.4	7.15 ± 0.02 ^a	0.09 ± 0.02 ^c	6.84 ± 0.05 ^{de}	12.3

Different letter in the same row indicate significant differences ($p < 0.05$).

Table 5. pH values, titratable acidities (TA), GanedenBC³⁰ counts (log CFU/mL), and viability of the polo breads containing GanedenBC³⁰ during storage under refrigeration temperature or at room temperature

		GanedenBC ³⁰ in Powder				GanedenBC ³⁰ in Egg Yolk			
		pH value	TA	log CFU/g	Viability (%)	pH value	TA	log CFU/g	Viability (%)
Raw Dough	Day	4.93 ± 0.01 ^c	0.36 ± 0.02 ^a	6.32 ± 0.09 ^a	100.0	4.96 ± 0.02 ^c	0.32 ± 0.01 ^a	6.30 ± 0.06 ^a	100.0
	0	5.66 ± 0.02 ^{bc}	0.25 ± 0.02 ^b	6.18 ± 0.04 ^b	71.4	5.74 ± 0.02 ^d	0.19 ± 0.01 ^{bc}	6.28 ± 0.03 ^a	95.0
Refrigeration Temperature	3	5.66 ± 0.01 ^{bc}	0.25 ± 0.02 ^b	6.13 ± 0.02 ^{bc}	63.8	5.76 ± 0.01 ^{cd}	0.18 ± 0.02 ^{bc}	6.25 ± 0.07 ^a	90.0
	6	5.65 ± 0.01 ^{cd}	0.21 ± 0.02 ^c	6.10 ± 0.02 ^{bc}	60.5	5.77 ± 0.02 ^c	0.18 ± 0.02 ^{bc}	6.23 ± 0.04 ^a	85.0
	9	5.64 ± 0.02 ^{cd}	0.20 ± 0.02 ^c	6.06 ± 0.01 ^{bc}	54.3	5.80 ± 0.01 ^b	0.18 ± 0.02 ^{bc}	6.12 ± 0.31 ^a	75.0
	12	5.68 ± 0.03 ^{ab}	0.19 ± 0.01 ^c	6.04 ± 0.01 ^{bc}	52.4	5.82 ± 0.01 ^{ab}	0.18 ± 0.02 ^{bc}	6.11 ± 0.05 ^a	65.0
	15	5.69 ± 0.02 ^a	0.18 ± 0.02 ^c	6.02 ± 0.01 ^c	49.5	5.83 ± 0.01 ^a	0.18 ± 0.02 ^{bc}	6.05 ± 0.21 ^a	60.0
Room Temperature	0	5.63 ± 0.01 ^d	0.24 ± 0.02 ^b	6.10 ± 0.14 ^{bc}	61.9	5.74 ± 0.02 ^d	0.19 ± 0.02 ^b	6.28 ± 0.03 ^a	95.0
	3	5.63 ± 0.01 ^d	0.21 ± 0.02 ^c	6.06 ± 0.01 ^{bc}	54.8	5.77 ± 0.01 ^c	0.17 ± 0.01 ^{bc}	6.25 ± 0.07 ^a	90.0
	6	5.65 ± 0.01 ^{cd}	0.21 ± 0.02 ^c	5.81 ± 0.02 ^d	30.5	5.77 ± 0.01 ^c	0.16 ± 0.02 ^c	6.22 ± 0.11 ^a	85.0

Different letter in the same row indicate significant differences ($p < 0.05$).

Table 6. pH values, titratable acidities (TA), GanedenBC³⁰ counts (log CFU/mL), and viability of the soda cookies containing GanedenBC³⁰ during storage under refrigeration temperature or at room temperature

		GanedenBC ³⁰ in Powder				GanedenBC ³⁰ in Egg Yolk			
		pH value	TA	log CFU/g	Viability (%)	pH value	TA	log CFU/g	Viability (%)
Raw Dough	Day	5.20 ± 0.01 ^e	0.21 ± 0.02 ^a	6.60 ± 0.06 ^a	100.0	4.78 ± 0.01 ^f	0.29 ± 0.01 ^a	6.96 ± 0.03 ^a	100.0
	0	6.47 ± 0.02 ^a	0.08 ± 0.01 ^b	6.49 ± 0.02 ^b	77.5	5.35 ± 0.02 ^{ab}	0.13 ± 0.03 ^b	4.30 ± 0.00 ^b	0.2
Refrigeration Temperature	3	6.34 ± 0.01 ^{cd}	0.06 ± 0.01 ^{bc}	6.43 ± 0.02 ^{bc}	67.5	5.33 ± 0.01 ^b	0.12 ± 0.02 ^b	4.30 ± 0.00 ^b	0.2
	6	6.35 ± 0.02 ^c	0.05 ± 0.02 ^{bc}	6.36 ± 0.03 ^{cd}	57.5	5.32 ± 0.02 ^b	0.12 ± 0.02 ^b	3.80 ± 0.71 ^b	0.1
	9	6.34 ± 0.01 ^c	0.05 ± 0.02 ^{bc}	6.32 ± 0.09 ^{cd}	52.5	5.32 ± 0.01 ^b	0.11 ± 0.02 ^b	4.30 ± 0.00 ^b	0.2
	12	6.36 ± 0.01 ^c	0.06 ± 0.01 ^{bc}	6.23 ± 0.04 ^{ef}	42.5	5.37 ± 0.02 ^a	0.11 ± 0.02 ^b	4.30 ± 0.00 ^b	0.2
	15	6.42 ± 0.01 ^b	0.05 ± 0.01 ^c	6.13 ± 0.00 ^{gh}	33.8	5.36 ± 0.04 ^a	0.11 ± 0.02 ^b	4.30 ± 0.00 ^b	0.2
Room Temperature	0	6.41 ± 0.02 ^b	0.07 ± 0.01 ^{bc}	6.39 ± 0.01 ^{cd}	61.8	5.24 ± 0.02 ^c	0.14 ± 0.02 ^b	4.30 ± 0.00 ^b	0.2
	3	6.35 ± 0.02 ^c	0.06 ± 0.01 ^{bc}	6.21 ± 0.01 ^{ef}	40.8	5.15 ± 0.02 ^d	0.14 ± 0.02 ^b	4.30 ± 0.00 ^b	0.2
	6	6.32 ± 0.01 ^d	0.06 ± 0.01 ^{bc}	6.04 ± 0.06 ^h	27.5	5.09 ± 0.01 ^e	0.14 ± 0.02 ^b	4.30 ± 0.00 ^b	0.2

Different letter in the same row indicate significant differences ($p < 0.05$).

Table 7. pH values, titratable acidities (TA), GanedenBC³⁰ counts (log CFU/mL), and viability of the sponge cakes containing GanedenBC³⁰ during storage under refrigeration temperature or at room temperature

		GanedenBC ³⁰ in Powder				GanedenBC ³⁰ in Egg Yolk			
		pH value	TA	log CFU/g	Viability (%)	pH value	TA	log CFU/g	Viability (%)
Raw Dough	Day	7.30 ± 0.02 ^d	0.07 ± 0.01 ^a	6.95 ± 0.01 ^a	100.0	7.09 ± 0.03 ^e	0.10 ± 0.01 ^a	7.48 ± 0.14 ^a	100.0
Refrigeration Temperature	0	7.53 ± 0.02 ^a	0.06 ± 0.01 ^b	6.76 ± 0.06 ^b	65.5	7.46 ± 0.01 ^{bc}	0.07 ± 0.01 ^b	6.64 ± 0.08 ^b	14.2
	3	7.46 ± 0.02 ^{bc}	0.06 ± 0.01 ^b	6.71 ± 0.01 ^b	58.2	7.50 ± 0.03 ^a	0.06 ± 0.01 ^{bc}	6.57 ± 0.02 ^{bc}	11.9
	6	7.45 ± 0.02 ^{bc}	0.05 ± 0.01 ^{bc}	6.67 ± 0.04 ^b	53.1	7.45 ± 0.02 ^{bc}	0.05 ± 0.01 ^c	6.50 ± 0.04 ^{bc}	10.3
	9	7.45 ± 0.05 ^{bc}	0.04 ± 0.00 ^{bc}	6.64 ± 0.03 ^b	49.7	7.47 ± 0.01 ^{ab}	0.05 ± 0.01 ^c	6.46 ± 0.02 ^{bc}	9.4
	12	7.43 ± 0.02 ^c	0.03 ± 0.01 ^c	6.50 ± 0.12 ^c	36.2	7.45 ± 0.02 ^{bc}	0.05 ± 0.01 ^c	6.46 ± 0.11 ^c	9.4

Room Temperature	15	7.42 ± 0.01 ^c	0.03 ± 0.01 ^c	6.49 ± 0.02 ^c	35.0	7.43 ± 0.02 ^c	0.06 ± 0.01 ^{bc}	6.28 ± 0.03 ^d	6.1
	0	7.56 ± 0.02 ^a	0.05 ± 0.01 ^{bc}	6.75 ± 0.05 ^b	64.4	7.45 ± 0.02 ^{bc}	0.07 ± 0.01 ^b	6.46 ± 0.02 ^{bc}	9.4
	3	7.48 ± 0.03 ^b	0.04 ± 0.01 ^{bc}	6.73 ± 0.02 ^b	61.0	7.35 ± 0.02 ^d	0.07 ± 0.02 ^{bc}	6.42 ± 0.12 ^{cd}	8.7
	6	7.46 ± 0.02 ^{bc}	0.04 ± 0.01 ^{bc}	6.36 ± 0.08 ^d	26.0	7.37 ± 0.02 ^d	0.05 ± 0.02 ^{bc}	4.30 ± 0.00 ^e	0.1

Different letter in the same row indicate significant differences ($p < 0.05$).

Table 8. pH values, titratable acidities (TA), GadenBC³⁰ counts (log CFU/mL), and viability of the toasts containing GadenBC³⁰ during storage under refrigeration temperature or at room temperature

		GadenBC ³⁰ in Powder				GadenBC ³⁰ in Egg Yolk			
		pH value	TA	log CFU/g	Viability (%)	pH value	TA	log CFU/g	Viability (%)
Raw Dough	Day	5.26 ± 0.01 ^c	0.16 ± 0.02 ^a	5.77 ± 0.03 ^a	100.0	4.87 ± 0.02 ^e	0.26 ± 0.02 ^a	6.55 ± 0.10 ^a	100.0
	0	5.65 ± 0.01 ^a	0.13 ± 0.01 ^b	5.63 ± 0.01 ^b	72.9	5.38 ± 0.02 ^c	0.09 ± 0.01 ^c	5.85 ± 0.01 ^b	19.7
Refrigeration Temperature	3	5.62 ± 0.02 ^b	0.12 ± 0.02 ^b	5.59 ± 0.02 ^{bc}	66.1	5.36 ± 0.01 ^{cd}	0.09 ± 0.02 ^c	5.71 ± 0.01 ^{bc}	14.2
	6	5.57 ± 0.02 ^c	0.13 ± 0.03 ^b	5.50 ± 0.08 ^{cd}	54.2	5.32 ± 0.02 ^d	0.09 ± 0.01 ^c	5.69 ± 0.01 ^{bc}	13.6
	9	5.56 ± 0.01 ^{cd}	0.12 ± 0.01 ^b	5.41 ± 0.00 ^d	44.1	5.36 ± 0.04 ^{cd}	0.09 ± 0.01 ^c	5.61 ± 0.01 ^{cd}	11.4
	12	5.54 ± 0.01 ^d	0.11 ± 0.02 ^b	5.20 ± 0.08 ^e	27.1	5.36 ± 0.02 ^{cd}	0.10 ± 0.01 ^c	5.57 ± 0.02 ^{cd}	10.3
	15	5.56 ± 0.02 ^{cd}	0.11 ± 0.01 ^b	4.95 ± 0.07 ^f	15.3	5.34 ± 0.04 ^{cd}	0.09 ± 0.01 ^c	5.43 ± 0.07 ^d	7.5
Room Temperature	0	5.57 ± 0.02 ^c	0.13 ± 0.02 ^b	5.64 ± 0.00 ^b	74.6	5.62 ± 0.01 ^a	0.14 ± 0.02 ^b	5.72 ± 0.01 ^{bc}	14.7
	3	5.61 ± 0.02 ^b	0.11 ± 0.01 ^b	5.54 ± 0.02 ^{bc}	59.3	5.58 ± 0.01 ^b	0.11 ± 0.01 ^c	5.57 ± 0.02 ^{cd}	10.3
	6	5.66 ± 0.01 ^a	0.11 ± 0.01 ^b	5.11 ± 0.05 ^e	22.0	5.57 ± 0.01 ^b	0.11 ± 0.01 ^c	5.44 ± 0.20 ^d	8.1

4. Conclusion

Generally, the raw dough of eight baking products had a lower pH value than their baking product. On the other hand, the pH values, TA, and viability of the chrysanthemum cookie, egg pastry cake, muffin, soda cookie, sponge cake, and toast made from GadenBC³⁰ added to flour powder had relatively higher activities than in egg yolk. In contrast, the viability of the moon cake and polo bread made from GadenBC³⁰ added to egg yolk had relatively high activities than in flour powder.

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