Food Technology Research Journal, Vol. 8, issue 2, 122-133, 2025

FTRJ

The Impact of Utilizing a Natural Stabilizer for Coating Ras Cheese

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Original Article

Article information

Received 15/05/2025
Revised 20/06/2025
Accepted 24/06/2025
Published 26/05/2025
Available online 30/06/2025

Keywords

Ras cheese; coating; pectin; starch; weight loss

ABSTRACT

This study evaluated the effect of edible coatings based on pectin and starch on the quality, shelf life, and safety of Ras cheese during ripening. Six treatments were prepared: an uncoated control and five coated cheeses with different ratios of pectin and starch (100:0, 0:100, 75:25, 50:50, and 25:75). The cheeses were ripened at $13 \pm 2^{\circ}C$ and 85% relative humidity for four months. Coated cheeses, particularly those with higher pectin content, exhibited significantly higher moisture, soluble nitrogen, total volatile fatty acids, and sensory scores ($p \leq 0.05$), alongside reduced weight loss and mold & yeast counts compared to the control. Throughout ripening, moisture decreased while fat, protein, and acidity increased. Coatings acted as moisture barriers, improved cheese appearance and flavor, and suppressed microbial spoilage. The findings suggest that pectin-based coatings can effectively enhance Ras cheese quality and prolong shelf life during ripening.

1. Introduction

Ras cheese is widely recognized as the most consumed hard cheese in Egypt. It is traditionally produced using unpasteurized cow milk or a blend of cow and buffalo milk (Awad, 2006). Ras cheese is typically aged over months in cool and humid environments, often in facilities with limited hygienic regulation and without the application of protective coatings. Such aging environments promote mold and yeast proliferation (El-Sayed et al., 2024), posing a significant challenge in Ras cheese production in Egypt. *Penicillium* and *Aspergillus* are among the most common mold genera found on cheese surfaces (Bullermann, 1981), and they are known for their proteolytic and/or lipolytic activities. Fungal growth not only leads to undesirable appearance and off -flavors but also poses potential health risks, as some mold species are capable of producing mycotoxins. Various approaches have been explored to prevent fungal contamination in cheese, including coating, waxing, and the application of agents like potassium sorbate, natamycin, and radiation (El-Sisi et al., 2015). Coating is widely used in the food and cheese industry as a key preservation approach. It helps safeguard the product by maintaining its safety, quality, and extending its usable storage time. Additionally, coatings aid in retaining the cheese's color and nutritional content (Rojas-Grau et al., 2009; Robertson, 2013; Costa et al., 2018). The sensory attributes and nutrient profile of cheese can be improved through selecting appropriate coating or film materials, which may also deliver functional benefits either by themselves or via the addition of flavoring agents, dyes, or sweeteners (Artiga-Artigas et al., 2017). In recent years, considerable interest has been directed toward the formulation and application of edible coatings in cheese manufacturing, owing to their biodegradability, safety, compatibility with biological systems, and proven effectiveness in food preservation (Muñoz-Tebar et al., 2023). Pectin is an example of a biopolymer commonly used in food packaging and preservation. It is a complex, water-soluble polysaccharide used to create edible coatings. Pectin appears as a white, amorphous, colloidal carbohydrate with a high molecular weight and is naturally found in ripe fruits, particularly citrus and apples. It is typically extracted from inexpensive and readily available sources, such as agricultural or food processing wastes and byproducts. Pectin based edible films and coatings, often loaded with active agents such as natural antimicrobials and antioxidants, have been used as effective alternatives to synthetic wax-based coatings.

Journal website: https://ftrj.journals.ekb.eg/
Published by Food Technology Research Institute, ARC
https://DOI: 10.21608/ftrj.2025.406797.1176

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These pectin coatings have been applied to various food products, significantly enhancing their shelf life. According to Diblan and Kaya (2018), cheese can be coated with pectin films containing antimicrobial compounds. Additionally, pectin coatings have shown potential in reducing lipid migration and moisture loss, while also improving the appearance and handling of food products. Zaleska et al. (2000) and Mariniello et al. (2003) developed hydrocolloid edible films using apple pectin, whey protein isolate, and whole soy flour. However, pectin-based coatings are generally poor moisture barriers. They can, nonetheless, reduce water loss from food by functioning as a sacrificial agent (Maftoonazad & Badii, 2009). Starch is another promising biopolymer used for food coatings and packaging due to its low cost, abundance, and excellent film-forming properties. Corn starch is considered one of the best types of starch for producing biodegradable plastics. It is the most widely produced starch globally (around 65%), followed by sweet potato (13%) and cassava (11%). Corn starch is also preferred in applications such as low-acid, heat-sterilized sauces and for enhancing whiteness and opacity in food formulations. Starch-based coatings are colorless and oil-free and are commonly used to extend the shelf life of fruits, vegetables, and other food products. However, due to their hydrophilic nature, they exhibit low water vapor barrier properties and are highly sensitive to moisture (Luchese et al., 2017). To improve the flexibility, extensibility, and structural stability of the polymer matrix, plasticizers and emulsifiers (also known as surfactants) are often incorporated. Furthermore, to reduce the hygroscopic nature of starch-based materials, blending them with hydrophobic compounds has become a cost-effective and versatile strategy for producing new materials with enhanced properties (Cazón et al., 2017; Sapper & Chiralt, 2018). Pectin and starch are biodegradable, natural polysaccharides widely used in food preservation. When incorporated into edible coatings, they help extend the shelf life of fruits, vegetables, and cheese by minimizing moisture loss and inhibiting microbial growth (Ahmed et al., 2007; Cerqueira et al., 2010). In view of the aforementioned, the goals of this study were to evaluate the effects of coating Ras cheese with different combinations from pectin and starch on cheese weight loss, cheese quality and growth of molds & yeasts on cheese and to monitor changes in cheese quality during ripening period.

2. Materials and Methods

Full-fat cow's milk was obtained from the farm of the Faculty of Agriculture, Cairo University. Freeze-dried lactic starter culture (YF-L904) for direct vat set (DVS), consisting of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*, was obtained from Chr. Hansen Laboratory, Denmark. Rennet powder was also sourced from Chr. Hansen Laboratory, Denmark. Food-grade table salt (NaCl) was purchased from the local market. Edible pectin and corn starch were obtained from El-Masry Ever Line Company, El-Gharbiya Governorate, Egypt.

Pectin coating formulation and film preparation

Five grams of edible pectin were suspended in 100mL of distilled water and heated to 90°C with continuous stirring for 30 minutes. Then, 2.5mL of glycerol was added as a plasticizer. Ras cheese samples were dipped into the coating solution and allowed to dry at room temperature.

Starch coating formulation and film preparation

Five grams of corn starch were mixed with 100 mL of distilled water at room temperature for 5 minutes, and 2mL of glycerol was added. The mixture was then transferred to a water bath and heated to 90°C for 30 minutes with agitation. After cooling, the coating was directly applied to the surface of Ras cheese, following the method of Yossef (2014).

Ras cheese manufacture

Full-fat cow's milk was pasteurized at 72°C for 15 seconds and immediately cooled to 40°C. Starter cultures (1% of each) were added, and the milk was left to ripen at 40°C for one hour. Rennet was then added to coagulate the milk within 40 minutes. The coagulum was cut and cooked at 38–40°C for 45 minutes, then held at this temperature for an additional 15 minutes. The curd was salted (3% w/w NaCl), transferred into molds (hooped), and pressed, following the method of Hofi et al. (1970). After a dry salting period of three days, the cheese blocks were cleaned and divided into six treatment groups as follows Table 1:

- C (Control): Uncoated Ras cheese (benchmark control)
- T1: Ras cheese coated with 100% pectin
- T2: Ras cheese coated with 100% starch
- T3: Ras cheese coated with a mixture of 75% pectin and 25% starch
- T4: Ras cheese coated with a mixture of 50% pectin and 50% starch
- T5: Ras cheese coated with a mixture of 25% pectin and 75% starch

All cheese treatments were ripened at a relative humidity of approximately 85% and a temperature of 13 ± 2°C. Samples were collected when fresh and at monthly intervals for up to four months.

Table 1. Pectin and starch concentration for Ras cheese coating

Ras Cheese treatments	Concentration of pectin and starch
C	Control cheese (uncoated)
T_1	100% pectin
T_2	100% starch
T_3	25% pectin and 75% starch
T_4	50% pectin and 50% starch
T_5	75% pectin and 25% starch

Physicochemical properties

Moisture, fat, ash, salt, and titratable acidity were determined according to the methods of the Association of Official Analytical Chemists (A.O.A.C., 2020). pH values were measured using a digital pH meter (Model: HANNA pH 213 Instruments). Total nitrogen (TN) and soluble nitrogen (SN) in the cheese samples were determined according to the method described by Ling (1963), while total volatile fatty acids (TVFA) were assessed following the method of Kosikowski (1986). The antioxidant activities of pectin and starch were evaluated as described by Huang et al. (2005).

Cheese weight loss

At the end of the ripening period, each cheese treatment was weighed, then scraped and cleaned, and weighed again. The weight loss was calculated as the difference between the initial and final weights and expressed as a percentage, according to the method of El-Sisi et al. (2015).

Organoleptic Evaluation

Sensory evaluation of the cheese treatments was conducted monthly during the ripening period by a panel of experts from the Dairy Research Department, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt. Evaluation was based on the scoring sheet developed by El-Shafei et al. (1995).

Microbiological analysis

Total bacterial counts (TBC), yeast and mold counts, and coliform counts were determined according to Marshall (2005). The proteolytic bacterial count was assessed using skim milk agar as described by Frank et al. (1992), while the lipolytic bacterial count was determined following the method of Luck (1981).

Statistical analysis

All experimental data were expressed as mean values. Statistical analysis was performed using one -way analysis of variance (ANOVA), followed by Duncan's multiple range test to determine significant differences at $P \leq 0.05$, using the SAS software package (SAS, 2008).

3. Results and Discussions

The chemical composition of cow's milk, pectin and starch used in Ras cheese is presented in Table 2.

Cheese weight loss

Coating Ras cheese with pectin and starch significantly reduced weight loss compared to the uncoated control, as shown in Figure 1. Although all treatments were ripened under good hygienic conditions, the uncoated control exhibited the highest weight loss (11.8%). An inverse relationship was observed between pectin concentration in the coating and weight loss: the treatment coated with 100% pectin (T1) recorded the lowest weight loss at 6.62%. This reduction may be attributed to the moisture barrier properties of both pectin and starch, which limit water evaporation and inhibit surface microbial activity. Specifically, their antimicrobial effects likely suppressed the growth of molds and yeasts on the cheese surface microorganisms known to contribute to spoilage and structural degradation (Fajardo et al., 2010; El-Sisi et al., 2015).

Table 2. Chemical composition of cow's milk, pectin and starch used in coated Ras cheese

Constituents	Cow's milk	Pectin	Starch
Dry matter (DM) %	12.69^{b}	91.34^{a}	92.87^{a}
Fat %	3.60^{a}	0.30^{b}	0.50^{b}
Protein %	3.15^{a}	0.32^{b}	0.41^{b}
Lactose or Carbohydrate*	4.96^{b}	88.87^{a}	91.5^{a}
Ash%	0.98^{b}	1.85^{a}	0.46^{c}
PH value	6.67^{a}	3.91^{b}	3.00^{c}
Acidity %	0.16^{a}	0.37^{b}	0.28^{c}
Total antioxidant activity **(DPPH) %	ND	8.32^{a}	6.25^{b}

The same letters in each row indicate no significant ($P \leq 0.05$).
*: Calculated by difference – TC% = [100- (protein + ash + fat + moisture)]
**: Reduction percent reduction of antioxidant activity of DPPH
ND: not determined, DPPH: 2,2 diphenyl-1-picrichydrazyl.

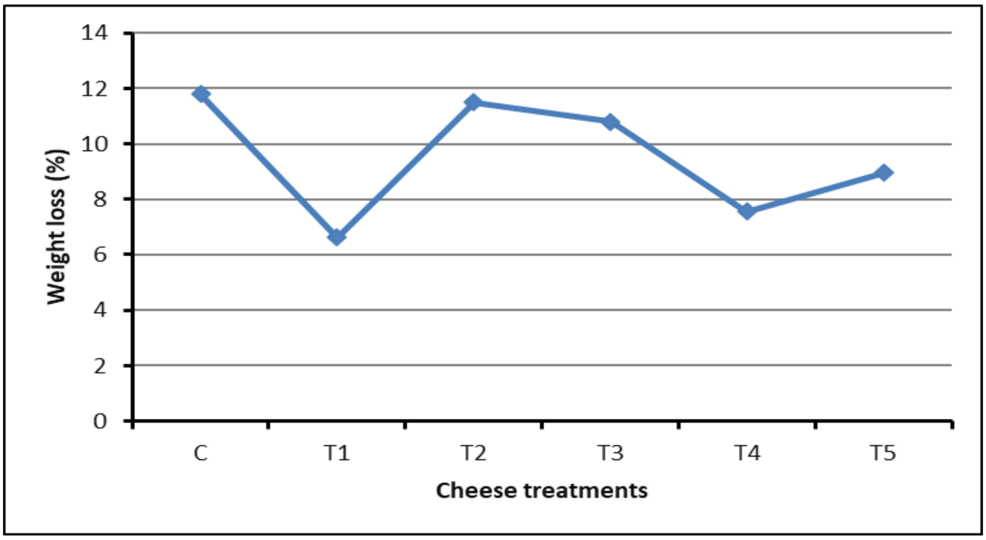

Figure 1. Cheese weight loss of coated Ras cheese after ripening

Physicochemical properties

The chemical analysis of the coated Ras cheese treatments during the ripening period is presented in Table 3. Coating the cheese with pectin and starch had a significant effect ($P \leq 0.05$) on moisture content. A positive correlation was observed between moisture content and the level of pectin used to replace starch in the coating. Increasing the concentration of pectin resulted in a significant ($P \leq 0.05$) enhancement in moisture retention during cheese ripening. Fresh Ras cheese samples had moisture contents ranging from 40.45% to 40.85%, which decreased after four months of ripening to a range of 30.03% to 32.83% across the various treatments. This decline in moisture is primarily due to water evaporation or water binding to proteins as "bound water" during the ripening process. The uncoated control had the lowest moisture content by the end of ripening, whereas the treatment coated with 100% pectin (T1) maintained the highest moisture content. This could be attributed to the moisture barrier properties of pectin, which reduce water loss. It is also possible that the hydrophilic nature of pectin allows it to interact with hydrophobic components of the cheese matrix at the surface, further enhancing its moisture retention capacity (El-Sisi et al., 2015).

Table 3. Effect of coating Ras cheese with pectin and starch on chemical composition during ripening period

Product property	Storage (months)	C (Control)	T_1	T_2	T_3	T_4	T_5
Moisture %	Fresh	$40.45^{c,a}$	$40.85^{a,a}$	$40.59^{b,a}$	$40.64^{a,a}$	$40.73^{a,a}$	$40.79^{a,a}$
	1	$37.35^{e,b}$	$38.81^{a,b}$	$37.98^{d,b}$	$38.22^{c,b}$	$38.45^{b,b}$	$38.63^{b,b}$
	2	$35.71^{d,c}$	$36.72^{a,c}$	$36.18^{c,c}$	$36.24^{c,c}$	$36.35^{c,c}$	$36.58^{b,c}$
	3	$33.36^{e,d}$	$34.43^{a,d}$	$33.57^{d,d}$	$33.68^{d,d}$	$33.95^{c,d}$	$34.17^{b,d}$
	4	$30.03^{c,e}$	$32.83^{a,e}$	$31.12^{c,e}$	$31.34^{c,e}$	$31.58^{b,e}$	$31.73^{a,e}$
Fat/dry matter % (F/DM)	Fresh	$45.89^{a,c}$	$46.49^{a,c}$	$46.29^{a,c}$	$46.04^{a,c}$	$46.23^{a,b}$	$46.28^{a,c}$
	1	$50.28^{c,b}$	$49.03^{d,b}$	$49.18^{d,bc}$	$50.99^{b,a}$	$51.45^{b,a}$	$52.14^{a,b}$
	2	$51.33^{b,a}$	$50.96^{c,a}$	$50.53^{c,b}$	$50.58^{c,a}$	$51.85^{b,a}$	$53.22^{a,a}$
	3	$51.77^{a,a}$	$51.09^{ab,a}$	$49.90^{c,b}$	$49.76^{c,b}$	$50.72^{b,a}$	$51.65^{a,b}$
	4	$51.74^{a,a}$	$51.36^{ab,a}$	$51.54^{ab,a}$	$50.61^{b,a}$	$51.01^{b,a}$	$52.00^{a,b}$
Protein %	Fresh	$18.62^{a,e}$	$18.46^{a,e}$	$18.35^{a,e}$	$18.47^{a,e}$	$18.33^{a,e}$	$18.27^{a,d}$
	1	$22.64^{a,d}$	$20.98^{b,d}$	$22.31^{a,d}$	$21.87^{ab,d}$	$22.14^{a,d}$	$21.95^{ab.c}$
	2	$25.10^{a,c}$	$23.15^{d,c}$	$24.64^{b,c}$	$23.62^{c,c}$	$23.97^{c,c}$	$23.55^{c,b}$
	3	$26.02^{a,b}$	$24.21^{c,b}$	$25.87^{a,b}$	$24.98^{b,b}$	$25.51^{ab,b}$	$25.01^{b,a}$
	4	$27.12^{a,a}$	$25.23^{d,a}$	$27.01^{a,a}$	$26.32^{b,a}$	$26.56^{b,a}$	$25.89^{c,a}$
Salt %	Fresh	$2.61^{a,d}$	$2.29^{b,c}$	$2.58^{a,d}$	$2.54^{a,e}$	$2.52^{a,c}$	$2.63^{a,c}$
	1	$3.31^{a,c}$	$2.71^{c,b}$	$3.20^{a,c}$	$3.11^{ab,d}$	$3.02^{b,b}$	$3.33^{a,b}$
	2	$3.61^{a,b}$	$2.82^{c,b}$	$3.50^{a,b}$	$3.30^{ab,c}$	$3.15^{b,b}$	$3.44^{ab,b}$
	3	$3.76^{a,b}$	$2.96^{ab,a}$	$3.61^{a,a}$	$3.62^{a,b}$	$3.54^{ab,a}$	$3.53^{ab,b}$
	4	$3.94^{a,a}$	$3.13^{b,a}$	$3.89^{a,a}$	$3.80^{a,a}$	$3.74^{a,a}$	$3.72^{a,a}$
Ash %	Fresh	$4.89^{a,c}$	$4.26^{b,c}$	$4.91^{a,d}$	$4.67^{a,d}$	$4.77^{a,d}$	$4.53^{ab,c}$
	1	$5.40^{a,b}$	$4.88^{c,b}$	$5.43^{a,b}$	$5.13^{a,c}$	$5.26^{a,c}$	$5.02^{b,c}$
	2	$5.63^{a,ab}$	$5.20^{b,ab}$	$5.65^{a,b}$	$5.52^{a,b}$	$5.60^{a,b}$	$5.33^{b,b}$
	3	$5.75^{a,a}$	$5.42^{b,a}$	$5.87^{a,a}$	$5.88^{a,a}$	$5.92^{a,a}$	$5.67^{a,a}$
	4	$5.97^{a,a}$	$5.60^{b,a}$	$5.99^{a,a}$	$5.90^{a,a}$	$5.95^{a,a}$	$5.86^{a,a}$

The letters before comma possess the factor of treatment. While those after comma possesses the factor of the storage period. The means with the same letter at any position did not significantly differ (*P≤0.05*)

Fat content is one of the most significant factors influencing cheese palatability, contributing to its texture, body, smoothness, and richness (Abd El-Monem, 2018). The fat-to-dry matter (fat/DM) content of all coated Ras cheese treatments increased during the ripening period. The data also show that protein content increased significantly ($P \leq 0.05$) throughout ripening. The lowest protein content among the coated cheese treatments was observed in sample T1 (100% pectin). The increases in fat/DM and protein content during storage are primarily attributed to moisture loss over the ripening period (Amer et al., 2023). Additionally, these changes may reflect the influence of the pectin and starch coatings on water retention and protein degradation. Proteolysis appeared to proceed more slowly in coated cheese than in uncoated samples (Mileriene et al., 2021). Salt and ash contents, presented in Table 2, also increased significantly ($P \leq 0.05$) in all coated cheese treatments over the ripening period, likely due to moisture loss through evaporation. The highest salt content was recorded in the uncoated (control) cheese. These findings are in agreement with results reported by Amer et al. (2023) and Ibrahim et al. (2023). Table 4 shows that acidity values were slightly higher in coated Ras cheese treatments compared to the uncoated control, while pH values exhibited an inverse trend. As the ripening period progressed, acidity increased due to lactic acid development, which is also linked to moisture loss. The highest acidity value was found in cheese coated with 100% pectin (T1).

coated with 100% pectin (T1). Acidity in cheese results from the original milk constituents as well as the metabolic activity during ripening. The increase in acidity is associated with the breakdown of proteins, amino acids, and fatty acids, which occurs through proteolysis and lipolysis. This observation aligns with Kebary et al. (2011), who reported that increased acidity during ripening may reduce cheese moisture content and aid in whey expulsion from the curd. Ripening indices including soluble nitrogen (SN) and total volatile fatty acids (TVFA) followed similar trends across treatments (Table 5), showing significant increases ($P \leq 0.05$) as the ripening period progressed. Coating Ras cheese with pectin and starch significantly increased ($P \leq 0.05$) the levels of these ripening indices. A positive correlation was observed between the pectin concentration in the coating and the values of SN and TVFA. This enhancement is likely due to increased moisture content, which promoted the activity of cheese microflora, particularly proteolytic and lipolytic bacteria, leading to intensified proteolysis and lipolysis. These findings are consistent with those reported by Abd El-Salam et al. (2011) and Aydin (2017).

Table 4. Effect of coating Ras cheese with pectin and starch on titratable acidity % (TA) and pH value during ripening period

Product* property	Storage (months)	C (Control)	T_1	T_2	T_3	T_4	T_5
TA* %	Fresh	$0.82^{a,d}$	$0.92^{a,d}$	$0.83^{a,d}$	$0.84^{a,d}$	$0.85^{a,d}$	$0.91^{a,d}$
	1	$1.12^{b,c}$	$1.27^{a,c}$	$1.15^{b,c}$	$1.20^{a,c}$	$1.22^{a,c}$	$1.25^{a,c}$
	2	$1.37^{b,bc}$	$1.59^{a,b}$	$1.51^{a,bc}$	$1.53^{a,bc}$	$1.55^{a,c}$	$1.57^{a,bc}$
	3	$1.58^{b,b}$	$1.67^{a,b}$	$1.60^{ab,b}$	$1.62^{a,ab}$	$1.64^{a,b}$	$1.66^{a,b}$
	4	$1.66^{b,a}$	$1.80^{a,a}$	$1.70^{b,a}$	$1.73^{a,a}$	$1.75^{a,a}$	$1.79^{a,a}$
pH value	Fresh	$5.79^{a,a}$	$5.65^{a,a}$	$5.72^{a,a}$	$5.70^{a,a}$	$5.69^{a,a}$	$5.71^{a,a}$
	1	$5.44^{a,b}$	$5.28^{b,b}$	$5.47^{a,b}$	$5.45^{a,b}$	$5.34^{a,b}$	$5.30^{ab,b}$
	2	$5.30^{a,c}$	$5.05^{b,c}$	$5.25^{a,c}$	$5.21^{a,c}$	$5.12^{b,c}$	$5.07^{b,c}$
	3	$5.16^{a,d}$	$4.93^{b,cd}$	$5.15^{a,c}$	$5.18^{a,c}$	$5.10^{a,c}$	$4.95^{b,d}$
	4	$5.11^{a,d}$	$4.87^{b,d}$	$5.06^{a,d}$	$4.99^{ab,d}$	$4.98^{ab,d}$	$4.90^{b,d}$

The letters before comma possess the factor of treatment. While those after comma possesses the factor of the storage period. The means with the same letter at any position did not significantly differ (*$P \leq 0.05$*).
*: Titratable acidity % (TA).

Table 5. Effect of coating Ras cheese with pectin and starch on ripening indices during ripening period

Product property	Storage (months)	C (Control)	T_1	T_2	T_3	T_4	T_5
WSN*/TN %	Fresh	$5.12^{a,e}$	$5.21^{a,e}$	$5.15^{a,e}$	$5.16^{a,e}$	$5.14^{a,d}$	$5.22^{a,e}$
	1	$14.54^{e,d}$	$20.05^{a,d}$	$15.47^{de,d}$	$16.20^{d,d}$	$17.38^{c,c}$	$18.10^{b,d}$
	2	$18.21^{de,c}$	$28.14^{a,c}$	$18.78^{d,c}$	$20.40^{c,c}$	$19.29^{cd,c}$	$25.17^{b,c}$
	3	$22.28^{e,b}$	$33.26^{a,b}$	$26.34^{d,b}$	$28.21^{c,b}$	$30.55^{b,b}$	$29.23^{b,b}$
	4	$25.11^{e,a}$	$39.80^{a,a}$	$30.12^{d,a}$	$32.95^{c,a}$	$33.27^{c,a}$	$37.88^{b,a}$
TVFA**	Fresh	$26.78^{a,e}$	$27.79^{a,e}$	$26.82^{a,e}$	$27.13^{a,e}$	$27.26^{a,e}$	$27.61^{a,e}$
	1	$43.95^{e,d}$	$55.50^{b,d}$	$45.06^{d,d}$	$48.52^{cd,d}$	$50.01^{c,d}$	$52.30^{b,d}$
	2	$66.75^{f,c}$	$71.80^{a,c}$	$67.46^{e,c}$	$69.82^{d,c}$	$70.07^{c,c}$	$70.90^{b,c}$
	3	$84.65^{e,b}$	$92.65^{a,b}$	$86.35^{d,b}$	$89.73^{c,b}$	$90.97^{b,b}$	$91.47^{b,b}$
	4	$95.07^{e,a}$	$116.50^{a,a}$	$97.29^{d,a}$	$98.46^{c,a}$	$99.66^{c,a}$	$106.41^{b,a}$

The letters before comma possess the factor of treatment. While those after comma possesses the factor of the storage period. The means with the same letter at any position did not significantly differ (*$P \leq 0.05$*).
*: Water soluble nitrogen% (WSN)/TN
**: Total volatile fatty acids (ml 0.1N NaOH/ 100g cheese) (TVFA).

Microbiological quality of ras cheese

Packaging plays a vital role in extending the shelf life of cheese and ensuring its microbiological safety (Han et al., 2018). As shown in Table 6, the total bacterial count (TBC) in all coated Ras cheese treatments was significantly higher ($p \leq 0.05$) than in the uncoated control during the four-month storage period at 15°C. The TBC increased during the initial months of ripening and then declined slightly toward the end of the period. The highest TBC was observed in the cheese coated with 100% pectin (T1), while the uncoated control showed the lowest. This increase may be attributed to the higher moisture content and water activity in pectin-coated cheese, which can promote microbial growth. Additionally, the reduced oxygen permeability of the coatings may have favored the proliferation of lactic acid bacteria. These findings are consistent with previous studies (Abd El-Monem et al., 2022; Elfadaly et al., 2023). Similarly, no molds or yeasts were detected until the second month, except the control one. After that point, their counts began to increase, with the highest levels recorded in the uncoated control by the fourth month. Coated cheeses exhibited significantly lower mold and yeast counts, likely due to the limited oxygen availability under the coatings, which inhibits fungal growth (Youssef et al., 2018; Ibrahim et al., 2023). Proteolytic and lipolytic bacterial counts of uncoated and coated Ras cheese are shown in Table 6. Proteolytic bacterial counts increased significantly during the first three months of ripening in all treatments. T1 exhibited a sevenfold increase in proteolytic bacteria, compared to a fourfold increase in the control. By the end of the ripening period (4 months), these counts declined slightly in all treatments. Lipolytic bacteria followed a similar trend but peaked earlier, in the second month, with counts ranging from 3.14 $x10^4$ to 4.53 $x10^4$ CFU/g for control and T1, respectively (El-Sisi et al., 2015). Overall, the microbiological quality of the coated Ras cheese was enhanced, contributing to extended shelf life during the four-month ripening period.

Table 6. Effect of coating Ras cheese on microbiological properties during ripening period

Product property	Storage (months)	C (Control)	T_1	T_2	T_3	T_4	T_5
Total bacterial count (10^6CFU/g)	Fresh	$4.90^{b,c}$	$6.01^{a,c}$	$5.91^{a,b}$	$5.94^{a,b}$	$5.96^{a,b}$	$5.98^{a,c}$
	1	$5.51^{c,b}$	$7.05^{a,b}$	$6.01^{b,b}$	$6.99^{a,a}$	$6.95^{a,a}$	$6.03^{b,c}$
	2	$6.60^{c,a}$	$7.70^{a,a}$	$7.05^{b,a}$	$7.02^{b,a}$	$7.08^{b,a}$	$7.51^{a,a}$
	3	$5.52^{c,b}$	$6.92^{a,b}$	$5.90^{b,b}$	$5.91^{b,b}$	$6.84^{a,a}$	$6.88^{a,b}$
	4	$3.52^{d,c,d}$	$4.71^{a,d}$	$3.75^{b,c}$	$3.81^{b,c}$	$3.77^{b,c}$	$3.82^{b,d}$
Mold & yeast (10^3CFU/g)	Fresh	ND	ND	ND	ND	ND	ND
	1	$1.34^{,d}$	ND	ND	ND	ND	ND
	2	$3.25^{a,c}$	$2.14^{b,c}$	$2.33^{b,c}$	$2.67^{b,c}$	$2.51^{b,c}$	$1.98^{c,c}$
	3	$5.22^{a,b}$	$3.00^{b,b}$	$3.19^{b,b}$	$3.22^{b,b}$	$3.24^{b,b}$	$2.93^{c,b}$
	4	$8.05^{a,a}$	$4.65^{e,a}$	$7.35^{b,a}$	$6.65^{c,a}$	$6.78^{c,a}$	$5.11^{d,a}$
Coliform (10 CFU/g)	Fresh	ND	ND	ND	ND	ND	ND
	1	ND	ND	ND	ND	ND	ND
	2	ND	ND	ND	ND	ND	ND
	3	ND	ND	ND	ND	ND	ND
	4	ND	ND	ND	ND	ND	ND
Proteolytic bacterial count (10^4 CFU/g)	Fresh	$1.62^{b,e}$	$2.12^{a,e}$	$1.71^{b,d}$	$1.68^{b,e}$	$1.91^{a,e}$	$1.95^{a,e}$
	1	$2.83^{d,c}$	$4.13^{a,c}$	$3.15^{c,b}$	$3.50^{b,c}$	$3.77^{a,c}$	$3.85^{a,c}$
	2	$3.75^{d,b}$	$5.32^{a,ab}$	$3.86^{d,b}$	$4.44^{c,b}$	$4.55^{c,b}$	$4.97^{b,b}$
	3	$4.66^{d,a}$	$7.47^{a,a}$	$4.83^{d,a}$	$5.85^{c,a}$	$5.89^{c,a}$	$6.71^{b,a}$
	4	$2.11^{c,d}$	$3.34^{a,e}$	$2.20^{c,c}$	$2.56^{b,d}$	$2.70^{b,d}$	$3.12^{a,d}$
Lipolytic bacterial count (10^4 CFU/g)	Fresh	$0.75^{d,d}$	$1.10^{a,d}$	$0.95^{b,e}$	$0.55^{e,d}$	$0.72^{d,d}$	$0.85^{c,e}$
	1	$1.62^{d,c}$	$2.81^{a,bc}$	$2.05^{c,c}$	$2.32^{b,b}$	$2.57^{a,b}$	$2.63^{a,c}$
	2	$3.14^{d,a}$	$4.53^{a,a}$	$3.34^{bc,a}$	$3.46^{bc,a}$	$3.73^{b,a}$	$4.22^{a,a}$
	3	$2.26^{d,b}$	$3.28^{a,b}$	$2.37^{c,b}$	$2.52^{c,b}$	$2.81^{b,b}$	$3.01^{ab,b}$
	4	$1.25^{b,c}$	$1.90^{a,c}$	$1.36^{b,d}$	$1.45^{b,c}$	$1.62^{a,c}$	$1.75^{a,d}$

The letters before comma possess the factor of treatment. While those after comma possesses the factor of the storage period. The means with the same letter at any position did not significantly differ (*P≤0.05*).
ND: not detected.

Organoleptic properties of ras cheese

The scores for the organoleptic properties of uncoated and coated Ras cheese samples throughout the ripening period are summarized in Figures 2-5. Flavor scores improved progressively for all cheese treatments as the ripening period advanced. The uncoated Ras cheese (control) consistently recorded slightly lower flavor scores compared to the coated samples, particularly by the fourth month. Although all cheese treatments were generally acceptable to the panelists, increasing the proportion of pectin in the coating improved the organoleptic characteristics of the cheese. The treatment coated with 100% pectin (T1) was the most preferred, achieving the highest overall sensory scores. These findings are consistent with those reported by El-Sisi et al. (2015); Jafarzadeh et al. (2021) and Ibrahim et al. (2023).

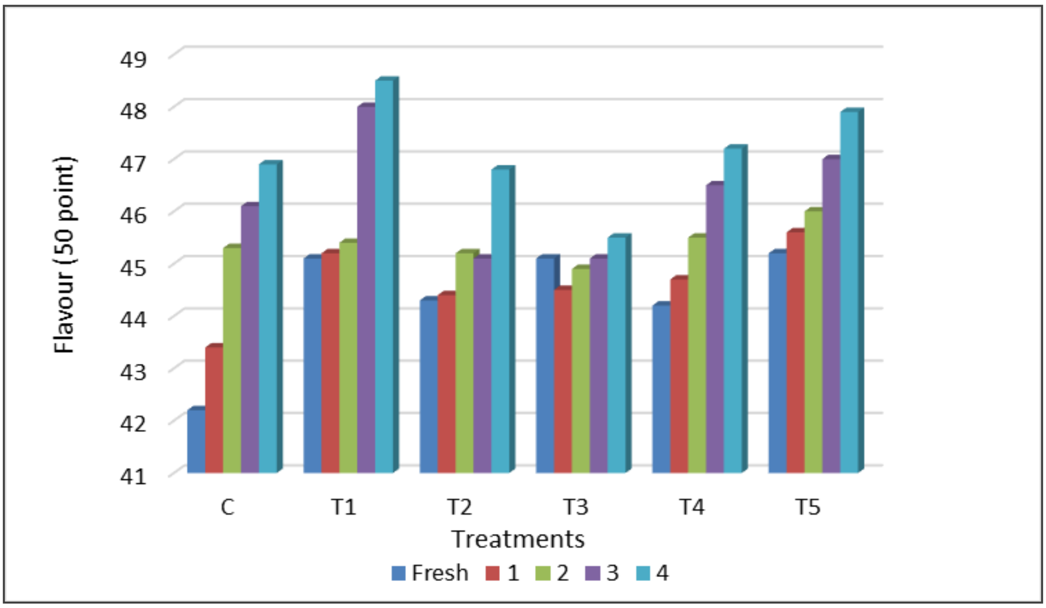

Figure 2. Flavour score of Ras cheese coating with pectin and starch

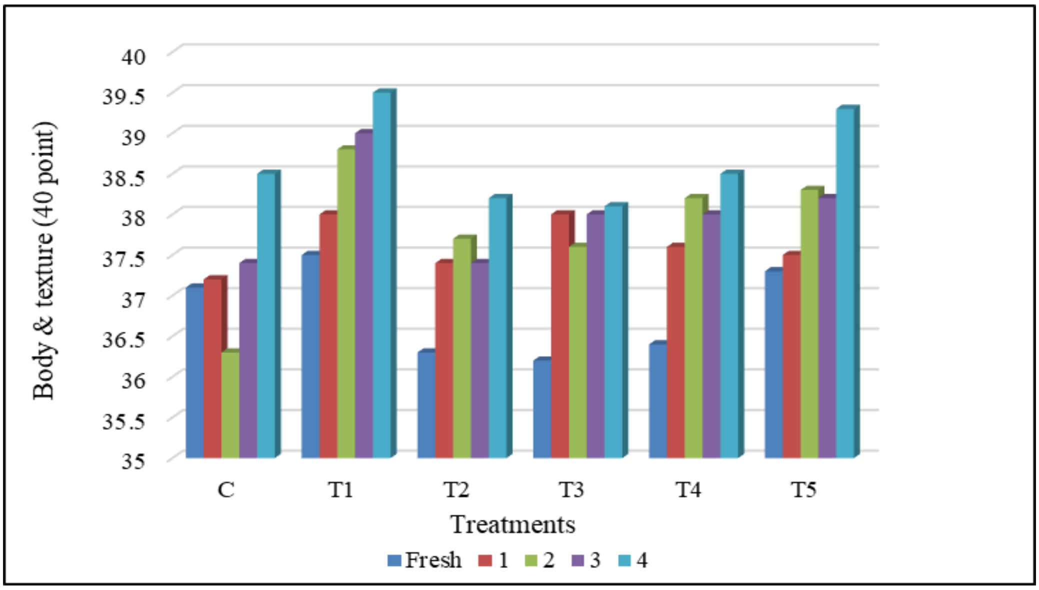

Figure 3. Body &texture score of Ras cheese coating with pectin and

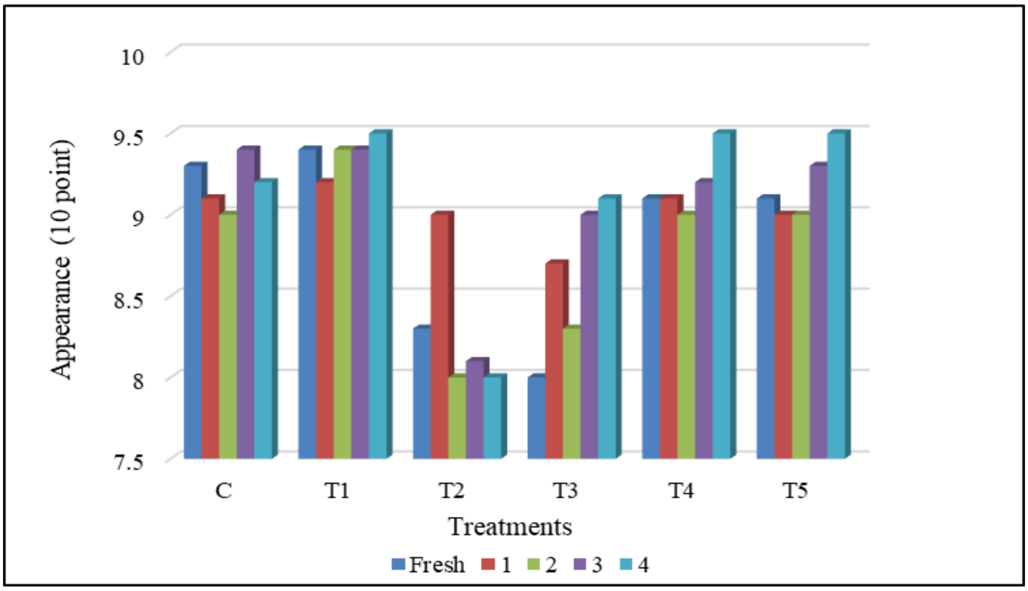

Figure 4. Appearance score of Ras cheese coating with pectin and starch

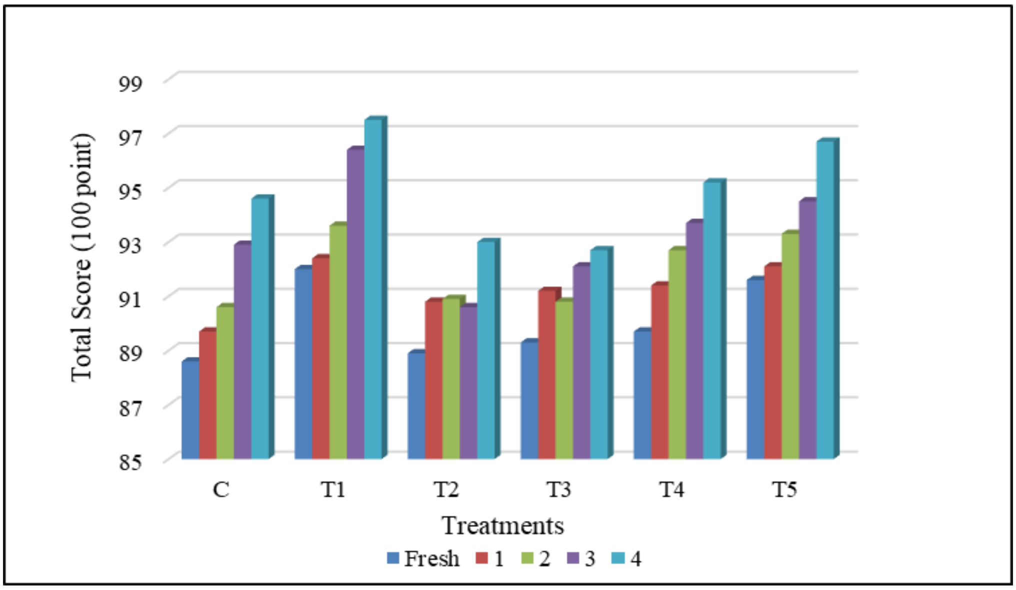

Figure 5. Total score of Ras cheese coating with pectin and starch

4. Conclusion

This study demonstrated that coating Ras cheese with different ratios of pectin and starch significantly influenced its chemical composition, microbial profile, and sensory characteristics during a four-month ripening period. Coatings containing higher proportions of pectin effectively reduced cheese weight loss and mold & yeast growth, while enhancing moisture retention, proteolysis, lipolysis, and organoleptic quality. Among all treatments, the 100% pectin coating showed the best overall performance. Therefore, the use of natural pectin-based coatings is recommended as an effective, clean-label approach to improve the quality, safety, and shelf life of Ras cheese during ripening. Further studies may explore combining pectin with antimicrobial agents or antioxidants to enhance functionality.

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