Volume 3 Issue 1
www.escientificlibrary.com
eScientific Library
ISSN: 2771-5027
ES Journal of Nutritional Health

Effect of Used Edible Coating from Cassava Starch on Shelf Life and Quality of Muffin

Research Article

DOI: 10.59152/ESJNH/1014

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Received: March 08, 2023; **Accepted:** March 15, 2023; **Published:** March 24, 2023

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Abstract

The aim of this study was to produce an edible coating and film from cassava starch and study the theological, mechanical properties, permeability and scanning electron microscopy (SEM) of the prepared films were determined. The thickness, tensile strength , elongation ,% solubility of produced by edible film with rosemary cassava starch with chitosan and gelatin the highest, followed by that of cassava starch –based film with rosemary essential oil. Therefore, the addition of rosemary essential oil to cassava starch films have the potential to provide a safe edible films decreased microbial growth and consequently prolonged the shelf life of quality of muffin, As well as improved the chemical changes and sensory properties of the quality of muffin. The substances used in this experiment were , film with % corn starch (A) , film with % cassava starch (B), film with 50 % cassava starch + 25 %chitosan +25% gelatin (C) and film with 25 % cassava starch + 37.5 %chitosan +37.5% Gelatin (D) compared with uncoated controls on quality attributes and prolong shelf- life of quality of muffin during storage. All products were stored at (4±1°C) for six week and the quality parameters such as weight loss, total microbial count, molds and yeast(M&Y), peroxide Value, water activity (aW), texture and sensory evaluation were determined. The results observed that treatment (D) was the best treatment in terms of reduction of microbial load followed by treatment (C) followed by treatment (B) followed by treatment (A) until six week of storage as compared to uncoated controls . The levels of decrease in chemical and microbial load in the samples from both of the edible films were related good quality muffin. As well as on the same physic –chemical tests and sensory. It is clear that the edible coating and films of the aromatic rosemary essential oils have kept the quality of muffin up to six week of storage.

Keywords

Starch, Cassava Starch, Mechanical, Viscosity, Vapor, Edible Coatings and Films, and Shelf Life and Quality of Muffin.

Introduction

Reducing, inhibiting, or retarding the growth of microorganisms, which could then extend the shelf life of the packaged food. Muffins are sweet, baked products that are highly appreciated by consumers due to their good taste and soft texture. This product is characterised by a typical porous structure and a high specific volume, which confer a spongy texture. Muffins are widely used as snacks among consumers, so the bakery and snack food industries continuously compete to be first in the market by improving quality and merchandising factors such as the cost, packaging, and shelf life of the products. Staling is one of the most important attributes of bakery products quality. Staling is a complex process that includes changes in mouth texture, loss of tenderness, humidity redistribution, and partial dryness. All these changes contribute to reducing consumer acceptability. Stability during storage or shelf life can be defined as the maintenance of the physical and sensorial characteristics associated with freshness, such as tenderness, compressibility, and humidity, and the minimization of the alterations associated with staling. Several studies have analysed how to minimise the textural changes in cakes and muffins during storage with edible films that cover the products [1]. The baking process itself is a decisive factor in producing high-quality baked goods. Baking is considered a simultaneous heat and mass transfer process, characterised by a rapid increase of the core temperature and the development of a dry surface crust. Also, the increase of the internal temperature is associated with several chemical reactions and physical changes, which are responsible for both the transformation of the cake batter into crumb and the product volume expansion. In consequence, baking process conditions—oven temperature, baking time, and oven humidity—strongly influence the development of all quality attributes [2]. From the different quality attributes, surface crust colour is one of the critical quality characteristics since its value directly affects the initial consumer's acceptance. Surface colour results from browning reactions such as combined sugar caramelization and maillard reactions. When the surface temperature exceeds 100 °C, browning reactions are activated and, therefore, the crust becomes darker. Researchers who studied the browning of different sweet baked goods proposed a kinetic model in order to predict lightness variation during cracker baking and analysed the effects of water activity and temperature on the browning kinetics of biscuit baking. Muffins are also characterised by a porous structure and a spongy texture. These attributes are measured, among others, by global density, crust/crumb ratio, moisture content (of crumb and crust), crumb porosity and density, and textural properties, which can all be influenced by operative conditions [3].

The development of cassava starch films that are plasticized with sugars and glycerol and reinforced. Information on the best formulation for producing composite films with superior mechanical and barrier properties. Incorporating antimicrobial agents in the formulation of cassava starch films since they carry natural additives could be considered a new trend in functional food packaging in the near future. Active packaging provides microbial safety for consumers [4]. Due to its availability, biodegradability, renewability, film-forming ability, and low cost, starch from different botanical sources (cassava, corn, wheat, rice, potato, pea, and others) is one of the most promising natural polymers for packaging applications. Studies have shown that the use of cassava starch as raw material to manufacture edible films and coatings provides a good aspect and an intense shine, making the food items more commercially attractive due to the more resistant, transparent, and efficient biodegradable packaging, which acts as barriers against water loss. Due to the food grade of the cassava starch film, it can be ingested as a whole packaged product. In addition, there is the concern of consumers for food safety, increasing the search for natural additives with antimicrobial action, among other functions, to be used in substitution to the synthetic additives normally used with this end in bakeries [4]. Novel food packaging technologies arose as a result of consumers' desires for convenient, ready-to-eat, tasty, and mildly processed food products with extended shelf lives and maintained quality. However, currently, researchers are exploring novel and reliable alternatives in order to delay bacterial growth and also contribute to preserving the freshness and quality of food products. Edible films are an example of these new products preservation methods. Edible coatings have been manufactured with incorporated antimicrobial and antioxidant agents, which can reduce spoilage events by enhancing the shelf life of food products [5,6]. The edible films can be consumed with the product as they are generally regarded as safe (GRAS) and they do not impart any extraneous flavours on the product. Coating of food products can be done by either dipping, spraying, brushing, extrusion, panning, or solvent casting [7].

The objectives of this study were: (1) to study the applications of some varieties of edible coating from cassava starch on the shelf life and quality of muffins by using treatments control. A, B, C, and D have been done to them as an edible film of prepared cassava starch + chitosan + gelatin edible coating and films in retardation of deterioration of muffins. (2) to investigate the change in weight loss, microbial total counts, Yeast & Moulds, Peroxide Value, aw, Texture and sensory evaluation of coated Muffin with storage time; (3) to compare the impact of one of these edible coatings with that of plastic packaging on the extension of muffin life; and (4) to investigate whether there is any additional beneficial effect of a combined treatment using edible coating and packaging.

Preparation of Different Materials and Methods

Materials

Materials: Cassava roots were obtained from the Crops Intensification Section of the Field Crops Research Institute (FCRI) in the winter seasons of 2019/2020 at the Agricultural Research Centre, Giza, Egypt. The roots were cleaned of impurities and foreign materials, then stored in a dry place at room temperature (25–2 °C) for future extraction. The preparation of Cassava Starch extract to produce edible coatings and films is being studied at the Central Lab of Agriculture Research Field Crops Research Department Food Technology Research Institute, Agricultural Research Centre, Giza, Egypt. The materials used in this experiment were: ethanol (95%), chloroform, and methanol, all produced by El Nasr Pharmaceutical Chemicals Company, Cairo, Egypt. Corn starch and citric acid were obtained from the El-Gomhouria chemical company. Glycerol and sodium hydroxide were obtained from Acmatic for Chemicals and Laboratory Equipment, Cairo, Egypt. Rosemary essential oil, gelatin, and sodium chlorides were obtained from Across Organics, Belgium. Whatman No. 1 filter paper and decanter 50 mesh were obtained from the across-organics company in New Jersey. U.S.A. plate count agar and potato dextrose agar were obtained from Win Lab Company (U.K.). Chitosan was obtained from Jenapharm, Germany.

Methods

Extraction of Cassava Starch

Cassava roots (1 kg) were first weighed, followed by peeling, washing, cutting, grinding, saving 750 um “refusal”, settling-successive washing “sodium chlorides”, settling-successive washing “supernatants”, fresh starch, staining, grinding, and drying starch. The cassava peelings were then steeped in deionized water at 3 °C (1 kg seed in 2 L deionized water) for 8 h. The remaining starch cake was suspended in deionized water, centrifuged, and the dark upper layer removed, repeating this process five times. The starch collected at the end of this process was suspended in aqueous 0.20% (w/w) NaOH at an alkaline pH value of 10.5 and gently stirred for 5 min at 15 C to avoid any rise in temperature during this process. The suspension was then centrifuged, suspended in deionized water, and neutralised carefully at pH 7 by adding NaCl (4%). After centrifugation, the starch cake was suspended in deionized water, centrifuged, and removed in order to remove any traces of the mucilage layer in the upper layer and any ionic components of the NaCl resulting from the neutralisation process. Dehydrated in an air dryer at 50 °C, followed by grinding starch into a fine powder [8].

Treatments

Storage Treatments of studied Cassava Starch on shelf life and quality of Muffins

The preparation of muffins was done using the following formula based on flour weight: 6.7% baking powder, 2.2% salt, 49% sugar, 106% milk, 27% liquid whole eggs, and 38% butter. A single-bowl mixing procedure was used. After baking 40.0 0.3 g of batter in paper cups for 30 minutes at 180 oC in a convection oven, the muffins were allowed to cool at room temperature. Preparation of bakery products, muffin The ingredients of cake modification, such as adding 150 g of soft wheat flour (72% ex.), 6.80 g baking powder, 14.76 g powdered milk, 1.50 g vanilla, 35 g sugar, 39.75 g eggs, 31.83 g corn oil, 3 g salt, and adjust the amount of water from 20 to 70 ml. For 5 minutes, cream sugar, eggs, and vanilla in a planetary mixer on speed 2 (170 rpm). The required quantities of powdered milk and water were transferred to the whipped sugar and oil and blended for 5 minutes at speed 2 (125 rpm) in the Hobart mixer to form a homogeneous mixture. Previously blended flour and baking powder mixtures were transferred to the above cream and mixed for 2 minutes at speed 2 (125 rpm). Required quantities of batter (450g) were poured into each of the aluminium cups (cakes) and baked at 170–190 °C for 20 min. They were packaged in polyethylene bags and stored at refrigerator temperature for analysis.

The bakery products were divided into groups as follows:

Preparation of the Film edible coating from Cassava Starch

Starch and cassava starch were used as film-forming ingredients. Edible film-forming solutions were obtained by dispersing starch and cassava starch (5% w/v) in water for 15 min (pH 10.7). Glycerol (30/100 g starch) was added, along with rosemary essential oil 0.1 ml, and the resulting dispersion was then magnetically stirred for 15 min at 75 C. The film-forming solution was then allowed to cool at room temperature. The film solution was diluted with 14.25 g of ethanol, and, for each formulation, a specific content of film solution was poured onto rectangular plates (2525 cm2 in area) of pecia plate, followed by drying at 35 °C for approximately 24 h in a conventional chamber dryer with forced air circulation [1]. The substances used in this experiment for edible coatings and films were divided into four groups for the modification of the matrix composition of the studied edible coatings and films: In this trial, the described film formation solution was modified by adding and dividing into four equal parts; one part (A) was film-forming based 100% Corn starch and glycerol, second part (B) was film-forming 100% Cassava starch, third part (C) was film-forming 50% Cassava starch + 25% Chitosan +25% Gelatin, four part (D) was film-forming based 25% Cassava starch + 37.5% Chitosan.

Table 1: The table shows the composition of the solubility edible coating from corn starch, cassava starch, gelatin, chitosan plasticizers such as glycerol, coefficients, and permissible percentages of starch.

Film code	films components %					
	Corn starch	cassava starch	Glycerol	Rosemary essential oil	Chitosan	Gelatin
A	100%	-	1.5	-	-	-
B	-	100%	1.5	0.1	-	-
C	-	50%	1.5	0.1	25%	25%
D	-	25%	1.5	0.1	37.5%	37.5%

Table 1 shows the formulas for edible coating from cassava starch [3].

1. Brookfield Engineering Labs was used to measure the parameters (shear rate and shear stress) to select the best solutions for edible coatings and films from cassava starch solutions combined with cinnamon essential oil. BROOKFIELD AMETK DVN EXT. At room temperature, the most appropriate solutions are selected. The methodology of the work Put the sample transformer in a water bath at a constant temperature to maintain the desired temperature, and then run the viscosity device between 10 and 60 rpm. The spindle SC4-18 was selected for measurement [9].
2. Microscopy and scanning electrons were used to measure edible coatings and films from cassava starch. SEM Schematic Overview of the Inspect S 150A Sputter Coater: Quanta FEG250 with Field Emission Gun, Fel Company Netherlands, Machine Type Inspect [10].
3. Film thickness: The film thickness was measured forchitosan, and 25% gelatin. the preparation of edibcassavaistarch films from Cassava Starch to produce edible film at diffcorntstarch andments of A = % Corn . C =ch =% cassava star, C starch + 25 % chitosan +25% Gelatin D =25 % cassava starch + 37.5 % chitosan + 37.5% gelatin, measured with a digital pecializer (Mitutoyo type digital indicators; the company's models are pk-1012 E, Japan), where the film strip was placed between the jaws of the pecializer and the gap and then slowly closed, taking an average of three readings [11].
4. % Solubility in Water: The edible coating and films from cassava starch at different treatments All A 0%, B 0.02%, C 0.04%, D 0.06%, E 0.02%, F 0.04%, and G 0.06% samples were first dried in a desiccator containing calcium chloride. The dry piece of 500 mg nano-film was then immersed in beakers containing 50 mL of distilled water for 24 hours with gentle spin-rocker incubation. Then the films were removed from the water and returned to the desiccator by weighing known and constant amounts, then calculating weight loss in water as a percentage of water weight loss based on the dry film as follows: % weight loss = initial dry weight-final dry weight (100/initial dry weight) [12].
5. Measuring the mechanical properties of a prepared edible coating and films made from cassava starch to produce edible coatings and films. Edible coatings and films from cassava starch at various treatments; measurement of tensile properties (tensile strength, elongation) using a CT3 texture analyzer. At various treatments, the non-edible film A = % Corn Starch; B = % Cassava Starch; C = 50% Cassava Starch + 25% Chitosan + 25% Gelatin D is composed of 25% cassava starch, 37% chitosan, and 37.5% gelatin. It was cut into 3-by-5-cm strips. They were held at each jaw end, the jaws were then moved partly at the exact speed until the modulus of the youngsters was automatically recorded, according to Hernandez, et al. [13].
6. Water vapour permeability (VWP) measurement The ASTM E96-95 method was used to determine the water vapour transmission rate [g/s.m2]. And water vapour permeability through the edible coating and films made from cassava starch. A round test cup was used to determine the VWP of the membrane nanoparticles upon different processing: A = 0%, B = 0.02%, C = 0.04%, D = 0.06%, E = 0.02%, F = 0.04%, and G = 0.06%.

The membrane was first cut into a round shape larger than the inner diameter of the beaker. The beaker was filled with 50% distilled water, the membrane was sealed on top with paraffin oil, and then the beakers were placed in a desiccator containing calcium chloride. Hourly cup weights were recorded over 10 hours, and samples from each film were tested. Linear regression was used to estimate the slope of this line in g/hr. The water vapour transfer rate (WVTR) and water vapour permeability were determined using the following: Water vapour transmission rate [g/(s.m2)] The water vapour permeability through films was determined gravimetrically using the ASTM method E96-95.WVPR = Δm/ΔtA WVP = WVPR.L/ΔRH

Where m/t is the moisture gain weight per time (g/S), A is the surface area of the film (m2), L is the film thickness (mm), and RH is the difference in relative humidity [14].

7. Measurement of gas permeability of edible coatings and films from cassava starch: Gas testing instrument, model Witt Oxybaby headspace gas analyzer, using an Instron 34SC-5 universal tensioning machine,UK,equipped with a load cell of 5 kN and a crosshead speed of 10 mm/min1 according to ASTM D 882-18 (O2/CO2), following the method described [15,16].

   P = Q•X/A•tp

Where P is the permeability of gas (m3/m•day•mmHg), Q is the quantity of gas diffused in m3, and X is the thickness of the film, A area of the film, m2, t is the time of day, and P is the pressure difference across the films.

Physico-chemical and microbiological properties

Chemical analysis of muffin

1) Moisture, ash, protein, crude fibre, and fat were determined according to the AOAC [17]. Carbohydrate content was calculated by difference**.**
2) Energy: The energy of a muffin was calculated by James (1995) [18] as follows: Energy (kcal) = “Fat x 9 + Protein x 4 + Total Carbohydrate x 4”.
3) The determination of the peroxide value was determined according to Pearson (1991).
4) **Weight loss:** Percentage was estimated according to the method of the AOAC [17].
5) **Texture Profile Analysis:** Texture Profile Analysis (TPA) was determined according to the method of (Bourne, 2003) as described follow: Samples were formed into a 50-mm-diameter cylinder with a 40-mm-high wall, and texture was determined by a universal testing machine (Cometech, B type, Taiwan) provided with software. In a TPA double compression test, an aluminium 25 mm diameter cylinder probe was used to penetrate to 50% depth at 1 mm/s speed.Firmness (N), Gumminess (N), Chewiness (N), Cohesiveness, Springiness, Adhesiveness, Negative Force (N), and Resilience were calculated from the TPA graphic. Both springiness and resilience give information about the after-stress recovery capacity. But, while the former refers to retarded recovery, the latter concerns instantaneous recovery (immediately after the first compression, while the probe goes up)**.**
6) Water activity was determined by the CX-1 water activity system (Decagon devices, Inc., Pullman, WA) in bread and pastries research at the Food Technology Research Institute, Giza, Egypt. Samples are placed in disposable plastic sample dishes that are inserted into the CX-1. A small fan circulates the air above the sample, speeding up vapour equilibrium. An infrared sensor measures the sample surface temperature equilibration. A small internal mirror is cooled until water condenses at the dew point temperature. The mirror and sample temperature are used to calculate the sample’s water activity [19].
7) **Microbial analysis:** The total microbiological count was determined according to Marshall [20]. All the microbial counts were carried out in duplicate.

i. Total plate count: The total colonies of bacteria were estimated using plate count agar medium. The plates were incubated at 37 °C for 48 h.

ii. Mould and yeast counts: Mould and yeast counts were determined using the American Public Health Association’s methods for microbiological examination of foods [21] with a malt extract agar medium. The plates were incubated at 25 °C for five days.

8) Organoleptic evaluation: Different products of the cake, Danish, and croissant were evaluated organoleptically as reported by Chen et al. [22]. The products were presented to ten well-trained members of staff from the food technology research institute and the agriculture research centre for sensory evaluation. The panellists were asked for their decision concerning colour, texture, taste, order, and overall acceptability, maximum score is 20 for each parameter.

9) Statistical analyses: sensory analysis, firmness, and peroxide value data were statistically analysed by Statistical Package v. 6.0 (Statsoft Inc.) for computing analysis of variance (ANOVA) and Fisher's least significant difference (LSD) (P 0.05) according to Gomez and Gomez [23].

Results and Discussion

Rheological properties of edible film from cassava starch to produce edible coating and films

The relation between viscosity and shear stress and the shear rate and shear stress of samples A, B, C, and D were measured at different room temperatures at different shear rates. (9.30, 18.60, 27.90, 37.20, 46.50, and 55.80 1/s).. Figure 1 shows how to choose the best and most suitable solutions for making edible films from cassava starch, as shown in Table 1 and Figures 1–4. The results show that the forming solution exhibits a trend of non-Newtonian pseudoplastic behaviour at different treatment levels (A, B, C, and D) and fits the power-low equation.. τ=kγn → (1) Where : τ: shear stress, Pa γ: shear rate 1/sec, k: consistency index , n: flow behavior index. Show that the shear stress increases with an increase in shear rate at different (A, B, C, and D).Also, from Table 1, it was observed that the relation between shear rate and viscosity decreases with letters (A, B, C, and D). It can be observed that apparent viscosity decreases with increasing shear rate; as noted, the shear rate increases with increasing shear stress [25,26]. The results indicated that as the shear rate increased**,** apparent viscosity decreased. K (consistency index) decreased as the concentration of edible film from cassava starch solutions increased (A, B, C, and D). The same trend was observed in

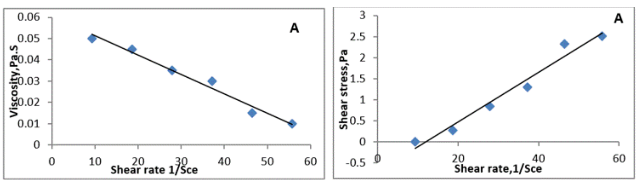

Figure (1-A): Effect of shear rate on apparent viscosity for (A) **Figure (1-A):** Effect of shear rate –shear stress for (A).

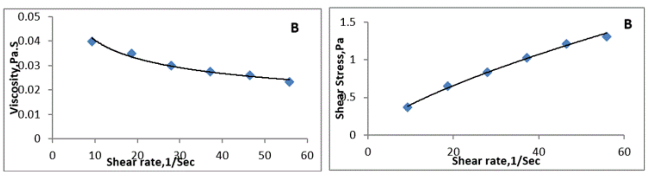

Figure (2-B): Effect of shear rate on apparent viscosity for (B) **Figure (2-B):** Effect of shear rate –shear stress for (B).

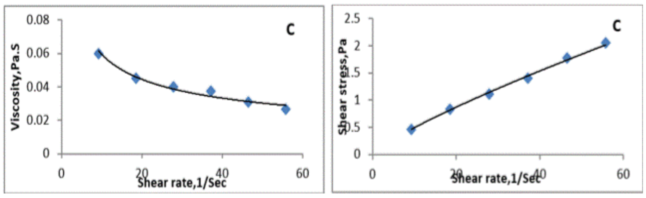

Figure (3-C): Effect of shear rate on apparent viscosity for © **Figure (3-C):** Effect of shear rate –shear stress for ©.

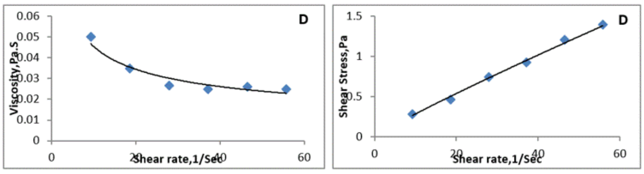

Figure (4-D): Effect of shear rate on apparent viscosity for (D) **Figure (4-D):** Effect of shear rate –shear stress for (D).

the treatments (A, B, C, and D) of edible film from cassava starch to produce an edible film-forming suspension solution, and it was higher than control samples (A), which had a consistency index of (0.0009). The flow Peciali index (n) increased with increasing concentrations of edible film from cassava starch (A, B, C, and D) to produce an edible film-forming suspension solution and did not show a trend for nanoedible film and coatings. It was higher than the control with samples A, which had blown pecialis (0.0.0603). This could be due to the effect of the consistency of changes in concentration, as well as the interaction effect between the average value of (k) and (n) for each level of single parameters associated with absolute expression, which must be eliminated as another function in order to generate the reported single parameter model. The reaction is interrupted because the particles tend to vibrate at lower and higher temperatures, also splitting larger particles into smaller particles. The results indicated the liquid solution's behaviour, the particles' type and size, and the presence of nanomaterials and electrolytes. Functionality, constant cost, and good availability of polysaccharides such as films and biopolymer films are prerequisites for their use in different industries, along with their specialised flow properties [26]. The results indicated the relation between shear rate and shear stress, instantaneous viscosity, and shear rate. The graph indicated that the solution exhibited

Table 2: Relation between (k) and (n) at cassava starch to produce edible coating and films.

Treatments	Apparent viscosity			Shear stress		
	k	n	R2	k	n	R2
A	0.0009	0.0603	0.9783	0.0589	0.7068	0.9684
B	0.0799	0.297	0.9774	0.0799	0.7035	0.9959
C	0.1567	0.399	0.959	0.0748	0.8189	0.99981
D	0.1138	0.421	0.9063	0.344	0.9182	0.9943

A = % Corn starch B =% cassava starch C= 50 % cassava starch + 25 %chitosan +25% Gelatin D =25 % cassava starch + 37.5 %chitosan +37.5% Gelatin

characteristics of typical non-Newtonian pseudoplastic fluid behaviour. The viscosity of each solution showed a high value at the shear rate and decreased linearly with increasing shear stress [27].

Physical and mechanical properties of prepared cassava starch to produce edible coating and films

The treatment, films prepared with cassava starch to produce procoatings andible coatings, indicates the thickness values at treatments A, B, C, ared D, wC, and hD, which gradually increase in thickness with increasing concentration. It was also discovered that the thickness values of cassava starch to produce edible coatings and films (B 118, C 178, and D 125 um) were less than the concentration of cassava starch to produce edible coatings and films as compared to the control, which had a thickness value of 104 um, which was higher than the treatments. It was also discovered that the tensile strength in treatments B, C, and D was 4.25, 332.87, and 23.69 N, respectively, while the elongation was 16.25, 23.25, and 48.50%,%, respectively, when compared to the first initial control samples, the A0% tensile strength (84.50 N) and elongation (4.250%).On the other hand, it was observed that the permeability of gases O2 and CO2 in treatments B, C, and D was 5.141, 2.825, and 4.004 and 9.528, 2.62, and 5.544, respectively, as compared with the first initial control samples. It was higher in the permeability of gases (O2, 19.M3/M210-7day.mmHg,mHg, and CO2, 15.16 M3/M210-8day.mmHg). It was also discovered that the permeability of wavapourapourthe percent solubility in water was higher iD (B, C, a1.036, (1.401.121,036, and 1.147.86, andd50.02,7respectively) 50.02).As compared with the first in the permeability control sit wavapourse1.438 [grm2.24 hrs and hr] and 52% solubilized with cassava starch to produce edible coatings and films from the Table 3, the results indicated that the thickness values at different treatments were A, B, C, and D, which gradually increased in thickness with increasing concentration. It was also noted that the cassava starch to produce edible coating and films B 118, C 178, and D 125 um were thinner than the concentration of samples of cassava starch to produce edible coating and films as compared to the control, which had a thickness value of A 104 um, where it was higher than the treatments. Tensile strength in treatments B, C, and D was 4.25, 32.87, and 23.69 N, respectively, while elongation was found to be less in treatments B, C, and D, 16.25, 23.25, and 48.50%, respectively, when compared to the first initial control samples, the A0% tensile strength (84.50 N) and elongation (4.250%).On the other hand, it was observed that the permeability of gases O2 and CO2 in treatments B, C, and D was 5.141, 2.825, and 4.004 and 9.528, 2.62, and 5.54, respectively, as compared with the first initial control samples. It was higher in the permeability of gases (O2, 19.72 M3/M210-7day.mmHg, and CO2, 15.16 M3/M210-8day.mmHg). It was also observed that the permeability of water vapour and the percent solubility in water were higher in B, C, and D (1.402, 1.036, and 1.121, and 46.17, 47.86, and 50.02, respectively). As compared with the first initial control samples, it was higher in the permeability of water vapour (1.438 [g] per m2 per 24 h) and the percentage solubility (52%). The tensile strength was periodically increased according to Priyadarshi et al. [28]. The high elongation of the film is always a desirable characteristic for use in food applications. Swarup Roy and Jong-Whan Rhim [29] All the main factors significantly affected the mechanics of the film, as the chitosan film below had an 18% higher elongation than the chitosan film, and in addition to the incorporation of thymol, this reduced the chitosan layer [15,30].

Scanning electron microscopy (SEM) microstructure of prepared films from cassava starch to produce edible coatings and films

There are four microscopic images of starch and cassava starch edible coatings, and the films used in this experiment were: film with % corn starch (A), film with

Table 3: The physical and mechanical properties and permeability of the prepared films from cassava starch to produce edible coatings and films.

Treatments	Thickness Um	Tensile strength (N/M2)	Elongation (%)	Oxygen (O2) Permeability M3.M/M2×10-7 day.mmHg	CO2 Permeability M3.M/M2 ×10-8 day.mmHg	Water vapors Permeability [g/m2.24hr]	"% Solubility" loss in weight after dipping in water and drying
A	104	84.5	4.250	19.72	15.16	1.438	52 %
B	118	24.7	16.25	5.141	9.528	1.402	46.17 %
C	178	32.87	23.25	2.825	2.62	1.036	47.86%
D	125	23.69	48.50	4.004	5.54	1.121	50.02 %

A = % Corn starch B =% cassava starch C= 50 % cassava starch + 25 %chitosan +25% Gelatin D =25 % cassava starch + 37.5 %chitosan +37.5% Gelatin

% cassava starch (B), film with 50% cassava starch + 25% chitosan + 25% gelatin (C), and film with 25% cassava starch + 37.5 % chitosan + 37.5% gelatin (D) to produce edible film. After taking the cross-section, the morphology of the surface was investigated using SEM images (Figure 5), and the surface roughness was estimated using cassava starch edible films. The SEM images showed that the cassava starch edible films were composed of granules and crystals of starch and were smooth without any noticeable delamination on the surface, which was found to rise with increasing concentration upon different treatments. In the figure, prepared edible coatings and films combined with film with cassava starch (B), film with 50% corn starch

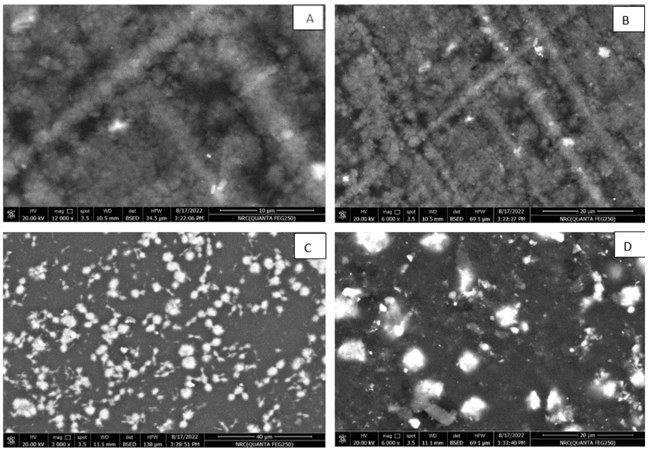

Figure 5: Microstructure of prepared films from cassava starch combined with gelatin and chitosan to produce edible films using scanning electron microscopy (SEM) technology using scanning electron microscopy (SEM) at different treatments. A =% Corn starch B =% cassava starch C= 50 % cassava starch + 25 %chitosan +25% gelatin D =25 % cassava starch + 37.5 %chitosan +37.5% gelatin.

+ 25% chitosan + 25% gelatin (C), and film with 25% cassava starch + 37.5% chitosan + 37.5% gelatin (D) are shown. It was found that the % film corn starch control (A), a 0% treatment, has cracks in the edible film due to poor treatment because it does not contain cassava starch, 37.5% chitosan, or any gelatin. The treatments in the figure also demonstrated that the addition of corn starch and corn starch properties results in edible films with a smooth surface flush A with some rough ridges, and treatment B discovered transparent roughness and elliptical droplets. Treatment B was homogeneous with bubble drops compared to a spherical morphological droplet. In general, the edible film is composed of a homogeneous solution with some compact fine grains and an intact smooth crystal morphology in a continuous matrix. The presence of granules and crystals of starch is observed. It can be concluded that these studies are useful for learning about the microstructure and membrane morphology, which can help in selecting the edible film formulas for coating and packing. Our results are in agreement with those obtained by Maria-Ioana Socaciu et al. [31]. SEM images found that the elegant starch film was smooth and intact without any deformation, and the surface was clear. The surface roughness was slightly increased in the films supplemented with grape seed extract, which was confirmed by the higher surface roughness of the CMC/grape seed extract film compared to the elegant CMC film [10].

Table 4: Effect of edible film and coatings on chemical composition of the prepared muffin calculated on (%D W) at zero time (%) of quality of Muffin during storage at 4°C.

Sample	Moisture %	Protein %	Fat content %	Ash %	Crude fiber %	Carbohydrate %	Energy (KCA)	Moisture %
Muffin	24.2	11.82	26.9	0.66	1.36	59.7	528.18	24.2

A = % Corn starch B =% cassava starch C= 50 % cassava starch + 25 %chitosan +25% Gelatin D =25 % cassava starch + 37.5 %chitosan +37.5% Gelatin.

Applications of chosen proper edible coating from cassava starch on shelf life and quality of Muffin:-

Physico-chemical and microbiological of coated quality of Muffin during storage period

Chemical analysis of muffin

The changes in the chemical composition of muffin products were determined during cold storage. The obtained results are shown in 4; The chemical composition results were as follows: moisture, ash, protein, crude fibre, fat content, and carbohydrate were determined. The percentages of moisture, protein, fat, ash, and carbohydrates were 24.2, 11.82, 26.9, 0.66, 1.36, and 59.7, respectively. And also ,energy was 528.18.

1. Weight loss percentage

The obtained results are presented in Table 5; it could be observed that the weight lost increased with increasing the storage period at cooled temperature for all tested samples packaged in both coated treatments and control ones. Control treatments indicated a higher rate of weight loss than the coated treatments. Weight and height values of muffins (control and coated) throughout storage time the weight of the control muffins decreased significantly during storage. Nevertheless, storage time did not significantly influence the weight of triticale-coated muffins. The water losses produced during storage in these muffins were negligible in relation to the total weight of the muffins, and consequently, this parameter did not change.

Table 5: Effect of edible film and coatings on weight loss (%) of quality of Muffin during storage at 4°C.

Storage Period / Treatment	One Week	Tow Week	Three Week	Four Week	Five Week	Six Week
Uncoated controls	2.87	4.65	reject	reject	reject	reject
A	2.31	4.11	5.24	5.92	7.21	7.63
B	1.51	2.73	3.22	5.36	5.81	6.12
C	0.06	0.25	0.46	0.51	1.62	2.68
D	0.37	0.96	1.55	2.14	2.81	3.22

A = % Corn starch B =% cassava starch C= 50 % cassava starch + 25 %chitosan +25% Gelatin D =25 % cassava starch + 37.5 %chitosan +37.5% Gelatin

The results in bread are caused by water redistribution at the molecular scale between protein and starch, which may result in volume changes or crumb contraction. This contraction is probably a result of the reorganization of the biopolymers contained in the crumbs, which undergo biochemical and physical changes [1,2].

2. Effect of storage period on total count of muffin products.

The total microbial count of different muffin products was investigated to assess one of the most important factors in the evaluation of muffin product quality. The changes in total counts of coated and uncoated control were determined during the cold storage period. The obtained results are recorded in Table 6. The results indicate that the counts gradually increased with increasing the storage period at cold temperatures in both samples packaged in coated and uncoated control forms. The uncoated control treatment indicates higher counts than the coated treatment. After six weeks of storage, the counts increased to 15 and 16 102 CFU/g for samples packaged in both coated and uncoated control forms, respectively, compared to the initial counts (1 and 0.50) 101 CFU/g. Meanwhile, the data revealed that the coating method and the presence of cinnamon oil delayed the deterioration of bakery products. We found that the total plate count of guar flour-supplemented muffins at ambient (30–50°C) and under-refrigerated (4–7°C) temperatures is represented. The total plate count in the control muffins was higher than in the guar flour supplemented muffins. Guar flour's higher water holding capacity results in lower water activity, which may contribute to slower bacterial growth in guar flour supplemented muffins. Total plate count varied significantly with respect to storage conditions and period. Muffins stored at ambient temperature showed the highest bacterial count and had a shorter shelf life than those stored at refrigerated temperatures [32,33].

Table 6: Effect of edible film and coatings on total microbial count of quality of Muffn during storage at 4°C.

Storage Period / Treatment	Zero time	One Week	Tow Week	Three Week	Four Week	Five Week	Six Week
Uncoated controls	1	40	120	reject	reject	reject	reject
A	0.50	25	70	135	reject	reject	reject
B	0.50	13	37	73	140	reject	reject
C	0.50	2	2	5	8	12	16
D	0.50	1	3	4	8	12	15

A = % Corn starch B =% cassava starch C= 50 % cassava starch + 25 %chitosan +25% Gelatin D =25 % cassava starch + 37.5 %chitosan +37.5% Gelatin

3. Effect of storage period on molds and yeast of muffin products

The changes in mould and yeast counts of muffin products were determined during cold storage. The obtained results are shown in Table 7. The results indicated that the mould and yeast counts gradually increased with increasing the storage period at a cold temperature in both samples packaged in coated and uncoated control forms. Mould and yeast counts are higher in uncoated samples than in coated samples.The counts reached 6 10^2 CFU/g after six weeks of storage in both coated samples, as compared with the initial counts of not more than 101 CFU/g. Guar-flour supplemented muffins showed a lower count than the control, which might be attributed to the lower water activity of the former. Further, the lower temperature conditions enhanced the shelf life of the product by reducing the multiplication rate of microflora at lower temperatures. Yeast and mould count varied significantly with respect to storage conditions and storage period. However, the rest of the samples were spoiled due to mould growth after the 28th day of storage analysis. Although muffins stored under refrigeration were suitable for consumption, their overall acceptability was markedly reduced [32,33].

Table 7: Effect of edible film and coatings on on molds and yeast of quality of Muffin during storage at 4°C.

Storage Period / Treatment	Zero time	One Week	Tow Week	Three Week	Four Week	Five Week	Six Week
Uncoated controls	ND	3	8	reject	reject	reject	reject
A	ND	2	6	12	reject	reject	reject
B	ND	2	4	8	13	-	-
C	ND	ND	1	2	4	5	6
D	ND	ND	ND	2	3	4	6

A = % Corn starch B =% cassava starch C= 50 % cassava starch + 25 %chitosan +25% Gelatin D =25 % cassava starch + 37.5 %chitosan +37.5% Gelatin

4. Effect of storage period on peroxide value of muffin products

From the result presented in Table 8 it could be noticed that the peroxide value for muffin products which treated by coating material was decreased peroxide value compared with control regardless storage period at cooled temperature. However, the peroxide value were 0.60 (meq. Peroxide / Kg oil) in all samples at zero time, then the peroxide value were 3.67-7.46 (meq. Peroxide / Kg oil) in all samples after stored 21 days at cooled temperature 4ºC. the effect of storage conditions on the peroxide value (meq/Kg) of supplemented muffins at room temperature (4-7 0 C). Control exhibited the highest peroxide value throughout the storage period, showing a high oxidation process. Among all samples, the muffins supplemented with guar flour showed lower peroxide values throughout the storage period than the control sample. A higher peroxide value indicates that the fat in the muffin has been auto-oxidized. The peroxide value varied significantly depending on the storage conditions and period [32].

5. Effect of storage on water activity (aW) of Muffn products

The effect of storage periods on water activity (aW) of bakery products shows in Table 9, it could be observed that, the water activity was ranged between 0.574 to 0.762 for all bakery products which stored at cooled temperature. The effect of storage condition on water activity of Guar flour supplemented muffins. An increase in water activity of muffins was observed with increases in storage period. The water requirement for growth of microorganisms was expressed in terms of moisture available or water activity. Water activity of control increased from 0.76 at zero day to 0.83 at 21st day of storage bread. Similar trend was observed [4,32].

Table 8: Effect of edible film and coatings on peroxide value of quality of Muffin during storage at 4ºC.

Storage Period / Treatment	Zero time	One Week	Tow Week	Three Week	Four Week	Five Week	Six Week
Uncoated controls	0.60	1.24	3.04	reject	reject	reject	reject
A	0.60	1.17	2.54	4.72	4.91	5.36	7.46
B	0.60	1.08	1.76	2.84	3.25	3.87	5.73
C	0.60	0.75	0.90	1.06	1.42	1.79	2.41
D	0.60	0.81	0.97	1.73	2.11	2.85	3.67

A = % Corn starch B =% cassava starch C= 50 % cassava starch + 25 %chitosan +25% Gelatin D =25 % cassava starch + 37.5 %chitosan +37.5% Gelatin

Table 9: Effect of edible film and coatings on aw of quality of Muffin during storage at 4ºC.

Storage Period / Treatment	Zero time	One Week	Tow Week	Three Week	Four Week	Five Week	Six Week
Uncoated controls	0.574	0.625	0.719	reject	reject	reject	reject
A	0.574	0.585	0.591	0.659	0.679	0.719	0.762
B	0.574	0.583	0.587	0.617	0.662	0.683	0.715
C	0.574	0.575	0.579	0.582	0.587	0.589	0.623
D	0.574	0.578	0.581	0.586	0.604	0.617	0.648

A = % Corn starch B =% cassava starch C= 50 % cassava starch + 25 %chitosan +25% Gelatin D =25 % cassava starch + 37.5 %chitosan +37.5% Gelatin

6. Effect of storage period on texture of quality of muffin products.

The effect of storage periods on the texture of bakery products is shown in Table 10. It could be observed that, The values of cohesiveness of the muffins varied between 0.47 and 0.60, with no significant differences ($p > 0.05$) between the 17 formulations and the control. The average values found for the parameter elasticity varied from 8.39 to 9.05 mm, whereas the control showed a value of 8.51 mm. Chewiness is a parameter of texture easily related to the sensorial analysis through trained panels and can be directly proportional to the hardness and cohesiveness, making it different from elasticity. This can be verified in the evaluation of the variables correlations, where it was possible to note the existence of a directly proportional correlation of this variable with hardness (R2 = 0.96) and an inversely proportional correlation with humidity and Wa (R2 = 0.58 and 0.65, respectively) [4].

7. Effect of storage period on sensory evaluation of quality of muffin products.

The mean scores of the sensory properties (texture, odour, taste, colour, and overall acceptability) are shown in Table 11. Fresh muffin products had a high palatability for panellists and were generally well accepted on the first day. The control treatment was rejected after two weeks of storage, while the coated treatment continued with the nanoedible coating for six weeks. On the other hand, the results of the statistical analysis showed that treatments (C and D) had the best appearance, followed by treatment (B). The C and D treatments had the highest taste and texture values, followed by A and B treatments throughout the storage period. In terms of overall acceptance, all treatments were well received when stored for the first time, but not after 6 weeks. Generally, it could be concluded that the effect of edible film and coatings prolonged its

Table 10: Effect of edible film and coatings on texture of quality of Muffin during storage at 4ºC.

Treatment and Storage period		Hardness	Adhesiveness	cohesiveness	gumminess	chewiness	springiness	resilience
Control	*Zero time*	17.95	0.20	0.67	11.96	76.10	6.36	0.26
A		17.95	0.20	0.67	11.96	76.10	6.36	0.26
B		17.95	0.20	0.67	11.96	76.10	6.36	0.26
C		17.95	0.20	0.67	11.96	76.10	6.36	0.26
D		17.95	0.20	0.67	11.96	76.10	6.36	0.26
Control	***one week***	33.98	0.17	0.59	9.98	63.00	4.31	0.09
A		23.42	0.20	0.56	10.50	65.12	7.50	0.19
B		20.39	0.20	0.50	10.35	71.00	7.37	0.16
C		15.08	0.24	0.49	11.10	73.22	7.45	0.20
D		10.29	0.30	0.56	11.82	76.00	7.42	0.21
Control	***.2weeks***	41.50	0.14	0.52	7.21	55.24	3.72	0.11
A		26.33	0.18	0.47	9.43	59.14	5.97	0.13
B		23.33	0.20	0.45	9.18	61.00	5.01	0.17
C		16.86	0.22	0.46	10.40	72.90	5.07	0.18
D		14.25	0.30	0.45	11.45	74.70	6.84	0.19
A	***3weeks***	35.10	0.16	0.32	7.72	49.00	5.37	0.13
B		29.51	0.20	0.33	8.59	53.80	5.11	0.17
C		20.34	0.23	0.30	10.04	60.90	5.21	0.24
D		17.07	0.30	0.36	11.15	72.30	6.56	0.26
A	***4weeks***	42.79	0.14	0.26	8.86	44.20	5.26	0.12
B		31.27	0.18	0.28	8.87	51.00	5.09	0.15
C		22.67	0.23	0.30	10.61	60.30	5.12	0.23
D		18.93	0.30	0.37	11.41	73.20	6.53	0.24
A	***5weeks***	50.47	0.12	0.22	6.18	38.10	5.10	0.05
B		33.01	0.17	0.27	7.21	57.50	5.43	0.06
C		24.88	0.21	0.29	1054	68.02	4.99	0.17
D		19.05	0.29	0.36	11.42	71.00	6.24	0.20
A	***6weeks***	54.26	0.12	0.19	5.44	33.05	4.03	0.04
B		36.21	0.15	0.24	6.72	55.36	4.22	0.05
C		25.18	0.20	0.28	10.34	62.14	5.01	0.16
D		19.65	0.30	0.35	11.21	70.12	6.13	0.18

Table 11: Effect of edible film and coatings on Sensory evaluation of quality of Muffin during storage at 4ºC.

Treatments		Taste	Oder	Texture	Color	Overall acceptable
Control	Zero time	20.0 ± 0. 12^{a}	19.75 ± 0.45^{a}	19.84 ± 0.31^{a}	20.0 ± 0.12^{a}	19.89 ± 0.13^{a}
A		18.65 ± 1.17^{a}	19.12 ± 0.74^{a}	18.79 ± 1.16^{a}	19.32 ± 0.98^{a}	18.83 ± 1.18^{a}
B		19.16 ± 0.12^{a}	18.81 ± 1.12^{a}	18.73 ± 1.12^{a}	19.45 ± 0.79^{a}	19.01 ± 0.82$_{a}$
C		19.92 ± 0.14^{a}	19.88 ± 0.91^{a}	19.61 ± 0.34^{a}	19.95 ± 0.27^{a}	19.87 ± 0.13^{a}
D		19.25 ± 0.43^{a}	18.74 ± 0.93^{a}	18.85 ± 1.12^{a}	19.71 ± 0.39^{a}	19.34 ± 0.69^{a}
L.S.D		1.07	0.962	1.16	1.02	1.081
Control	One week	13.47 ± 0.94^{C}	15.65 ±1.15^{b}	13.91± 0.96^{C}	17.85± 1.85^{a}	14.64 ± 0.94^{C}
A		15.62 ± 1.43^{b}	18.21 ± 1.69^{a}	15.71 ± 2.64^{b}	18.24 ± 1.98^{a}	16.12 ± 1.61^{b}
B		17.82 ± 1.39^{ab}	18.64 ±1.27^{a}	16.84 ± 2.16^{ab}	19.13 ± 1.26^{a}	17.95 ± 1.03^{ab}
C		19.72 ± 0.82^{a}	18.63.± 1.24^{a}	18.17 ± 1.37^{a}	19.74 ± 0.93^{a}	19.43 ± 0.95^{a}
D		18.93 ± 1.59^{a}	18.19 ± 1.05^{a}	17.11 ± 1.48^{ab}	19.35 ± 1.36^{a}	18.23 ± 1.66^{a}
L.S.D		0.793	1.14	0.745	0.87	1.018
Control	2 weeks	9.59 ± 2.32^{e}	13.27 ± 2.04^{C}	9.73 ± 2.17^{e}	15.23 ± 3.32^{C}	10.32 ± 1.65^{d}
A		14.71 ± 2.15^{bc}	16.46 ±1.23^{bc}	13.96 ± 1.85^{bc}	17.98 ± 1.35^{ab}	15.78 ± 1.75^{bc}
B		17.26 ± 1.16^{ab}	18.21 ±1.72^{ab}	16.81 ± 1.85^{ab}	18.94± 1.02^{a}	17.56 ± 1.67^{ab}
C		19.27 ± 1.04^{a}	19.42 ± 0.93^{a}	17.36 ± 1.54^{ab}	19.26± 0.36^{a}	19.34 ± 0.96^{a}
D		18.21 ± 1.13^{a}	18.61 ± 1.05^{a}	17.01± 1.64^{ab}	18.63 ± 0.52^{a}	17.91 ± 1.41^{a}
L.S.D		0.614	1.472	1.137	1.264	0.897
A	3 weeks	13.86 ± 1.22^{C}	16.15 ±1.41^{bc}	13.12 ± 1.16^{bC}	17.28±1.25ab	15.02 ± 1.39^{bc}
B		17.14± 1.27^{ab}	16.22 ± 1.32^{b}	15.91 ± 1.22^{b}	18.14 ± 1.61b	16.42 ± 1.26^{b}
C		18.92 ± 0.96^{a}	18.75 ± 1.18^{a}	17.13 ±1.58^{ab}	19.03 ± 1.12^{a}	18.99 ± 1.05^{a}
D		18.15 ± 1.38^{a}	18.05 ± 1.36^{a}	16.85 ± 1.67^{ab}	18.15 ± 1.85^{a}	17.41 ± 1.13^{a}

L.S.D		1.27	2.68	1.87	0.95	1.871
A *B* *C* *D*	4 weeks	11.62 ± 1.53c 16.12 ± 0.68^{b} 18.37 ± 1.37^{a} 17.55 ± 0.98^{a}	14.25 ± 1.65c 15.73 ± 1.45^{b} 17.34 ± 1.32^{a} 17.12 ± 0.24^{a}	10.41± 1.26d 13.83 ± 1.41^{bc} 16.3 ± 1.21^{ab} 15.26 ± 1.32^{b}	15.87± 1.62b 17.94 ± 1.51^{a} 18.53 ± 1.42^{a} 17.34 ± 0.89^{a}	13.84 ± 1.56^{bc} 16.02 ± 1.18^{b} 18.35 ± 1.36^{a} 17.42 ± 1.02^{a}
L.S.D		1.082	0.645	1.113	1.06	1.078
A *B* *C* *D*	5 weeks	10.83 ± 1.13^{cd} 14.21 ± 1.29^{c} 17.34 ± 1.82^{a} 16.92 ± 1.79^{ab}	12.81 ±1.59^{c} 12.14 ±1.57^{c} 17.11.±1.64^{a} 16.49 ±1.15^{ab}	9.71 ± 2.14^{d} 10.31 ± 2.46^{d} 15.95 ± 1.71^{b} 15.01 ± 1.28^{b}	13.24 ± 1 .96^{c} 14.33 ± 1.16^{c} 18.14 ± 0.96^{a} 17.25 .± 1.06^{a}	11.62 ± 1.81^{cd} 13.45 ± 1.01^{c} 17.93 ± 0.95^{a} 16.13 ± 1.16^{ab}
L.S.D		0.568	1.187	0.672	0.843	1.019
A *B* *C* *D*	6 weeks	8.71 ± 2.15^{e} 11.16 ± 1.12^{cd} 16.87 ± 1.34^{b} 15.26 ± 1.13^{b}	11.28 ± 1.43^{c} 10.11 ± 1.12^{d} 17.02 ± 1.03^{a} 15.94 ±1.22^{ab}	8.66 ± 1.95^{e} 8.38 ± 1.75^{d} 15.26 ± 1.84^{b} 13.57 ± 1.72^{c}	11.63 ± 1.25^{d} 12.44 ± 1.26^{c} 17.96 ± 0.65^{a} 16.54 ±1.23^{ab}	9.18 ± 1.75^{e} 11.26 ± 1.07^{d} 17.54 ± 0.96^{a} 15.92 ± 1.35^{ab}
L.S.D		1.415	1.654	1.613	2.519	1.624

A = % Corn starch B =% cassava starch C= 50 % cassava starch + 25 %chitosan +25% Gelatin D =25 % cassava starch + 37.5 %chitosan +37.5% Gelatin .

shelf life, freshness, and eating quality upon storage at a cold temperature. However, storage of the coated Also, packaging with an edible coating had a large effect on the keeping quality and shelf life of the examined samples. Based on the results obtained in this study, it can be concluded that these results may be useful for application in the field of the dating industry and its products [33]. The averages reached in the sensorial evaluation of the attribute colour of the muffins with active edible coatings resulted in a low c orrelation with the attribute taste ($R2 = 0.38$). These results mean that only 38% of the formulations with the best evaluations for colour tend to show the best evaluation for the attribute taste. For the texture evaluation, the statistical analysis shows that the tested variables did not exert an effect with a significant difference ($p > 0.05$) on the parameter [4].

Conclusions

This investigation was carried out as a trial to use cassava starch in the preparation of edible coating and films for muffins during storage at 41 oC for six weeks. The prepared coating was evaluated through the determination of some physical, chemical, and microbial properties. Also, the stored coated muffins were evaluated. The results indicated that a film with rosemary essential oil (D) was the best one in terms of reduction of microbial load, followed by films with (C), (B), and (A) until six weeks of storage, as compared to uncoated controls. It is clear that the edible coating containing aromatic essential oils and (gelatin + 25% cassava starch + 37.5% chitosan + 37.5% gelatin) has kept the quality characteristics of the muffin up to six weeks of storage

Acknowledgements

None.

Conflict of Interest

Authors declare that there is no conflict of interest.

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