Preparation of edible casings with natural biological characteristics from green tea extract

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Abstract. In this study, the envelope of whey proteins was fortified with green tea extract, where the effectiveness of green tea extracts was measured in which the aqueous alcohol solution was used at different concentrations as a solvent for the purpose of choosing a specific concentration of the alcohol solution on which the rest of the studies would be conducted in addition to determining the proportions of the extraction relative to the dry matter for each, where the proportions were (aqueous, alcoholic 25%). Alcoholic 50% and alcohol 75%) and the percentages for extraction were respectively (18.6%, 21.33%, 24%, and 25.14%). Where it was found that there is clear effectiveness in inhibiting the growth of E. coli bacteria, and the radial halos measured for the types of concentrations of extracts (aqueous, alcoholic 25%, alcoholic 50%, alcoholic 75%), respectively (24.6, 24.2, 22.8, 11.5 mm). The minimum concentration of inhibition was measured for dry matter and included a group of negative bacteria (Escherichia coli, Salmonella spp.) Furthermore, Gram-positive bacteria (Bacillus spp.), moreover, to the yeast (Candida albican), where the diameters of the halos reached the minimum concentration of inhibition (17.6), 16.6, 10.7, 10.3), respectively. The casings fortified with the alcoholic extract of green tea showed a very high antioxidant efficiency compared to the standard concentration of BHA, where the efficacy for them was (69.78% and 30.24%) respectively. Finally, both oxygen and water vapour's permeability values were measured to find and evaluate the confinement casings' properties. The values of the permeability of the control membrane to oxygen reached 92.02 (ml / m2 * day), while the water vapour permeability of the casings sample supported by the extract decreased to 69.98 (ml / m2 * day).

Key Word: Concentrations, Green Tea, Whey Proteins, Biological Characteristics

1. Introduction

Food preservation generally represents all measures taken to prevent food corruption, precisely all ways to limit food corruption microbial. Two types of conservation methods have been used for a long time: conservation methods and chemical conservation methods. However, these methods may not necessarily kill or eliminate all microorganisms, but they are often sufficient only to make environmental conditions unfavourable to microorganisms [1].
The most common natural methods used to conserve food are sterilization, pasteurization (thermal treatment), cooling and freezing (low-temperature preservation), drying (reducing water content), and conservation by radiation. In contrast, there are ways of chemical preservation, which depends on adding a specific chemical that inhibits microorganisms' growth and in the best conditions can be killed and known as compounds (preservatives) [2]. Due to environmental benefits and technological problems, such as the factors that are sensitive to the methods of manufacturing thermal polymers, as well as the extrusion and injection processes during molding, the integration of microbial agents in biological casings is very appropriate if these factors are integrated into a plastic wrap [1,3]. Most of the biochemical casings is edible, produced, and formed under cold conditions, including edible covers or so-called bio-encapsulates on cellulose, carrageenin, genes, kasines and whey proteins where microbial agents are combined [3].

One of the antimicrobial agents that can also be used in this type of packaging is green tea extract as it acts as an antioxidant. Various health benefits have been shown in green tea consumption. Scientific research has shown that the compounds in tea have anti-cancer, antimicrobial, and antiviral properties. Also, these compounds protect against heart disease and have anti-diabetic properties [4]. Moreover, the secret of the multiple benefits of green tea is due to the contents of its multiple sheets of phenols, the most important of which are the Flavoniods, specifically the catechins group, which makes up 90-80% of flavonoids and about 40% of the water-soluble solids that make it a substance. It has Oral Health Benefits [5]. This study aimed to develop the functional character and increase the possibility of preserving the foods that are coated with the edible proteins produced by the simple proteins and casinine casings by including the green tea extract as it plays an essential role in reducing the growth of fungi.

2. Materials and Methods

2.1. Green tea extracts preparation

Dried green tea leaves (Mahmood) brand was obtained from the domestic markets at Baghdad city, then pulverized using an electrical grinder. Tea leaves were then sieved using a sieve (100) to obtain a powdered green tea. The extraction procedure was attributed from [6]. The extraction procedure was done by preparing four types of mixture composed of water and ethyle alcohol (0:100), (75:25), (50:50), (25:75), and (alcohol: water), powdered tea was mixed with the aqueous solution in a conical flask size 500 ml ratio 10/100 weight/weight. The flask was then vibrated into a vibrator aquarium at 250 circles/minute at 60°C for 240 minutes. The extract was then filtrated using Whatman no:1 paper. After that, it was evaporated using a rotary evaporator to obtain a concentrated extract. Finally, the extract was dried oven at 50 °C for a one night to get a dried granule extract.

The hundred percent of the extract = (weight of the dried granule extracted / weight of the powdered green tea leaves)*100

(1)

2.2. Measuring the antimicrobial activity of green tea extract

The antimicrobial assay was carried out by utilized agar well [7], diffusion technique by adding 100μL of E. coli cell suspension (1×10⁷ cell/mL) on the nutrient agar and spread with a glass spreader and left for 10 min to dry, then 6mm wells were made and supplied with 50 μL of (0.0, 0.1, 0.2, 0.4, 0.6, 0.8) mg/mL of plant extracts were added and incubated for 24 h at 37 °C. The inhibition zone diameter was
calculated for duplicate. Minimum inhibitory concentration (MIC) for *E. coli* isolate was determined by serial dilution procedure. Ten sterile test tube supplemented with (10, 20, 40, 60, 80, 100) µg/mL of plant extracts inoculated with 100 µL of previous activated *E. coli*. All tubes were incubated at 37 °C for 24 h. The result was recorded depending on the turbidity (OD₄₅₀).

2.3. **Incorporating of green tea extract in whey protein isolate**

Casings solution was prepared according to [8], with some modifications as follows, 10 gm of the isolated whey protein was dissolved in a 100 ml distilled and nonionic water with solution stirring until the full dissolution using a hot plate magnetic motor for 30 minutes. The mix was then heated at 90 °C with a continuous stir. The solution was cooled at room temperature and then filtrated using medical gauze to avoid any coagulation or undissolved particles in the solution. pH was then modified to 7 using sodium hydroxide 1.5% gleserol was added to the solution, and mixed 5 minutes. Alcohol extract for the green tea was added to the prepared solution with various concentrations 1%, 2%, 3%, 4%, and 5%. The vacuum pump was used to remove the air bubbles in the casings solution for 10 minutes; the solution was maintained in the fridge to avoid oxidations.

2.4. **Casings forming**

Casings pretreatment was done according to [9]. The prepared solution was poured in discs 8.5 mm diameter per 8 gm per disc, it was then dried at 21 °C for 48 hours to produce isolated casings whey proteins. They were then maintained in spatula and green tea extract in polyethene plastics at 25 °C and 50 % RH until the tests' date, tissues were removed by the knife from the discs.

2.5. **Minimum inhibitory concentration**

Identifying the minimum inhibitory concentration for the study's casings was done according to the modified method of [10]. It used the green tea extract added to the isolated casings whey proteins as active material against the microbial organism. The test included a group of microbial organisms; the first group involved the *Bacillus Spp*, the second group was *salmonella spp*, and *Escherichia-coli* in addition to the *Candida-albicans*. Bacterial farms were grown at N.A medium and maintained at 4C, loop full bacterial grown at the previous medium was taken from the medium to activate the microbial organism. They were vaccinated in 100 ml nutrient broth medium for the bacterial and Potato's dextrose broth for the Candida-albicans. They were incubated at 37 C and 30 C consecutively until the required growth phase. After that, the vaccine's density was modified to fit Mcverland level 0.5 (CFU/108ml). The required casings samples were cut to discs 6 ml diameter and sterile using the ultraviolet for 10 minutes per side. The discs were poured at mouler hintor at 20 ml concentration per plate and vaccinated by a bacterial vaccine 0.1 ml incorporated CFU/108ml after dilution. Discs were added to the medium where each plate incorporated four discs, two of them are considered repetitive for the cover sample, the concentration of the green tea extract added to the casings were (1%, 2%, 3%, 4%, and 5%) to specify the minimum inhibitory concentration for the aforementioned microbial organisms. However, the other two discs were referenced samples for the casings without green tea extract. The plates were incubated at 37 C for 24 hours until the formation of the light-dark circles around the discs, the diameter of the dark circle was measure using the accurate digital
micrometer to 0.01 mm. The minimum inhibitory concentration is defined as the minimum concentration of the antibiotic inhibiting bacterial growth.

2.6. Antioxidant activity of casings

The antioxidant activity of the casings was assessed using (DPPH) (2, 2-diphenyl-1-picrylhydrazyl) according to [11]. The samples were pretreated by dissolving them in 10 ml from the previously prepared casings per 10 ml in a distilled and deionized water, as explained above. It was centrifuged for 10 minutes at 20 C at 10000g speed. A 0.2 ml of the suspended casings was mixed with 2 ml from 0.2mm from the ethanol solution Dissolved in DPPH. They were mixed using the vortex and left for 30 minutes in the darkness and then centrifuged at 8000g for 5 minutes. The photometry was measured using a spectrophotometer for the casings sample, and the reference control sample using 517-nanometer wavelength repeated three times, and the activity was evaluated according to the following equation

\[
\text{SCAVENGING ACTIVITY( S,A) } \% = \times 100
\]

\[
\frac{\text{ABS blank} - \text{ABS sample}}{\text{ABS blank}} \times 100
\]

S.A: Free radical throttle activity
ABS blank: Absorption value for alcohol solution DPPH on 517 wavelength
ABS sample: absorption value for the extracted sample on 517 wavelength

2.7. Fourier transform infrared spectroscopy (FTIR)

The Infrared spectrum for the casings supported by the extract was studied using FTIR, and the essential bands were recorded on a wide range of a wavelength 400 -4000 cm-1

2.8. Mechanical properties investigations

2.8.1 Oxygen permeability determination

Oxygen permeability was determined according to [12]. for the casings samples using Oxygen permeability Tester where the oxygen O2 was flowing for a specified ratio with Nitrogen gas N2 to mimic the composition of the atmosphere. Those gases were pushed under 20 J pressure on the casings to evaluate the gasses' permeability passing through the casings from the other side, and this procedure was done at 23 C and 50% relative humidity.

2.8.2 Water Vapor Permeability determination

The modified standard procedure for the American Society for the testing and Materials (ASTM E 96-95) was followed in this research, is entitled as the cups procedure as it was applied by [13]. The weighting methodology determined water Vapor Permeability; the cups used in this experiment were made locally using Teflon material with various diameters 3.4, 3.4, 4.5 (exterior, interior, depth),
respectively. The cup was filled with a dried material called calcium chloride (CaCl₂) until 0.6 cm from the cup's upper edge. The upper surface was lubricated with silicon fat, and the casings sample was cut circularly, similar to the diameter of the mouth cup to fit the mouth of the cup. It was fixed by an iron ring similar to the diameter of the cup (the exterior and the interior) to adhere to the surface's casings sample. A sensitive balance then weighed the cup to a nearest 0.001 gm. The cups were dried on a desiccator incorporated sodium chloride (NaCl) to achieve 75% relative humidity and then left 24 hours. After that, seven consecutive readings were taken per day for one week to observe the increase in weight. After drawing a logarithmic paper relationship between the increases in the cup weight during the experiment time, water vapour permeability was evaluated. A straight line was drawn indicated a steady state. The straight-line slope was evaluated by (gm/day) using the linear slope; the constant increase in the cup weight after achieving the steady-state was used in evaluating water vapour permeability.

\[
WVP = \frac{W}{t} \times (X \times \Delta P \times A)
\]

(3)

W/t= the volume of the water-permeable during the measured time according to the linear slope (R²0.99) through the weight recorded during seven days (g/day)
A= the area exposed to the permeation (cm²)
X= casings thickness (cm)
The partial pressure which is different according to casings and is evaluated according to the \( \Delta p = \)
following equation:

\[
\Delta P = S(R1 - R2)
\]

(4)

S= the pressure of the saturated vapor on 25 C (3166 KPa)
R1= the relative humidity for the glass drier evaluated using RH meter
R2= the relative humidity under the cup's casings (0% RH) estimated according to the relative humidity of the salt used.

2.8.3 Solubility in water determination

Solubility in water determination was done according to [14]. the casings were cut into small pieces and dried using an oven at 100 C until the constant is achieved, the initial dry weight was recorded to the fourth digit 0.0001 gm, the dried casings were then put in 100 ml of distilled water and gently stirred for 24 hours, the solution was filtrated using Whatman No.1 to restore the non-dissolved remaining casings, the left casings were dried at 100 C to record the initial dry weight. The hundred percent of the solubility was evaluated according to the following equation:

The solubility = \( \frac{\text{initial weight} - \text{final weight}}{\text{initial weight}} \times 100 \)

(5)

3. Results and Discussion

3.1. Preparing green tea extract

Four different extraction solutions were used to prepare the tea extract to see their efficiency for this purpose. The results obtained when extracting the dried leaves of green tea reflect the extraction percentages according to the extracts' different concentrations.
(75% alcoholic - 50% alcohol - 25% - aqueous 100%) amounted to 25.14%, 24%, 21.33%, 18.6% respectively. The results of the statistical analysis indicate that there are no significant differences in the 50% and 75% extraction ratio, and the higher percentage of alcoholic extract compared with aqueous extraction is due to the quality and quantity of phenolic compounds that dissolve alcohol higher than in water [15] (Table 1).

Table 1. The percentages of the types of extracts to the dry matter of green tea leaves

| Kinds of green tea extracts | Extraction ratio |
|-----------------------------|------------------|
| Alcoholic extract 75%       | 25.14            |
| Alcoholic extract 50%       | 24               |
| Alcoholic extract 25%       | 21.33            |
| 100% aqueous extract        | 18.6             |

3.2. Measurement of the inhibitory effect of green tea extracts on coliform bacteria

In order to choose the best extraction solution for green tea with the highest inhibitory effect on microorganisms from among the studied extraction solutions, which include (75% alcohol - 50% alcohol - 25% - 100% water), E.coli bacteria were chosen due to their being satisfactory and contaminated. For food, especially in unpasteurized dairy products (S.P.J, 2013), the results conducted on Gram-negative bacteria (E. coli) showed that all types of extracts have the ability to inhibit the growth of bacteria. Figure 1

![Figure 1](image)

**Figure 1.** Antimicrobial activity of the ethanolic extract of green tea at different extracted ratio A. (25:75 E: W), B. (50:50 E: W), C. (75:25 E: W) D (0:100 E: W) against *E. coli*
The inhibition is due to the phenolic compounds' presence, specifically the catechins that the extract contains[16]. Among the most important compounds that have efficacy against *E. coli* and some Gram-positive bacteria is the epigallocatechin gallate (EGCG) compound, whose role is to inhibit the function of the cytoplasmic membrane of the bacteria by stimulating the process of transporting particles. The reason for the increase in the diameter of the halos for the alcoholic extract compared with the aqueous extract may be due to the higher concentration of EGCG in the alcohol extraction than in the aqueous extract, which is due to the main role in effectiveness [17].

He results of the statistical analysis indicate that there are no significant differences in the 50% and 75% where Rate (75%, 50%) gave an inhibition aura of 24.6 and 24.2 mm in diameter, respectively, which is the highest value among the rest of the four types of extracts and Significant differences were observed between the 50% and 75% extraction rates and the rest of ratios. At the same time, the researcher mentioned that the diameter of the aura inhibition of *E. coli* bacteria was at a concentration of 15µl, 20µl (i.e., the assay concentration was 10µl (24 mm and 21 mm), respectively. In comparison, the inhibition halos' diameter for the alcoholic extracts reached 25%, and the aqueous extract was 11.5 and 22.8 mm, respectively. It is possible that the reason for this difference in the values of inhibition halos was due to the quality and quantity Phenolic compounds extracted with alcohol compared to water extracts [18, 15].

The alcoholic extract (50%) was chosen as the most appropriate solution due to its antimicrobiological effectiveness compared to the rest of the concentrations and because the colour of the resulting extract was acceptable after adding it to the casings.

| Kinds of green tea extracts | The diameter of areolas formed to inhibit the growth of *E. coli* (mm) |
|-----------------------------|-------------------------------------------------------------|
| Alcoholic extract 75%       | 24.6                                                        |
| Alcoholic extract 50%       | 24.2                                                        |
| Alcoholic extract 25%       | 22.8                                                        |
| 100% aqueous extract        | 11.5                                                        |

3.3. Determine the minimum concentration of inhibition

In this examination, the isolate casings of whey proteins was used to which the alcoholic extract of green tea was added in the ratio (50%) at a concentration of 1%, 2%, 3%, 4% and 5% of the volume of the membrane solution, where its effect on inhibiting the growth of a group of bacteria, some of which positive for the cream stain, was studied. And another negative for cram colour in addition to yeast. The results proved in Table 2 showed that adding green tea extract to the whey protein casings inhibited the growth of gram-positive and negative bacteria, and the reason for the inhibition was due to the phenolic compounds contained in the extract. [15], stated that tea catechins and Also flavonols, which are the predominant group of polyphenols in green tea leaves that have the anti-microbiological activity of aqueous and alcoholic tea extracts which include) Epicatechin (EC), epicatechin gallate (ECG), epigallocatechin (EGC), epigallocatechin gallate (EGCG) Against the positive and negative bacteria for the gram stain, and it was proven that the compound epigallocatechin gallate interferes with the bacterial outer membrane.

As the results of the statistical analysis showed that there are significant differences (P < 2) in percentage green tea extract at a concentration of 3% was the lowest concentration to inhibit the growth of all tested bacteria, as it reached the diameter of the aura of inhibition of *E. coli, Salmonella spp. Candida albicans, Bacillus spp.* (11 mm, 20 mm, 10 mm, 7 mm, and 14 mm) (Figure 2) respectively, and the addition of the extract at a concentration of 4% led to an increase in the diameter
of the visible halos, which was (17.8 mm, 16.1 mm, 19.3 mm, and 18.5 mm) respectively, and also led to the addition of the extract at a concentration of 5% to an increase in the diameter of the visible halos, which was (21.8 mm, 20.7 mm, 19.3 mm, 18.5 mm) respectively, and about the concentration of 2%, the halo of inhibition was (5.1 mm, 9.6 mm, 22.5 mm, 22.1 mm) respectively. Using a concentration of 1%, the aura of inhibition appeared only on *Bacillus* sp, reaching 13.5 mm. [19], that the diameters of inhibition of *Bacillus* sp and at a concentration of 4, 3% of green tea extract added to casings isolated from soybean proteins reached 6.8 mm for both of them, while there were no signs of inhibition of both *E.Coli* and *Salmonella*. Concentrations of 2.1% did not show any aura of inhibition of all types of bacteria.

Green tea extract's inhibitory efficacy lies in affecting the cell wall's functions and the cytoplasmic membrane[7]. It is likely that the difference in the sensitivity of bacteria among them is due to the difference in the structure of the cell wall, and that the outer membrane works to control the movement of substances entering and leaving, so there is no effect on the function of this The membrane leads to a defect in the entry of nutrients into the cell and thus inhibition of the bacteria (Table 3), and on this basis the effectiveness of the extract in inhibiting the growth of bacteria is determined [18].

**Table 3.** The effect of adding different concentrations of green tea extract to casings prepared from whey protein isolate in inhibiting some microorganisms.

| Type of bacteria      | Areola diameter (mm) | %1 | %2 | %3 | %4 | 5% |
|-----------------------|----------------------|----|----|----|----|----|
| *Escherichia coli*    |                      | N.Z| 5.1| 10.3|17.8|21.8|
| *Salmonella spp.*     |                      | N.Z| 9.6| 10.7|16.1|20.7|
| *Bacillus spp*        |                      | 13.5|14.9|16.6|19.3|22.5|
| *Candida albicans*    |                      | N.Z| 15.2|17.6|18.5|22.1|
| L.S.D                 |                      |    | 0  |4.2 | 2.6 | 6.7 |10.5|
3.4. Measurement of the antioxidant efficacy of casings

The evaluation of the antioxidant efficacy of the DPPH method indicates that the whey protein coatings alone without adding tea extract showed antioxidant efficacy and reached 25.6%. [20], indicated the activity of the whey proteins (α-lactalbumin and β-lactoglobulin). [21], reported that the antioxidant activity of the whey protein casings was 15%, and this activity increased from 25.6% to 55.23% as a result of adding the alcoholic extract (50%) of green tea at a concentration of 2% to the casings isolated from whey proteins, as shown Figure 3, by increasing the concentration of green tea to 3%, the antioxidant activity increased to reach 69.78%. Where the results of the statistical analysis showed significant differences and this is in agreement with the findings of [22], when studying the effect of adding green tea extract on the properties of polyamide casings, the antioxidant activity increased by increasing the concentration of green tea from 2.5 - 20% to 67.2 - 88.75%, respectively, as indicated by [23], for the high effectiveness of catching free radicals. When adding green tea extract to the casings of rice starch mixed with chitosan and increasing this effectiveness when increasing the concentration of the extract, and when assessing the effectiveness of the control model of BHA (synthetic), which is used in food with a concentration of (0.02%), the antioxidant activity was (30.24%), which reflects The casings to which the extract was added were superior in effectiveness.

The antioxidant activity is attributed to the content of green tea of phenolic compounds, especially the main ones such as (EC), (EGC), (EGCG), (GCG), (CG), (GC), (GCG), and (C) in addition to what it contains carotenoids, tocopherols, vitamin C and minerals such as chromium, manganese, selenium and zinc if the phenolic compounds inhibit free radicals based on the electron-giving groups and thus prevent the emergence of the radical chain and also because of the link with the catalysts of transition ions and then forming bonds with free radicals by interacting with them to inhibit the oxidation process Fats [23].

Figure 2. Inhibiting the growth of microorganisms by isolate casings of whey protein containing green tea extract against different microorganisms.
Figure 3. The values of the antioxidant efficacy of different membrane samples.

3.5. Infrared spectroscopy with a device FTIR

Using the FTIR device to know the active groups of the whey protein casings fortified with green tea extract as an active substance, the readings appeared in a clear crest as in Figure 4 and started from 3425.58 - 3024.38, which is due to the bonds of OH groups and free NH groups that form the active groups. In the films, then the frequencies 2704.20 - 2947.23 that refer to the CH sums, then the frequencies from 2400 - 1658.78, which refer to the vibrating sums of CO and CN and are likely to be subordinate to Amide I (Amide I), and the frequencies 1550.77 - 1446.61 that refer to sums NH, which is likely to be subordinate to Amide II (AmideII), while the frequencies from 1346.31 - 1226.7 refer to NH groups and are likely to be subordinate to Amide III (Amide III) 1188.15 - 817.82 This region represents the oscillation and curvature of the bonds of the CC groups. It is expected that It is dependent on the glycerol as for the rest of the groups below the frequency of 400 are not essential, and no organic compound is devoid of them [24,7].
Figure 4. The tops of the active groups shown by the infrared spectrum analyzer with a device FTIR.

3.6. Reservative properties

2.5.1 Casings permeability to oxygen

The permeability of casings to oxygen is one of the most important characteristics as it protects the permeability of oxygen to and from within the nutrient content [20]. It was found that the addition of green tea extract at the appropriate concentration of 3% to the casings of isolate whey proteins led to a decrease in the permeability of the casings. For oxygen when compared with the control membrane sample, which was without an extract, the permeability values of the whey protein casings for oxygen (control model) were 92.02 (ml / m² * day) and the permeability value of the extract-supported casings sample was 69.98 (ml / m² * day). The results are close to what the researcher indicated [26], where the permeability values of the crack proteins ranged from 76.1 (ml / m² * day) Figure 5. The reason for the decrease in permeability may be due to a change in the crystalline form of the polymer, while the presence of amorphous regions in the polymer network makes the gases diffuse quickly across the casings, so it is a reason for the increase in permeability and when adding the extract to an increase in the crystalline state of the casings, which gave it a more remarkable ability to trap gases and this decrease An influential role in the effectiveness of antioxidant agents, as their role is limited by the high cohesion of the membrane bonds and their limited movement, which reduces the movement of antioxidants, but the indirect role in reducing is through the amount of oxygen passing through and thus limiting oxidation processes, and the relative humidity has a role It also affects the effectiveness of antioxidants, as the low humidity reduces the oxygen permeability across the casings, thus reducing the process of fat oxidation, and here the influential role of the membrane against oxidation in reducing the oxygen permeability [25].
2.5.2 Casings permeability to water vapour

The process of measuring the water vapour permeability of casings is carried out because of its importance in food packaging processes and its effect on determining the storage life because it changes the organoleptic properties of food products in addition to creating a suitable environment for the growth of microorganisms, and because the enzymes that lead to food degradation work in an aqueous medium and for the process of forming casings, temperature and humidity. Ambient relativity affects membrane permeability [27].

The permeability of the crack proteins casings for the control model was 0.65 (g. Mm. / Hr. 0.2 MPa) while the permeability value of the membrane sample supported by the extract was 0.26 (g. Mm. / Hr. 2.2 MPa) as in Figure 6. This result is less than what was reported by [28], where the permeability value ranged between 3.1-15 (gm. Mm / hr 2. MicPascal) addition of green tea extract improved the membrane's retaining properties against water vapour. The reason for this decrease in the membrane permeability value to water vapour is the compact internal structure of the whey protein casings after interfering with green tea extract, which reduces the transport of water vapour through these protein films [31-33].
2.5.3 **Casings are soluble with water**

The results mentioned in Figure 7 show that the ability of the casings to solubility in water increased when the extract was added to the membrane, as the solubility of the casings of the whey proteins (control model) reached 43.4%, while the solubility of the casings to which the extract was added reached a concentration of 51.1%. And that these results are in excellent agreement with the results confirmed by [29], where they stated that the solubility values of protein sheath models reached 42.4% and this value increased with the addition of the supporting materials and this characteristic is due to an increase in the autoimmune when supplementing with the materials because of what the crack proteins possess from the ability to bind with chemical compounds and thus form soft structures that increase the solubility of casings in water [30,31].

![Figure 7. The values of the solubility of the films in the water of the casings to which the extract was added](image)

**4. Conclusion**

The whey protein isolate alone can be used in the manufacture of casings for the purpose of food packaging, and it is possible to reinforce the shrimp protein casings with biologically active materials and use them as natural food wrappers such as green tea, due to their nutritional value addition and ease of use, as the shrimp protein films fortified with alcoholic extract of green tea have been proven. Its ability to inhibit several microorganisms, in addition to its high antioxidant effectiveness, which makes it efficient for preservation purposes.

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