

Preservation Effect of Two-Stage Cinnamon Bark (*Cinnamomum Burmanii*) Oleoresin Microcapsules On Vacuum-Packed Ground Beef During Refrigerated Storage

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Abstract. The purpose of this study was to determine the effect of two stage cinnamon bark oleoresin microcapsules (0%, 0.5% and 1%) on the TPC (Total Plate Count), TBA (thiobarbituric acid), pH, and RGB color (Red, Green, and Blue) of vacuum-packed ground beef during refrigerated storage (at 0, 4, 8, 12, and 16 days). This study showed that the addition of two stage cinnamon bark oleoresin microcapsules affected the quality of vacuum-packed ground beef during 16 days of refrigerated storage. The results showed that the TPC value of the vacuum-packed ground beef sample with the addition 0.5% and 1% microcapsules was lower than the value of control sample. The TPC value of the control sample, sample with additional 0.5% and 1% microcapsules were 5.94; 5.46; and 5.16 log CFU/g respectively. The TBA value of vacuum-packed ground beef were 0.055; 0.041; and 0.044 mg malonaldehyde/kg, respectively on the 16th day of storage. The addition of two-stage cinnamon bark oleoresin microcapsules could inhibit the growth of microbia and decrease the oxidation process of vacuum-packed ground beef. Moreover, the change of vacuum-packed ground beef pH and RGB color with the addition 0.5% and 1% microcapsules were less than those of the control sample. The addition of 1% microcapsules showed the best effect in preserving the vacuum-packed ground beef.

1. Introduction

Beef is nutritious food. It contains 66 g of water, 18.8 g protein, 14 g fat, 11 mg calcium, 170 mg phosphorus, 2.8 mg iron, and 207 kcal of energy every 100 g [1]. Microbes can cause meat spoilage and decrease its shelf life. *E. coli* is one of microbe which often contaminates the beef [2]. Components of fat in beef can be oxidized on contact with oxygen [3]. This will influence the odor because of the oxidation process on unsaturated fatty acids. Sliced beef has a lower level of damage when compared with ground beef due to its larger surface area [4].

One compound that has the ability to act as an antimicrobial and antioxidant is cinnamaldehyde. Cinnamaldehyde is contained in cinnamon bark [5]. Natural antioxidant activity found in cinnamon extract [6]. Cinnamaldehyde at levels of 50 µl/ml can kill all microbial activity, while at the concentration of 0.78 to 12.5 µl/ml cynamaldehyde can inhibit the growth of microbes such as *Aeromonas hydrophila* and *Enterococcus faecalis* [7]. Cinnamon oleoresin can provide an antimicrobial effect against *Pseudomonas fluorescens* and *Pseudomonas putida* [8]. Cinnamaldehyde of cinnamon bark oleoresin (*Cinnamomum burmanii*) obtained by maceration, contains cinnamaldehyde extract amounting to 65.88% [9]. Oleoresin is sticky and highly concentrated, making difficult to apply to food [10]. Oleoresin also easily loses its constituent components, such as cinnamaldehyde compound that has



properties as an antioxidant and antimicrobial properties, so a microencapsulation process is needed. The changes of flavor in the cinnamon oleoresin (*Cinnamomum burmanii*) can be prevented by using the process of microencapsulation [11]. This process can improve the stability of the components of flavor, and make oleoresin into a powder to make it easier to apply to foodstuffs. Cinnamaldehyde in oleoresin microcapsules is equal to 47.95% [11]. It will be used as a preservative.

One method of packaging beef that can be used is vacuum packaging [12]. This packaging can maintain the quality of the beef for 14 days of storage [13]. Vacuum-packed also carried out ground beef with the addition of essential oil and hyssop over 15 days of storage [14]. So in this research the storage of ground beef will be continued for 16 days to discover how the quality of vacuum-packed ground beef is affected by the addition of two-stage cinnamon bark oleoresin microcapsules.

2. Methodology

2.1. Two-Stage Cinnamon Bark Oleoresin Preparation

Two-stage cinnamon bark oleoresin was made by preparation of cinnamon bark size reduction passes 30 mesh and detained 50 mesh. The cinnamon bark was obtained from Bubakan Village, Girimarto, Wonogiri. Cinnamon bark essential oil is produced by the steam distillation method for four hours, and the ratio of cinnamon powder and distilled water is 1: 4 [15]. Having obtained the oil, cinnamon powder residue is dried until it contains a maximum moisture content of 12% (SNI 01-3714-1995). And then, the residue was extracted with ethanol 70% with the ratio of cinnamon powder and ethanol 70% is 1 : 6 at 70-75°C for four hours extraction. This process was followed by evaporation using a rotary vacuum evaporator "IKA Coateng L11" at 80°C and 60 rpm [9]. Having obtained the essential oils and oleoresin cinnamon, both were then mixed together.

2.2. Microencapsulation Process

The microencapsulation process was implemented using a homogenizer "Ultra Turax® Basic® Woke" and followed by spray drying "SD-Basic Lab Plant". Materials that were prepared were distilled water, the coating material, and oleoresin. Then an emulsion was made with a ratio of coating material such as gum arabic and maltodextrin DE 10-12 (1: 3) to distilled water at 20:80. Then two-stage cinnamon bark oleoresin was mixed into the total suspension at 10%. The microencapsulation process was implemented with a spray dryer inlet temperature of 109°C and with a feed rate of 15 or 20 ml per minute [11].

2.3. Application of Two-Stage Cinnamon Bark Oleoresin Microcapsules.

Fresh ground beef was prepared by using a sterile blender (blender sprayed with 96% alcohol and dried). 50 g of ground beef was added with two-stage cinnamon bark oleoresin microcapsules at 0%; 0.5%; and 1%, then mixed together [16]. After that, the ground beef was vacuum-packed in a nylon pack and stored in a refrigerator. Over the next 16 days, TPC testing was conducted [17], as well as TBA [18], pH [19], and color (Lutron Electronic RGB-1002) on days-0,4,8,12, and 16.

3. Result and Discussion

3.1. TPC

Table 1. Analysis of TPC of Ground Beef with the addition of Two-Stage Cinnamon Bark Oleoresin Microcapsules During Refrigerated Storage ($4 \pm 1^{\circ}\text{C}$)

Micro-capsules	TPC (log CFU/g)				
	Day-0	Day-4	Day-8	Day-12	Day-16
0%	5.27 ^{Aa} ± 0.16	5.50 ^{ABa} ± 0.35	5.85 ^{Bb} ± 0.02	5.89 ^{Bc} ± 0.01	5.94 ^{Bb} ± 0.10
0.5%	5.26 ^{Aa} ± 0.30	5.26 ^{Aa} ± 0.05	5.28 ^{Aa} ± 0.14	5.30 ^{Ab} ± 0.00	5.46 ^{Aa} ± 0.00
1%	5.00 ^{Aa} ± 0.05	5.08 ^{Aa} ± 0.00	5.04 ^{Aa} ± 0.06	5.16 ^{Aa} ± 0.06	5.16 ^{Aa} ± 0.20

The figures with the same small superscript letters in the same column and large superscript letters in the same row show no significant difference at the 5% significance level.

TPC with the addition of two-stage cinnamon bark oleoresin microcapsules did not show a significant increase when compared to the control. Essential oil of cinnamon bark contains cinnamaldehyde as an antibacterial agent up to 92.84% [20]. It also contained cinnamon residue oleoresin with 12.22% cinnamaldehyde [21]. Cinnamon bark oleoresin microcapsules contains 60.5% cinnamaldehyde [11]. The blending process of the essential oils and oleoresin will provide two-stage cinnamon bark oleoresin with more cinnamaldehyde contents, which will have an inhibitory effect on the number of microbes. The TPC value on day 0 at concentrations of 0%; 0.5%; and 1% were 5.27; 5.26; and 5.00 log CFU/ g respectively. TPC value from this research was almost equal to the value of TPC on day 0 of the study by the other research in which a sample of ground beef TPC control value was 5.525 log CFU/g [22].

Until the 16th day of storage, all samples still had a TPC value below 6 log CFU/g. This is below the maximum standard TPC value. The TPC control sample was higher than the sample with addition two-stage cinnamon bark oleoresin microcapsules. It affects the value of TPC. Cinnamon bark oleoresin microcapsules contains essential oils and contains active compounds such as polyphenols, cinnamaldehyde and antibacterial compounds [23]. Cinnamaldehyde is the main active compounds in cinnamon and plays a role in the inhibition of microbial activity. Cinnamon bark essential oils contains 37.12% cinnamaldehyde and cinnamon bark oleoresin contains 12.22% cinnamaldehyde [15].

The active compound can inhibit the growth of pathogenic microbes or spoiled microbials. It can degrade the cell wall, damaging the cytoplasmic membrane, damaging cellular components, and causes coagulation and malfunction of microbial cells [24]. At low concentrations, cinnamaldehyde will inhibit the enzymes that work in cell cytokine interactions and functions of cells. At higher concentrations, cinnamaldehyde will act as an ATPase inhibitor, and at lethal concentrations, cinnamaldehyde will act to damage the cell membrane [25]. Active compounds in cinnamaldehyde can decrease the amount of ATP in intracellular microbes [26]. Cinnamaldehyde will increase the permeability of cell membranes and cause cytoplasm leaks [27]. The compound of cinnamaldehyde on the microcapsules will work to reduce the amount of ATP and increases the permeability of cell membranes [26,27].

Essential oils are known to have an inhibitory effect against gram positive and negative bacteria [28]. Cinnamon oil contains (*Cinnamomum zeylanicum*) which is 91.042% cinnamaldehyde [29]. Gram-positive bacteria are more sensitive to the essential oil of cinnamon [29]. Some of the oil molecules bind to membrane proteins and inhibit the synthesis of peptidoglycan, therefore the level of inhibition is increased.

3.2. TBA

Table 2. Analysis TBA Ground Beef with the addition Two-Stage Cinnamon Bark Oleoresin Microcapsules during Refrigerated Storage ($4 \pm 1^\circ\text{C}$)

Micro-capsules	TBA (mg malonaldehida/kg)				
	Day-0	Day-4	Day-8	Day-12	Day-16
0%	0.045 ^{Aa} \pm 0.006	0.050 ^{Ab} \pm 0.005	0.050 ^{Aa} \pm 0.008	0.051 ^{Aa} \pm 0.001	0.055 ^{Ab} \pm 0.003
0.5%	0.035 ^{Aa} \pm 0.003	0.037 ^{Aa} \pm 0.004	0.039 ^{Aa} \pm 0.000	0.040 ^{Aa} \pm 0.002	0.041 ^{Aa} \pm 0.005
1%	0.033 ^{Aa} \pm 0.000	0.036 ^{Aa} \pm 0.001	0.037 ^{Aa} \pm 0.004	0.039 ^{Aa} \pm 0.005	0.044 ^{Aa} \pm 0.000

The figures with the same small superscript letters in the same column and large superscript letters in the same row show no significant difference at the 5% significance level.

The higher concentration of two-stage cinnamon bark oleoresin microcapsules, will provide an inhibitory effect against oxidation. The addition of 1% microcapsules produce lower TBA values. Cinnamaldehyde as an antioxidant agent can inhibit oxidation reactions, thus rancidity in ground beef can be inhibited and the shelf life is longer. Antioxidants work by reducing the level of rancidity in material. Antioxidants will scavenge free radicals in the material that cause rancidity and act as chelating metals [30]. Two-stage cinnamon bark oleoresin microcapsules will give lower TBA values than the control sample. Cinnamaldehyde include phenolic components, which are phenolic primary antioxidants that prevent the formation of free radicals and turn them into more stable products [30].

The TBA acceptance limit value is equal to 2 mg/kg malonaldehyde. If the TBA values exceed these limits then the meat is not suitable for consumption because it is rancid [31]. TBA value of ground beef with the addition of two-stage cinnamon bark oleoresin microcapsules in this study showed the TBA value to be below 2 mg/kg for 16 days of storage. The beef was still considered safe for human consumption because the value was still below the limit TBA for consumption.

3.3. pH Value During Storage

Table 3. Ground Beef pH analysis with the addition of Two-Stage Cinnamon Bark Oleoresin Microcapsules during Refrigerated Storage ($4 \pm 1^{\circ}\text{C}$)

Micro-capsules	Ph				
	Day-0	Day-4	Day-8	Day-12	Day-16
0%	$5.5^{\text{Bc}} \pm 0.04$	$5.5^{\text{Bc}} \pm 0.00$	$5.5^{\text{Bb}} \pm 0.00$	$5.5^{\text{Ba}} \pm 0.04$	$5.2^{\text{Aa}} \pm 0.04$
0.5%	$5.4^{\text{Bb}} \pm 0.04$	$5.4^{\text{Bb}} \pm 0.00$	$5.5^{\text{Cb}} \pm 0.00$	$5.4^{\text{Ba}} \pm 0.07$	$5.1^{\text{Aa}} \pm 0.00$
1%	$5.3^{\text{Ba}} \pm 0.04$	$5.3^{\text{Ba}} \pm 0.00$	$5.4^{\text{Ba}} \pm 0.04$	$5.4^{\text{Ba}} \pm 0.04$	$5.2^{\text{Aa}} \pm 0.04$

The figures with the same small superscript letters in the same column and large superscript letters in the same row show no significant difference at the 5% significance level

Samples with addition of microcapsules have a lower pH value than the control. Maltodextrin made from cassava starch is supplemented with HCl to inactivate the α -amylase enzyme, which does not reverse the neutralization process, so maltodextrin has a low pH [32]. Maltodextrin has a pH of 4.3 for 6.5 to 7.9 DE [32]. From these results, it may be possible that greater addition of two-stage cinnamon bark oleoresin microcapsules will produce a lower pH. The manufacture of maltodextrin with a DE of 17% and 17.4% gives 5 for pH values [33]. If the pH value is low, it would affect the levels of acidity of ground beef. In this study, the pH value of maltodextrin is 4.08, wherein the pH value is quite low.

The pH value of the control samples decreased from 5.5 to 5.2 on the first day and 16th day of storage. The pH value of the samples with 0.5% microcapsules addition decreased from 5.4 to 5.1 from the first day to the 16th day. The pH value of the sample with addition of 1% microcapsules decreased from 5.3 to 5.2 from the first day to the 16th day. The decrease in the pH value of a control sample of ground beef, adding 0.5%, and 1% microcapsules were 0.3; 0.3; and 0.1 respectively. The decrease in the pH value of the sample with additional 0.5% and 1% was lower than the control sample. The addition of 1% microcapsules was more effective because of the higher content of cinnamaldehyde. This is an antibacterial agent that will inhibit the growth of gram-positive bacteria such as *Staphylococcus aureus*, *Bacillus cereus*, *E. faecalis*, and *Micrococcus luteus*. The bacteria include lactic acid bacteria in which there is a zone of inhibition of the bacterial activity [7]. It is possible for this compound to inhibit the activity of lactic acid bacteria on meat. So in this study, the addition of 1% microcapsules was found to inhibit the rate of decrease in the pH value due to the activity of lactic acid bacteria.

In the earlier days of storage, there was an increase in the pH value of the sample to which two-stage cinnamon bark oleoresin microcapsules had been added. Samples with addition of 0.5% microcapsules increased from 5.4 to 5.5 on day 8 and sample with addition of 1% microcapsules increased from 5.3 to 5.4 on the eighth day. This is possible due to the growth of bacteria that produce more alkaline metabolites in the samples [34].

3.4. Color Change During Storage

The value of R increasingly rise during storage. This compares to a pH value of meat that still has a low pH value, where low pH values give a bright red meat color [35]. This can be seen from the pH value that is proportional to the TPC. A Higher value of TPC and a lower pH value increase the number of microbes (lactic acid bacteria) growing on ground beef during storage. Fresh beef contains myoglobin pigment which can change color to bright red when a process of oxygenation occurs, and this makes the pigment oksimyoglobin, and vice versa. If the meat is oxygenated for longer, then the color will change to brown or make the metmyoglobin pigment. Brown beef can turn back to red-purple or bright red with oxygen reduction [35].

Table 4. Color analysis (RGB) of Ground Beef with the addition of Two-Stage Cinnamon Bark Oleoresin Microcapsules during Refrigerated Storage ($4 \pm 1^{\circ}\text{C}$)

	Microcapsules	Day-0	Day-4	Day-8	Day-12	Day-16
R	0%	240.8 ^{Aa} \pm 0.4	228.5 ^{Aa} \pm 12.7	242.5 ^{Aa} \pm 1.4	291.0 ^{Ca} \pm 6.4	273.0 ^{Bb} \pm 6.4
	0.5%	225.3 ^{Aa} \pm 3.9	247.0 ^{ABa} \pm 17.0	261.8 ^{BCb} \pm 5.3	287.5 ^{Ca} \pm 15.6	255.8 ^{Bb} \pm 7.4
	1%	229.0 ^{Aa} \pm 7.1	244.3 ^{Aa} \pm 1.1	265.5 ^{Bb} \pm 7.8	279.5 ^{Ba} \pm 13.4	230.8 ^{Aa} \pm 5.3
G	0%	124.0 ^{ABb} \pm 0.0	113.0 ^{Aa} \pm 5.7	131.5 ^{Ba} \pm 9.2	163.5 ^{Ca} \pm 10.6	153.5 ^{Cb} \pm 13.4
	0.5%	116.5 ^{Aa} \pm 0.7	128.5 ^{ABa} \pm 10.6	137.5 ^{Ba} \pm 2.1	166.5 ^{Da} \pm 0.7	151.0 ^{Cb} \pm 0.0
	1%	115.0 ^{Aa} \pm 1.4	128.0 ^{ABa} \pm 9.9	145.0 ^{Ca} \pm 4.2	146.5 ^{Ca} \pm 7.8	136.0 ^{BCa} \pm 4.2
B	0%	104.0 ^{Ab} \pm 1.4	99.8 ^{Aa} \pm 6.7	112.0 ^{ABa} \pm 7.8	135.5 ^{Ca} \pm 10.6	128.0 ^{BCa} \pm 10.3
	0.5%	95.5 ^{Aa} \pm 0.7	106.0 ^{ABa} \pm 7.8	112.8 ^{Ba} \pm 3.9	135.3 ^{Ca} \pm 0.4	126.0 ^{Ca} \pm 2.8
	1%	94.3 ^{Aa} \pm 1.1	108.0 ^{Ba} \pm 9.2	120.8 ^{Ca} \pm 2.5	121.0 ^{Ca} \pm 3.5	112.8 ^{BCa} \pm 3.1

The figures with the same small superscript letters in the same column and large superscript letters in the same row show no significant difference at the 5% significance level

All the samples had decreased R value. It is possible, because the response of the environmental conditions are different on ground beef against humidity, room temperature, and light intensity. For example the oxidation of myoglobin decrease red color of ground beef. The decrease of red color is influenced by the texture of the meat, water content, pigments, and activators enzyme that play a role in the formation and degradation of the color of the meat [36]. The control samples tended to have a higher R value when compared with the sample with the added microcapsules. A Higher concentration (0.5% and 1%) give smaller color changes of the meat when viewed from R day 0 to day 16 (difference value R), which means that the color of the meat can be maintained. This is comparable to the TBA value of ground beef, where the value of TBA is lower with the addition of 1% two-stage cinnamon bark oleoresin microcapsules. Contact with oxygen can be inhibited due to the presence of cinnamaldehyde compounds and here is a reduced color change with the addition of two-stage cinnamon bark oleoresin microcapsules. When the packaging is opened, the beef will be in direct contact with oxygen and will have a bright red color. Flesh color will change to a bright red when the meat is exposed to air and a myoglobin oxygenation reaction occurs, forming bright right oksimyoglobin [36].

The value of G (greenness) indicated ground beef metmyoglobin color at a wavelength of 555 nm (the green part of meat color) [37]. On the inside of myoglobin in the meat, green or violet dark colors will increase during storage. The appearance of green or yellow green in the flesh indicates damage to fresh meat. A greenish color can also be caused due to the activity of bacteria in ground beef [38]. A greenish color is comparable to the value of the TPC of ground beef during storage which increases.

Cinnamon bark oleoresin microcapsules affects the quality of the G color in ground beef. The change of green color value of ground beef with the addition of microcapsules is lower than the control sample. This is possible because the active compounds in two-stage cinnamon bark oleoresin microcapsules can inhibit the reduction of myoglobin in meat during storage. So the green color as an indicator of spoiled meat can be inhibited by the addition of microcapsule [38].

Longer storage will give higher G value. There are a correlation with blue color formation and the activity of bacterial. It is possible for yellow color pigments to form during the storage. The yellow color is formed because of the marbling fat content in beef [36]. The yellowness increases with the length of storage time.

Two-stage cinnamon bark oleoresin microcapsule affects the quality of the beef color. The higher of the concentration, the lower of the discoloration of the meat compared to a control sample. The content of the active compounds in two-stage cinnamon bark oleoresin microcapsules will inhibit the reduction of myoglobin in the meat [37], depending on the length of storage.

4. Conclusion

The addition of two-stage cinnamon bark oleoresin microcapsules at concentration of 0.5% and 1% affects the value of TPC, TBA, pH, and the color of ground beef during low temperature storage. It can also inhibit the growth of microbes (TPC) and inhibit the process of fat oxidation (TBA) when compared with control samples. The addition of two-stage cinnamon bark oleoresin microcapsules at concentration

of 0.5% and 1% can minimize the changes in pH value and reduce the increase of the color value (R, G, and B) when compared with control samples.

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