Cassava starch-chitosan-sorghum micro-fibrillated cellulose biocomposite wrapping film to prevent COVID-19 outspread

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Abstract. To prevent virus spreading, the corpse or the coffin of COVID-19 patients need to be wrapped in plastic. Low-density polyethylene (LDPE), a crude oil-based wrapping plastic, is difficult to decompose in nature after use. In this study, biocomposite wrapping film was developed from cassava starch and chitosan, with the addition of sorghum Micro-Fibrillated Cellulose (MFC) by levels of 1%, 2%, 3%, 4% and 5%. Cassava starch (raw starch) was modified by acetic anhydride to produce acetylated cassava starch (acetylated starch) which is less hydrophilic thus enhance the compounding ability with LDPE. The sorghum MFC was obtained from sorghum fibers after following processes: soda pulping, bleaching and fibrillation with a super grinder. The addition of 1% sorghum MFC into raw starch-chitosan increased the tensile strength and modulus of elasticity by 33% and 17%, respectively. On the other hand, the addition of 2% sorghum MFC into acetylated starch-chitosan increased the elongation by 38%. Wrapping film needs to have good elongation ability so that it can be stretched during application. Based on elongation characteristic, acetylated cassava starch-chitosan with addition of 2% sorghum MFC can be developed to be a candidate for biocomposite wrapping film to prevent COVID-19 outspread.

1. Introduction
The COVID-19 pandemic situation is still in an alarming stage. On June 11, 2021, data from the Indonesia Ministry of Health stated that 1,894,025 people have been confirmed positive for COVID-19 (accumulated) with 106,315 people as active cases and the death reaching 52,566 people [1]. The spread of COVID-19 occurs very quickly, through droplets of positive COVID-19 patients. Even the COVID-19 patient corpse still has potential to spread the virus through fluids that come out of the corpse [2]. According to Dr. Otto Yang, a professor in the Department of Medicine and the Department of Microbiology, Immunology and Molecular Genetics at UCLA's David Geffen School of Medicine, the COVID-19 is still present in the...
respiratory secretions of recently deceased patients and potentially still reproducing in lungs cells of the corpse [3]. Forensic & Medic legal Specialist at dr. Moewardi RSUD, dr. Novianto Adi Nugroho, explained that the corona virus can indeed survive for several hours in the corpse of COVID-19 deceased patients [4]. Thus, workers who handle the corpse of COVID-19 deceased patients must be equipped with complete Personal Protective Equipment (PPE), including clothing, glasses, gloves, mask and head coverings.

The Jakarta Health Office through Circular Number 55/SE/Year 2020 concerning the handling of COVID-19 patient corpse, stated that the standard body bag as a container for the COVID-19 patient corpse must meet the following requirements: a thick plastic that is impermeable to water and does not leak. After the body bag is sealed, the outside of the body bag is immediately disinfected to kill viruses. The corpse of COVID-19 patients should not be removed from the body bag and must be buried together with it. The Indonesian Ministry of Health has issued guidelines for handling the COVID-19 patient corpse [5] as follows: (1) the corpse is disinfected using a disinfectant solution, (2) cover all corpse holes, and scars with waterproof plaster, (3) put the corpse into a body bag that is not translucent, (4) disinfect the outside of the body bag and the room, (5) the corpse is put in a wooden coffin, tightly closed the coffin using silicone glue, then wrapped in plastic and disinfected before entering the hearse.

Currently, based on BNPB (National Disaster Management Agency) standards, body bags are made using materials namely anti-bacterial PVC tarpaulin with a thickness of 0.50 mm and a weight of 500 gm². Unfortunately, this type of body bag is difficult to decompose in the soil because its long carbon chain makes it difficult for microorganisms to break down. In addition to the use of body bags, wrapping plastic can be applied to wrap the corpse for optimizing security [6,7], so thus to wrap the coffin. Commercial wrapping plastics are made of LDPE sourced from crude oil that is also non-biodegradable. Thus, the development of bioplastics to wrap corpses or coffins becomes urgent need.

Starch, which is a natural polymer containing amylose and amylopectin, has been used as a raw material for bioplastics film. However, the disadvantages of using starch as a raw material for bioplastics film are that the resulting bioplastic film is easily soluble in water, susceptible to high temperatures and has a rigid (inflexible) structure [8,9]. The hydroxyl groups in the amylose and amylopectin chains make starch very easy to bind to water so it is susceptible to moisture and easily soluble. Chemical modification by means of acetylation, which is replacing the hydroxyl group with an acetyl group, is a way to reduce the hydrophilic nature of starch [10]. The other way to overcome limitation of starch-based bioplastic is by using chitosan as a combination of ingredients in the formulation, because it is more hydrophobic with additional antimicrobial properties [11,12]. Cellulose in form of nano crystalline [13,14] or micro-fibrillated [15,16] has been utilized as reinforcement in starch-based film. The aim of this study was to investigate the effect of sorghum MFC addition on the mechanical and thermal properties of cassava starch-chitosan based biocomposite film.
2. Materials and Methods

2.1. Materials

The materials used in this study were commercial cassava starch (brand: Gunung Agung), acetic acid glacial and acetate anhydride obtained from Merck (used without further purification) and distilled water for starch modification. Sorghum fibers (*Sorghum bicolor* (L.) Moench var Lepeng) were obtained from the experimental field at LIPI Cibinong Science Center. Technical grade sodium hydroxide and sodium chlorite (25% in solution) from Merck were used for sorghum fibers pulping and bleaching process, respectively. Industrial grade shrimp chitosan was purchased from PT Biotech Surindo.

2.2. Modification of cassava starch

Modification of cassava starch was carried out by reacting 75 g cassava starch into 135 mL acetic acid glacial solution and 138 mL acetic anhydride in beaker glass, then stirred and heated it on a hot plate stirrer until temperature reached 40°C. Thereafter, 12.45 mL acetic acid glacial and 1.05 mL of concentrated sulfuric acid as a catalyst were added to the solution, and then the reaction was continued for 120 min at room temperature. The acetylation reaction was conducted in fume hood. At the end of reaction, cold distilled water (50 mL) was added gently to precipitate acetylated starch. Acid solution was removed by filtering with filter paper. Acetylated starch was then oven-dried at 80°C for 2 h. After drying, the acetylated starch was mashed and sieved with 80 mesh sieve.

2.3. Production of sorghum micro-fibrillated cellulose (sorghum MFC)

Sorghum stalks were processed in drum chipper and ring flaker to obtain sorghum fiber. The sorghum fiber (600 g) was then reacted with 10% (w/v) NaOH (10 L) in the digester at a temperature of 100°C, for 2 h. When the reaction has finished and the digester temperature has dropped, the sorghum pulp and black liquor were removed from the digester. The pulp was then rinsed under running water until there is no residual NaOH for further bleaching process.

The pulp sample from the previous process was then added with 4.8 L of distilled water, followed by adding 120 mL of 25% sodium chlorite (NaClO$_2$) and 10 mL of 100% glacial acetic acid. The sample was heated in the digester for 3 h, at a temperature of 80°C. After reaction completed, the bleached pulp of sorghum was washed with running water to remove residual bleaching solution.

Sorghum bleached pulp (1 wt%) in 2 L distilled water was processed by Masuko Super Fine Grinder in three steps of fibrillation which were: with gap 3 (5 cycles), followed by fibrillation with gap 5 (5 cycles) and fibrillation with gap 7 (3 cycles).

2.4. Production of biocomposite film from cassava starch-chitosan filled with sorghum MFC

Chitosan, 50% of the dry weight of starch (Table 1) was dissolved in 180 mL acetic acid glacial (2%) at 70°C for 3 h. Process was conducted in a water bath and stirred at a constant speed of 250 rpm. Afterward, unmodified cassava starch (namely raw starch) or acetylated cassava starch (namely acetylated starch) was added and dissolved by continuing stirring and heating at 70°C for 1 h, until starch was gelatinized and looks like a clear gel. After starch solution was gelatinized, glycerol plasticizer, 10% of the starch and chitosan dry weight was added and stirred again until homogeneous for 15 min at the same speed and temperature. Finally, sorghum MFC was added at level of 1%, 2%, 3%, 4% and 5%, and stirred again until homogeneous for 15 min with the same speed and temperature.

The mixture solution was then poured into a mould (flexi glass) with dimension of 20 cm × 20 cm and a thickness of ±5 mm. The mixture solution was spread evenly on the surface of flexy glass. The solution was then cooled to room temperature for ±3 days, until it forms a film sheet (bioplastic). The bioplastic film was removed from the mould using tweezers for further characterization.
Table 1. Biocomposite film formulation.

| Code | Chitosan (g) | Starch (g) | Sorghum MFC (g) |
|------|-------------|------------|-----------------|
| 1    | 1.833       | 3.667      | 0.000           |
| 2    | 1.815       | 3.630      | 0.055           |
| 3    | 1.797       | 3.593      | 0.110           |
| 4    | 1.778       | 3.557      | 0.165           |
| 5    | 1.760       | 3.520      | 0.220           |
| 6    | 1.742       | 3.483      | 0.275           |

2.5. Analysis of biocomposite film characteristics

2.5.1. Evaluation of biocomposite film mechanical properties. Tensile strength test was carried out accordance with ASTM-882-75b “Tensile Properties of Thin Plastics Sheeting”. Samples were cut in sizes of 2.5×10 cm. Tensile strength was measured with Universal Testing Machine (UTM) Shimadzu AGS-X 10kN with speed testing of 1 mm/min. The test results were observed after sampling for 4 times.

2.5.2. Evaluations of biocomposite film thermal properties. The thermal properties test was performed using the Differential Scanning Calorymeter (DSC) 4000 Pyris Perkin Elmer. As much as 5 mg biocomposite film was placed in an aluminium pan. Afterward, the sample was placed in the combustion chamber which has been flowed with nitrogen gas at a speed of 20 mL/min. The method used was heating from -20 to 300°C with a heating speed of 5°C/min.

3. Results and Discussion

3.1. Mechanical properties of biocomposite film
The mechanical strength of starch-based biocomposite films needs to be measured for evaluating their ability as corpse or coffin wrappers. The measured mechanical properties were tensile strength, elongation at break and Modulus of Elasticity (MOE). The manufacture of biocomposite films in this study used 10% glycerol. According to Larotonda et al. [17], the use of glycerol as much as 10% produces a starch-based film with higher tensile strength than without glycerol or with the use of glycerol as much as 5% or 20%. Figure 1 shows the tensile strength and elongation of a starch and chitosan-based biocomposite film with the addition of sorghum MFC at levels of 1%, 2%, 3%, 4% and 5%. In general, the tensile strength of raw starch-chitosan based biocomposite films, which ranged from 16.18 to 21.46 MPa, was higher than that of acetylated starch-chitosan based biocomposite films (5.16 to 12.45 MPa). This biocomposite film tensile strength of this study was higher than that of research results by Mina et al. [18], which reported that the tensile strength of natural cassava starch-based films was 1.418 MPa while the tensile strength of acetylated cassava starch-based films was 0.747 MPa. The addition of chitosan and sorghum MFC was proven to increase the tensile strength of biocomposite films.
Figure 1. Tensile strength (a) and elongation (b) of biocomposite film made from cassava starch-chitosan and sorghum MFC with level of 1%, 2%, 3%, 4%, 5%.

The interesting result of this study was that the tensile strength of film made from raw cassava starch increased by introducing sorghum MFC. Meanwhile, the strength decreased for the films made from acetylated cassava starch (Figure 1a). The addition of 1% sorghum MFC into the raw cassava starch-chitosan solution could increase the tensile strength of the film by 33%. Meanwhile, the addition of 1% sorghum MFC into acetylated cassava starch-chitosan solution resulted in a reduction of the film tensile strength to -39%. Sorghum MFC in biocomposite films made from raw starch-chitosan still appears to be in the form of fairly long fibrils, so that it can act as a reinforcement in biocomposites (Figure 2a). Meanwhile, the decrease of acetylated cassava starch-chitosan film tensile strength could be caused by the morphology of sorghum MFC. When sorghum MFC was dispersed in acetylated cassava starch-chitosan solution, it was hydrolyzed into short fibers which can no longer act as a reinforcement in film-based biocomposites as shown in Figure 2b.

Figure 2. Morphology of biocomposite film, made from raw starch-chitosan (a) or acetylated starch-chitosan (b) and 1% sorghum MFC (magnification 1000x, observed by Keyence Digital Microscopy).

The elongation of acetylated cassava starch-chitosan film was higher than that of raw cassava starch-chitosan film. The biocomposite film elongation in this study was higher than of the research results reported by Mina et al [18], which states that the elongation of natural cassava starch-based films was 0.261 mm/mm, while the elongation of acetylated cassava starch-based films was 0.457 mm/mm. In this study, the elongation of raw cassava starch-chitosan based biocomposite films, which ranged from 2.70 to 7.26%, was lower (Figure 1b), when compared to acetylated cassava starch-chitosan based biocomposite films (10.01...
to 22.28%). Elongation relates to the ability of a molecule to stretch without breaking its bonds. The presence of acetyl groups weakens the bonds between starch molecules [19]. Thus, acetylated starch has higher swelling and solubility capabilities than raw starch. Therefore, glycerol molecules can play a greater role in the plasticization process of acetylated starch compared to raw starch. Films made from acetylated starch-chitosan with the addition of 2% sorghum MFC showed the highest elongation value (22.28%) or increase by 38% of acetylated starch-chitosan film without sorghum MFC addition. The glycerol molecules and sorghum MFC were optimally interacted in acetylated cassava starch-chitosan solution at 2% sorghum MFC content. On the other hand, the introduction of more than 2% sorghum MFC can trigger agglomeration that caused the reduction in the elongation of acetylated starch-chitosan film.

The mechanical properties of starch-based films are strongly influenced by temperature and moisture content of the material which relates to the phenomenon of gelatinization and retrogradation of starch [18]. The presence of amylose or amorphous molecular structure causes the retrogradation ability of starch. Retrogradation is the re-formation of hydrogen bonds from amylose molecules which are linked back together by very strong bonds. The structure of raw starch is more amorphous than of the acetylated starch structure.

The MOE of the raw cassava starch-chitosan film was much higher (Figure 3), ranging from 1.06 to 1.65 GPa, compared to the MOE of the acetylated cassava starch-chitosan film (0.05 to 0.40 GPa). The MOE indicates the stiffness of the material, the ability to withstand loads while maintaining its structure. During the heating process, when mixing starch-chitosan and sorghum MFC, the raw cassava starch experienced a retrogradation phenomenon that was more pronounced than in acetylated cassava starch. As a result, the film of raw cassava starch-chitosan was stiffer than the film of acetylated cassava starch-chitosan.

![Figure 3. Modulus of elongation of biocomposite film made from starch-chitosan and sorghum MFC with level of 1%, 2%, 3%, 4%, 5%.](image)

The addition of 1% sorghum MFC has increased the MOE value of the raw cassava starch-chitosan film by 17%. However, the more addition of sorghum MFC can no longer increase the MOE value of the film. Even in acetylated cassava starch-chitosan based films, the addition of sorghum MFC decreased the MOE value of the film. Due to the presence of heat and acetic acid during film making, the amorphous portion of the cellulose in the sorghum MFC will be reduced and causes the sorghum MFC to become more crystalline. The addition of the sorghum MFC into the acetylated cassava starch-chitosan solution prevented the movement of starch molecules. The retrogradation was then inhibited and resulted a film with a low MOE value.
3.2. Thermal properties of biocomposite film

Differential Scanning Calorimetry (DSC) is a technique used to investigate the response of polymers to heating. DSC can be used to study the melting of a crystalline polymer or the glass transition ($T_g$). Because starch consists of an amorphous (amylose) and a crystalline (amylopectin) region, the exact $T_g$ is difficult to be detected. Determination of the gelatinization characteristics of acetylated cassava starch by analysis using DSC involves onset temperature ($T_o$), peak temperature ($T_p$), conclusion temperature ($T_c$), difference between $T_c$ and $T_o$, and enthalpy of fusion. The onset temperature is the temperature at which the viscosity of the starch solution begins to increase. Peak temperature is the temperature at which the starch is gelatinized ($T_p=T_g$). While the conclusion temperature is the final temperature when the maximum viscosity is reached. The $T_c-T_o$ is a comparative measure in which an increase in this value indicates a high amount of granule modification in the amorphous and crystalline regions [20, 21]. In this study, acetylated cassava starch gelatinization temperature was detected at 58.63°C (Table 2). In general, raw cassava starch gelatinization temperature was at 68°C and gelatinization temperature of acetylated cassava starch with degree of substitution = 0.5 and 1.5 were 61°C and 51°C, respectively [22]. The difference of gelatinization temperature between raw cassava starch and acetylated cassava starch was in agreement with the difference gelatinization enthalpy. Degree of Substitution (DS) of acetylated cassava starch is the average number of acetyl groups attached per monomeric unit of starch. The higher DS means more acetyl groups attached to starch monomer to substitute its hydroxyl groups. Energy to break acetyl groups was lower than to break hydroxyl groups. Therefore, enthalpy of gelatinization of acetylated cassava starch was lower than of raw cassava starch [22].

In this study, the DSC curve of chitosan shows an endothermic peak at 67.70°C. According to Guinesi et al [23], the DSC curves of commercial purified chitosan with degree acetylation of 15.9% shows an endothermic peak at 70°C that can be associated with the loss of water. Chitosan requires quite high energy to evaporate water from its surface (Figure 4), which was 267.07 Jg$^{-1}$ (Table 2). Most of water molecules will be bound to chitosan hydroxyl groups instead of amino groups (Figure 5). Since, the hydrogen bonds with the hydroxyl groups of chitosan are stronger than the ones with the amino groups, one could be expected that a higher temperature would be necessary to remove such water molecules.

| Code   | $T_o$ (°C) | $T_g$ (°C) | $\Delta H_g$ (J/g) | $T_c$ (°C) |
|--------|------------|------------|-------------------|------------|
| A      | did not analyzed | 17.46 | 58.63 | 80.62 | 108.21 |
| Acetylated cassava starch B | 17.46 | 58.63 | 80.62 | 108.21 |
| Chitosan Chi | 21.90 | 67.70 | 267.07 | 101.23 |
| Acetylated starch+chitosan (2:1) film | 1.26 | 28.73 | 185.76 | 59.38 |
| Raw starch+chit+ sorghum MFC 1% A2 | 9.79 | 49.17 | 343.39 | 100.01 |
| Raw starch+chit+ sorghum MFC 3% A4 | 9.97 | 50.85 | 277.11 | 135.72 |
| Raw starch+chit+ sorghum MFC 5% A6 | 13.09 | 58.75 | 240.55 | 129.57 |
| Acetylated starch+chit+ sorghum MFC 1% B2 | 10.88 | 55.31 | 255.23 | 136.69 |
| Acetylated starch+chit+ sorghum MFC 3% B4 | 11.37 | 50.65 | 330.60 | 110.78 |
| Acetylated starch+chit+ sorghum MFC 5% B6 | 11.92 | 72.64 | 268.84 | 117.86 |

Table 2. Thermal properties of biocomposite film.
Figure 4. Differential Scanning Calorimetry thermogram of acetylated cassava starch, chitosan, film made from acetylated starch+chitosan (2:1).

There is a difference in the structure between chitosan and acetylated cassava starch. Chitosan contains amino groups and hydroxyl groups, while acetylated cassava starch contains acetyl groups and hydroxyl groups (Figure 5). When acetylated cassava starch and chitosan are mixed to make a biocomposite film, the energy required to evaporate water from film surface decreased to 185.76 Jg⁻¹.

Figure 5. Structure of chitosan (a) [24] and acetylated cassava starch (b) [25].

DSC result of raw cassava starch-chitosan-sorghum MFC and acetylated cassava starch-chitosan-sorghum MFC biocomposite films can be seen in Figure 6. The $T_o$ and $T_g$ temperature of raw starch-chitosan based biocomposite film were higher with the addition of sorghum MFC, thus the enthalpy ($\Delta H$) was also affected by sorghum MFC addition (Table 2). This shift to higher temperature for gelatinization indicated that raw cassava starch-chitosan based biocomposite film, gelatinized hardly with the addition of sorghum MFC. This finding is in agreement with study reported by Karimi et al. [15] and Silviana et al. [26]. In the case of raw cassava starch-chitosan based biocomposite film with addition of sorghum MFC 5%, a significant decreasing of heat of gelatinization ($\Delta H_g$) was observed, and it could be ascribed to a reduction of cellulose crystallite size. The heat of gelatinization ($\Delta H_g$) as calculated from the area under the peak for all samples (Table 2). The $\Delta H_g$ values decreased by increasing the fiber content in raw cassava starch-chitosan based biocomposite films. These results are representative of films crystallinity reduction in accordance with amorphous cellulose content.
Figure 6. Differential scanning calorimetry thermogram of biocomposite film, made from cassava starch-chitosan (a) or acetylated cassava starch-chitosan (b) with addition of sorghum MFC.

The $T_o$, $T_g$ temperature and the enthalpy ($\Delta H$) of acetylated cassava starch-chitosan based biocomposite film were higher with the addition 3% sorghum MFC, compared with the addition of 1% sorghum MFC (Table 2). This higher enthalpy of fusion for gelatinization indicated that acetylated cassava starch-chitosan based gelatinized hardly with the addition of 3% sorghum MFC. The $\Delta H_g$ values increased by increasing the fiber content from 1 to 3%. However, the $\Delta H_g$ values decreased when 5% sorghum MFC was added into acetylated cassava starch-chitosan based biocomposite film. These results are representative of changes in the crystallinity of biocomposite films caused by the interaction between acetylated cassava starch crystallites and amorphous cellulose. The acetylated cassava starch-chitosan biocomposite film with the addition of 3% sorghum MFC showed the highest crystallinity compared to other biocomposite films in this study.

3.3. The requirements on biocomposite film for corpse or coffin wrapping

The plastic wrapping film for corpse or coffins of COVID-19 patients requires characteristics which are impermeable to water and does not leak but can be decomposed in the soil to prevent pollution. Plastic wrapping film needs to have good elongation ability so that it can be stretched during application as a wrapper. The results of this research proved that acetylated starch, when added with chitosan and 2% sorghum MFC, was able to produce biocomposite films with an elongation of 22.28%, tensile strength of 6.23 MPa and MOE of 50 MPa. The MOE value indicates the stiffness of a material, so even though the MOE value of the biocomposite film is quite low, it does not become a necessity in films for applications as wrappers. Therefore, based on research results, biocomposite film made from acetylated cassava starch-chitosan with addition of 2% sorghum MFC can be developed to be a candidate as a wrapping film to prevent COVID-19 outspreading.

4. Conclusion

The requirements of wrapping plastic for the COVID-19 corpse or coffin are stretchable, water-resistant (no liquid leakage) and biodegradable. This research is a preliminary study on the development of cassava starch-based biocomposite films for wrapping the corpses or coffin COVID-19 patients.

The addition of sorghum MFC as much as 1% into raw cassava starch-chitosan increased the tensile strength and modulus of elasticity of the biocomposite film by 33% and 17%, respectively. On the other hand, the addition of 2% sorghum MFC into acetylated cassava starch-chitosan increased biocomposite film elongation by 38%. The gelatinization process of raw cassava starch-chitosan was easier with the addition of 1% sorghum MFC, than of 3% or 5% sorghum MFC.
Further research is needed to evaluate the properties of biocomposite films water resistance, crystallinity and biodegradation properties, to prove the potential use of cassava starch-chitosan-sorghum MFC-based biocomposite films for wrapping the corpse or coffin COVID-19 patient.

References
[1] Komite Penanganan COVID-19 dan Pemulihan Ekonomi Nasional 2021 Situasi COVID-19 di Indonesia https://covid19.go.id/p/berita/data-vaksinasi-covid-19-update-11-juni-2021
[2] Dijkstraen L G M, Gelderman H T, and Duijst W L J M 2020 Review: The safe handling of a corpse (suspected) with COVID-19 J. Forensic Leg. Med. 73 101999
[3] Nissa R S I and Anggraeni S P 2020 https://www.suara.com/health/2020/04/17/122430/peneliti-duga-tubuh-jenazah-corona-covid-19-masih-bisa-tularkan-virus?page=all
[4] Adhi I S 2020 https://health.kompas.com/read/2020/04/14/175900568/kunci-penularan-virus-corona-dari-jenazah-pasien-covid-19?page=all
[5] Putra R S 2020 Pedoman pemulsaran dan penguburan jenazah akitub covid-19 di masyarakat https://promkes.kemkes.go.id/download/enjn/files547914May_Guidebook%20Jenazah_Kemenkes.pdf
[6] Khoo L S, Lai P S, Saidin M H, Noor Z, and Mahmood M S 2018 Cling film plastic wrap: An innovation for dead body packaging, preservation, and transportation by first responders as a replacement for cadaver body bag in large scale disasters Forensic Sci. Int. 285 50-7
[7] Khoo L S and Mahmood M S 2020 Durability of cling film plastic wrap usage on dead body towards human decomposition changes Forensic Sci. Int.: Synergy 2 72-75
[8] Jiang T, Duan Q, Zhu J, Liu H, and Yu L 2019 Starch-based biodegradable materials: challenges and opportunities Adv. Ind. Eng. Polym. Res. 3 8-18
[9] Gadhave R V, Das A, Mahanwar P A, and Gadekar P T 2018 Starch Based Bio-Plastics: The Future of Sustainable Packaging Open J. Polym. Chem. 8 21-33
[10] Schmidt V C R, Blanco-Pascual N, Tribuzi G, and Laurindo J B 2019 Effect of the degree of acetylation, plasticizer concentration and relative humidity on cassava starch films properties Food Sci. Technol. 39 2 491-99
[11] Cacique P P, Mirella N M R, Barbosa I O, and Wentz A P 2017 Bioplastics production from starch and chitosan blends Perspectivas da Ciência e Tecnologia 9
[12] Luchese C L, Pavoni J M F, Zagonel dos Santos N, Quines L K, Pollo L D, Spada J C, and Tessaro I C 2018 Effect of chitosan addition on the properties of films prepared with corn and cassava starches J. Food Sci. Technol. 55(8) 2963-73
[13] Alves J S, dos Reis K C, Menezes E G T, Pereira P V, and Pereira J 2015 Effect of cellulose nanocrystals and gelatin in corn starch plasticized film Carbohydr. Polym. 115 215-22
[14] Nasution H, Harahap H, Al Fath M T, and Afandy Y 2018 Physical properties of sago starch biocomposite filled with Nanocrystalline Cellulose (NCC) from rattan biomass: the effect of filler loading and co-plasticizer addition IOP Conf. Series: Materials Science and Engineering 309 012033
[15] Karimi S, Dufresne A, Tahir PM, Karimi A, and Abdulkhani A 2014 Biodegradable starch-based composites: effect of micro and nano reinforcements on composite properties J. Mater. Sci. 49 4513-21
[16] Lendvai L, Karger-Kocsis J, Kmetty A, and Drakopoulos S X 2016 Production and characterization of microfibrillated cellulose-reinforced thermoplastic starch composites J. Appl. Polym. Sci.
[17] Larotonda F D S, Matsui K N, Soldi V, and Laurindo J B 2004 Biodegradable films made from raw and acetylated cassava starch Braz. Arch. Biol. Technol. 47(3) 477-84
Acknowledgments
The authors would like to thank Indonesia Endowment Fund for Education and the Indonesia Ministry of Research and Technology for research funding through the COVID 19 research and innovation consortium program with contract number 50/F1/P-KCOVID-19.2B3/IX/2020. The authors also acknowledge the facilities, scientific and technical support from Advanced Characterization Laboratories Cibinong – Integrated Laboratory of Bioproduct, Indonesian Institute of Sciences through E- Layanan Sains Lembaga Ilmu Pengetahuan Indonesia (LIPI).