Effect of Combining Microbial Cellulose Pulp from Nata de Tomato with Tomato Powder on Paper Qualities

D Sugiarto¹, K C Wanta¹ and Y I P A Miryanti¹

¹Department of Chemical Engineering, Faculty of Industrial Technology, Parahyangan Catholic University, Bandung, INDONESIA.

E–mail: kcwanta@unpar.ac.id

Abstract. Tomato is a fruit that does not last long (perishable), so it is necessary to find another alternative to increase its economic value. One of those alternatives that can be done is by making a fermented product called nata de tomato. Nata de tomato contains microbial cellulose which is formed by the bacteria Acetobacter xylinum. This microbial cellulose has some advantages over the typical cellulose found in common plants. Thus, it potentially could be further developed in the papermaking. This research was conducted to study the effects of combining microbial cellulose pulp from nata de tomato with tomato powder on paper quality, such as water content, grammage and water absorbency. In this research, the tomato filtrate was used as a growth medium for Acetobacter xylinum to produce nata de tomato. Then, nata de tomato was shredded into pulp, while its waste was dried into tomato powder and used as additional material for the pulp. This research was designed using a single factor experiment with variation in the addition of tomato powder by 0, 1, 3 and 5 % (w/w). The effects of this variation observed using variance analysis and significant test using the LSD (Least Significant Difference) method.

1. Introduction

Tomato is one of the species of fruit that has the Lycopersicum genus and ranks second after potatoes that are interested in the public for consumption[1]. Tomato commonly consumed because it has a lot of benefits and vitamin sources. At first, other than as fresh fruit that can be consumed directly, tomatoes are only used as food and cooking spices. At present, the use of tomatoes has been more developed, such as for flavoring various kinds of dishes and also as industrial materials to be consumed in processed form, such as tomato juice drinks.

However, tomato is a fruit that does not last long (perishable) because it contains much water. So it is necessary to find another alternative in its use to increase its economic value, such as by making a fermented product called nata de tomato[2]. This nata product contains fiber, known as microbial cellulose. Microbial cellulose has several advantages compared to cellulose found in woody plants, which has a better structure, has a degradation ability and has a high level of purity because it does not contain lignin, pectin or hemicellulose. These are the reasons that make nata de tomato products have the potential to be developed further, such as for papermaking[3].

The increasing demand for paper products also increases the need of cellulose which generally comes from woody plants. Other sources of cellulose are needed in order not to increase deforestation rates. Utilization of microbial cellulose is an alternative to overcome weaknesses in the use of cellulose from woody plants in paper production. The use of microbial cellulose in the papermaking
does not require the addition of hazardous chemicals that can damage the environment. Besides, the paper products made by microbial cellulose are more easily degraded, so that it will be more eco-friendly. Through this research, it hoped that paper product can be produced with the same quality as a paper product from woody plants and better productivity can be obtained[4].

2. Research Methods
The materials used in this research include tomatoes, Acetobacter xylinum, nitrogen sources such as ammonium sulfate (ZA fertilizer), acetic acid (25% vinegar) as an acid regulator and carbon sources such as white sugar. The tools used in this research include a blender, calico as a filter, stainless pan, stoves, stirrer, plastic container and tray dryer. This research consists of three steps, the raw materials preparation, the preliminary step and the main step of research.

The raw materials preparation step was done by washing and cutting tomatoes, smoothing the tomatoes using a blender and filtering using calico to separate the filtrates and the residues. In the preliminary step, nata de tomato and the tomato powder were made. Nata de tomato was made by cooking the tomato filtrates obtained from the raw materials preparation step by the addition of 0.005% (w/v) ZA fertilizer, 0.025% (w/v) white sugar and 0.01% (v/v) of 25% vinegar. Furthermore, the filtrate was put into a plastic container covered with sterile newspaper and given the Acetobacter xylinum as much as 0.2% (v/v) after the filtrate was cooled down. This fermentation was carried out for eight days at room temperature.

Tomato powder was made by drying the residues obtained from the raw materials preparation step using a tray dryer at a temperature of 60°C then smoothed with a blender and filtered out with a -80 mesh size. Tomato powder was stored using an aluminum ziplock bag in the refrigerator. In the main step of research, the paper was made from nata de tomato by shredded its cellulose into a pulp using a blender and then filtered out to reduce its water content. Tomato powder produced in the preliminary step was added to the pulp by 0, 1, 3 and 5% (w/w). Furthermore, the pulp will be mold into sheets and dried using a tray dryer at a temperature of 60°C.

Quality analysis conducted on paper products includes water content, grammage and water absorbency. The water content of paper products was analyzed using a moisture analyzer. Paper grammage was calculated by weighing the mass of paper per unit area. Water absorbency of paper products was analyzed by wetting the surface of the paper per time unit and then weighing.

3. Result and Discussion
The paper produced in this research is presented in Figure 1. This research can be said to be successful because physically, the main run and the duplo run produce the same characteristic, which can be seen from the color and texture. The addition of tomato powder affects the physical paper. The more addition of tomato powder into microbial cellulose pulp will darken the paper color and enhance its surface roughness. This phenomenon is according to the aim of tomato powder addition, which is to give color for paper products.

Figure 1. Paper Product (a) Without Tomato Powder Addition (b) Addition of 1% (w/w) Tomato Powder (c) Addition of 3% (w/w) Tomato Powder (d) Addition of 5% (w/w) Tomato Powder
Figure 2 presents the appearance of paper products through a microscope with a magnification of 40×. The figure shows paper that produced without the addition of tomato powder has a denser fiber structure than the paper that produced with the addition of tomato powder. The more addition of tomato powder into microbial cellulose pulp, the higher the strain that occurs between fiber bonds. It can be evidenced by the microscope light that can penetrate the paper products.

![Figure 2. Paper Products with a magnification of 40×](image)

Table 1 shows the result of this research on the value of water content, grammage and water absorbency of paper products with the addition of tomato powder by 0, 1, 3 and 5% (w/w). It can be used as a multifunctional paper which in SNI 6601-2011 has a water content between 3.5-6.5%. This paper product can also be used as an art paper that has a grammage between 100-150 g/m². Art paper can be used to print magazines, brochures, or certain documents. Overall, the water absorbency of paper produced in this study is lower than the water absorbency on standard wrap paper, which is 119.73 g/m². This results show that paper produced by microbial cellulose from nata de tomato has a high resistance to water penetration [5].

![Table 1. Effect of Tomato Powder Addition to Paper Quality](table)

3.1. Water Content
Water content analysis obtained from this research ranged from 4.65-6.505% where these paper products can be used as a multifunctional paper, which in SNI 6601-2-11 has a water content between 3.5-6.5%. Tomato powder addition into microbial cellulose pulp produced paper with higher water content. The increase of water content can occur because paper products without the addition of tomato powder have denser fibers so that the number of free OH- groups becomes less and its water content becomes lower [5]. The results obtained from the water content analysis of the paper products are shown in Figure 3.
Calculations using the single factor experimental design presented in Table 2, which provide the conclusion that the addition of tomato powder affects the paper quality.

| Table 2. Experimental Design Calculation for Water Content |
|---------------------------------|---|---|---|---|---|
|                   | SS   | DOF | MS  | Fo  | Fo, table | Conclusion |
| Treatment         | 3,468138 | 3   | 1,156046 | 147,5019 | > 6,59 | affects |
| Error             | 0,03135   | 4   | 0,007837   |          |        |         |
| Totals            | 3,499487   | 7   |          |        |        |         |

3.2. Grammage

Paper grammage analysis obtained from this research ranged between 97,892-132,761 g/m². This paper product can be used as an art paper that has a grammage between 100-150 g/m². Art paper can be used to print magazines, brochures and certain documents. The more addition of tomato powder into microbial cellulose pulp, the higher the grammage of paper products. The increase of paper grammage can occur because the tomato powder addition will accumulate and increase its weight. The results obtained from the grammage analysis of the paper products are shown in Figure 4.
To determine the effect of tomato powder addition on paper grammage, the analysis was done using a single factor experimental design. Based on the calculation presented in Table 3, it can be concluded that the addition of tomato powder into microbial cellulose pulp affects the paper grammage.

### Table 3. Experimental Design Calculation for Paper Grammage

|          | SS    | DOF | MS    | Fo   | Fo, table | Conclusion |
|----------|-------|-----|-------|------|-----------|------------|
| Treatment| 1265,667 | 3   | 421,889 | 35,59518 | > 6,59    | affects    |
| Error    | 47,40968 | 4   | 11,85242 |       |           |            |
| Totals   | 1313,077 | 7   |        |       |           |            |

#### 3.3. Water Absorbency

Water absorbency analysis was conducted to study the ability of paper products to absorb water. The result of water absorbency analysis in this research ranged from 38,091-78,475 g/m². This result lower than the water absorbency of standard wrap paper, which is 119,73 g/m². This shows that paper produced from microbial cellulose has a fairly high resistance to water penetration [4].

The addition of tomato powder into microbial cellulose pulp affects the increase in water absorbency of paper products. The increase of water absorbency can occur because tomato powder is a solid material that cannot absorb water and it can reduce the effectiveness of bonds between fibers in the paper. As a result, there are many air cavities in the contact area between fibers so that water absorbency by paper products can be more easily happen [4]. The results obtained from the water absorbency analysis of the paper products are shown in Figure 5.

![Figure 5. Effect of Addition of Tomato Powder to Water Absorbency](image)

Calculations using a single factor experimental design presented in Table 4 shows that the addition of tomato powder into microbial cellulose pulp affects the water absorbency of paper products.

### Table 4. Experimental Design Calculation for Water Absorbency

|          | SS    | DOF | MS        | Fo        | Fo, table | Conclusion |
|----------|-------|-----|-----------|-----------|-----------|------------|
| Treatment| 1665,287 | 3   | 555,0957  | 41,99843  | > 6,59    | affects    |
| Error    | 52,86823 | 4   | 13,21706  |           |           |            |
| Totals   | 1718,155 | 7   |           |           |           |            |
4. Conclusions
Multifunctional paper and art paper can be made by microbial cellulose pulp from nata de tomato which is formed by the bacteria *Acetobacter xylinum*. The addition of tomato powder into microbial cellulose pulp has a significant effect marked by the increase of water content, grammage and water absorbency of paper products.

References
[1] Pracaya, I. (2009). *Bertanam Tomat*: Kanisius.
[2] Gould, W. A. (1992). CHAPTER 1 – Introduction & History of the Tomato Industry. In W. A. Gould (Ed.), *Tomato Production, Processing and Technology* (pp. 3-17): Woodhead Publishing.
[3] Darmansyah. (2010). Evaluasi Sifat Fisik dan Sifat Mekanik Material Komposit Serat/Resin Berbahan Dasar Serat Nata de Coco dengan Penambahan Nanofilter. Tesis Fakultas Teknik. Universitas Indonesia, Depok.
[4] Syamsu, K., Haditjaroko, L., Pradikta, G. I., and Roliadi, H. (2014). Campuran Pulp Tandan Kosong Kelapa Sawit dan Selulosa Mikrobial Nata de Cassava dalam Pembuatan Kertas. *Jurnal Ilmu Pertanian Indonesia, 19*(1), 14-21.
[5] Syamsu, K., Pespitasari, R., and Roliadi, H. (2012). Penggunaan Selulosa Mikrobial dari Nata de Cassava dan Sabut Kelapa sebagai Pensubstitusi Kayu dalam Pembuatan Kertas. *Jurnal Agro Industri Indonesia, 1*(2).