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# Carotenoid and Moisture Stability of Red Fruit (*Pandanus conoideus*) Oil Powder during Storage

**Desak Putu Ariska Pradnya Dewi[1*], William[1], Samantha Tanardi[1], Katherine[2], Muhammad Abdurrahman Mas[1], Iwan Surjawan[1]**
[1]Department of Food Technology, School of Life Sciences, Indonesia International Institute for Life Sciences, Jakarta 13210, Indonesia
[2]Department of Biotechnology, School of Life Sciences, Indonesia International Institute for Life Sciences, Jakarta 13210, Indonesia

## ABSTRACT

The aim of this study was to evaluate the carotenoid and moisture stability of spray-dried and freeze-dried red fruit oil with different wall materials during storage. Red fruit emulsion was prepared by mixing sodium caseinate, maltodextrin and whey protein isolate in different ratios (1:0 (MW1), 3:1 (MW2), 1:3 (MW3) and 0:1 (MW4)), water, and red fruit oil followed by spray or freeze drying. The result showed that the carotenoid content of all samples was stable, but the moisture content changed during storage. Freeze-dried samples showed higher carotenoid and moisture content compared to spray-dried samples throughout the storage.

**Keywords**: carotenoid, maltodextrin, red fruit oil, spray and freeze drying, whey protein isolate

## INTRODUCTION

Red fruit oil is known to be a potential natural food colorant due to its high carotenoid content. However, the oil form limits its application in aqueous systems, so modification into a powder can still be an attempt. The modification process can be done by spray drying and freeze drying. Spray drying is a continuous system with low cost. Meanwhile, freeze drying is suitable for thermosensitive material (Šeregelj *et al.* 2020). During the process, the choice of wall material is critical. Maltodextrin (MD) has good solubility and protects against oxidation, while Whey Protein Isolate (WPI) has high diffusivity, which promotes uniform distribution during encapsulation (Mohammed *et al.* 2020). Natural colorants tend to be less stable during storage due to their sensitivity to light, oxygen, and heat, resulting in quality degradation. Therefore, it is essential to determine the stability of the carotenoid and moisture content during storage prior to incorporating the powder into a product.

## METHODS

An emulsion was prepared by mixing sodium caseinate (NaCas) and wall materials in water, followed by the addition of oil (Table 1). The emulsion was Spray Dried (SD) at 150°C inlet temperature, 80–100°C outlet temperature, 45 Hz air fan speed, 250 Hz atomization, and 50 ml/min flow rate. For the freeze drying process, an emulsion was Freeze Dried (FD) for 24.5 hours, followed by grinding and sieving. Samples were stored in an aluminum pouch with moisture absorber at room temperature. Carotenoid and moisture contents were measured weekly for 4 weeks. The carotenoid content was measured according to the method Mas *et al.* (2023). The moisture content was measured using a rapid moisture analyzer. All measurements were performed in triplicate.

The data was analyzed using IBM SPSS Statistics. The effects of storage and treatment were analyzed using repeated measures ANOVA with Bonferroni test and one-way ANOVA with Tukey's HSD post hoc test, respectively.

## RESULTS AND DISCUSSION

### Carotenoid stability

The initial carotenoid content of FD and SD samples was 1,685.5–2,106.5 and 594.4–2,003.9 ppm, respectively (Table 2). During storage, the carotenoid content tended to fluctuate with

*Corresponding Author: tel: +6285234001027, email: desak.dewi@i3l.ac.id
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decreasing trend (except FD MW4), which could be attributed to the relatively short storage period in order to see the trend. Despite the changes, the effect was not significant (p>0.05), indicating that all treatments could protect the carotenoid content during 4 weeks of storage. FD samples resulted in higher carotenoid content than SD samples. A combination of stable emulsion and low processing temperature preserved carotenoid content during freeze drying. Spray drying used atomization and high temperature, resulting in fine material with high surface area and thus susceptible to degradation (Šeregelj *et al.* 2020). Carotenoid content of FD and SD samples was significantly affected by formulation (p<0.05). The lowest and highest carotenoid content was obtained from SD MW1 and FD MW3, respectively. Šeregelj *et al.* (2020) reported that maltodextrin had poor encapsulation, while a combination of protein and carbohydrate resulted in better protection.

**Moisture stability**

The moisture content of FD samples was stable during storage (p>0.05) (Table 3). In addition, the initial moisture content of FD samples was relatively high (3.93–6.00%), which could potentially absorb less moisture. The high moisture content could be caused by insufficient time for secondary drying, which is important for desorption of removed bound water (Vilas *et al.* 2020). The moisture content of SD MW2 and MW4 increased significantly while MW1 decreased significantly during storage (p≤0.05). Spray dried MW2 and MW4 had the lowest initial moisture content, which caused the powder to absorb more moisture during storage (Fwernandes *et al.* 2013). The contact between liquid spray and hot air accelerated the water removal.

Table 1. Formula of freeze and spray dried red fruit oil

| Formula | MD: WPI | MD (g) | WPI (g) | NaCas (g) | Oil (g) | Water (g) |
|---|---|---|---|---|---|---|
| MW1 | 1:0 | 200 | 0 | 20 | 100 | 680 |
| MW2 | 3:1 | 150 | 50 | 20 | 100 | 680 |
| MW3 | 1:3 | 50 | 150 | 20 | 100 | 680 |
| MW4 | 0:1 | 0 | 200 | 20 | 100 | 680 |

MW1 (1:0); MW2 (3:1); MW3 (1:3); MW4 (0:1); MD: Maltodextrin; WPI: Whey Protein Isolate

Table 2. Carotenoid content (in ppm) of red fruit oil powder*

| Method | Formulation | W0 | W1 | W2 | W3 | W4 |
|---|---|---|---|---|---|---|
| Freeze drying | MW1 | 2,089.8±299.5$^{aBC}$ | 1,876.9±118.6$^{aB}$ | 1,932.9±22.6$^{aCD}$ | 1,774.1±33.5$^{aBC}$ | 1,981.1±4.9$^{aE}$ |
| | MW2 | 1,685.5±53.2$^{aBC}$ | 1,689.5±24.0$^{aB}$ | 1,700.5±43.3$^{aBC}$ | 1,783.2±22.5$^{aBC}$ | 1,656.9±10.8$^{aC}$ |
| | MW3 | 2,106.5±6.9$^{aC}$ | 2,086.6±191.2$^{aB}$ | 2,153.6±22.6$^{aD}$ | 2,212.2±160.4$^{aE}$ | 2,088.5±25.5$^{aF}$ |
| | MW4 | 2,081.1±59.4$^{aC}$ | 2,263.0±240.8$^{aB}$ | 2,076.8±22.8$^{aCD}$ | 2,046.2±34.1$^{aDE}$ | 2,281.9±15.8$^{aG}$ |
| Spray drying | MW1 | 594.4±137.2$^{aA}$ | 768.9±216.1$^{aA}$ | 796.9±301.9$^{aA}$ | 1,238.3±13.7$^{aA}$ | 518.2±28.5$^{aA}$ |
| | MW2 | 1,511.1± 240.4$^{aB}$ | 1,567.7±496.9$^{aB}$ | 1,548.2±129.7$^{aB}$ | 1,343.8±193.8$^{aA}$ | 1,126.9±64.6$^{aB}$ |
| | MW3 | 1,795.6±156.1$^{aBC}$ | 1,861.9±132.3$^{aB}$ | 1,710.9±47.7$^{aBC}$ | 1,617.2±13.7$^{aB}$ | 1,683.6±18.6$^{aC}$ |
| | MW4 | 2,003.9±240.3$^{aBC}$ | 2,035.1±431.0$^{aB}$ | 1,390.6±172.8$^{aB}$ | 1,910.8±11.5$^{aCD}$ | 1,772.1±22.2$^{aD}$ |

*Different lowercase and uppercase letters indicate significant differences in storage time (row) and treatment (column), respectively (p<0.05)

MW1 (1:0); MW2 (3:1); MW3 (1:3); MW4 (0:1)

Table 3. Moisture content (%) of red fruit oil powder*

| Method | Formulation | W0 | W1 | W2 | W3 | W4 |
|---|---|---|---|---|---|---|
| Freeze drying | MW1 | $5.22 \pm 0.11^{aD}$ | $5.33 \pm 0.02^{aE}$ | $5.25 \pm 0.03^{aE}$ | $5.5 \pm 0.06^{aE}$ | $5.38 \pm 0.12^{aD}$ |
| | MW2 | $6.00 \pm 0.12^{aE}$ | $5.96 \pm 0.09^{aF}$ | $5.85 \pm 0.06^{aF}$ | $5.92 \pm 0.15^{aF}$ | $6.07 \pm 0.17^{aE}$ |
| | MW3 | $3.93 \pm 0.05^{aC}$ | $4.07 \pm 0.04^{aC}$ | $4.03 \pm 0.04^{aC}$ | $4.06 \pm 0.1^{aC}$ | $4.10 \pm 0.06^{aC}$ |
| | MW4 | $4.03 \pm 0.07^{aC}$ | $4.33 \pm 0.04^{aD}$ | $4.31 \pm 0.02^{aD}$ | $4.34 \pm 0.02^{aD}$ | $4.18 \pm 0.23^{aC}$ |
| Spray drying | MW1 | $3.34 \pm 0.14^{aB}$ | $3.12 \pm 0.02^{abB}$ | $3.05 \pm 0.08^{acA}$ | $2.94 \pm 0.10^{cdA}$ | $3.04 \pm 0.03^{adA}$ |
| | MW2 | $2.72 \pm 0.08^{aA}$ | $3.25 \pm 0.05^{abB}$ | $2.99 \pm 0.06^{abA}$ | $3.82 \pm 0.13^{bC}$ | $3.55 \pm 0.10^{bB}$ |
| | MW3 | $3.10 \pm 0.19^{aB}$ | $2.83 \pm 0.11^{aA}$ | $2.90 \pm 0.08^{aA}$ | $3.02 \pm 0.07^{aA}$ | $3.00 \pm 0.06^{aA}$ |
| | MW4 | $2.72 \pm 0.10^{aA}$ | $3.26 \pm 0.15^{abB}$ | $3.41 \pm 0.13^{abB}$ | $3.36 \pm 0.01^{abB}$ | $3.23 \pm 0.06^{bAB}$ |

*Different lowercase and uppercase letters indicate significant differences in storage time (row) and treatment (column), respectively ($p<0.05$)
MW1 (1:0); MW2 (3:1); MW3 (1:3); MW4 (0:1)

## CONCLUSION

All formulations processed by both spray and freeze drying showed stable carotenoid content during storage. Freeze dried samples showed higher carotenoid and moisture content compared to spray dried samples. In further studies, the storage period can be extended and color measurement can be performed to ensure the stability of the colorant.


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## DECLARATION OF CONFLICT OF INTERESTS

The authors have no conflicts of interest to declare.

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