ความคงตัวของแกมมาโอรีซานอลในน้ำมันรำข้าวที่ผ่านกระบวนการเอนแคปซูเลชันด้วยวิธีสเปรย์ดราย
The Stability of Gamma-Oryzanol in Encapsulated Rice Bran Oil Powder Using a Spray Dryer

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บทคัดย่อ

น้ำมันรำข้าว เป็นน้ำมันพืชที่ประกอบไปด้วยสารพฤกษเคมี เช่น โทโคฟีรอล โทโคไตรอีนอล ไฟโตสเตอรอล และแกมมาโอรีซานอล อย่างไรก็ตาม แม้ว่าน้ำมันรำข้าวมีสารพฤกษเคมีสูงแต่ยังคงมีกรดไขมันไม่อิ่มตัวที่ส่งผลต่อการเกิดปฏิกิริยาออกซิเดชัน กระบวนเอนแคปซูเลชันโดยวิธีทำแห้งแบบพ่นฝอยเป็นกระบวนการหนึ่งที่ทำให้ผลิตภัณฑ์อยู่ในรูปแบบของผงมีความคงตัวเพื่อช่วยป้องกันหรือลดการเกิดปฏิกิริยาออกซิเดชัน และรักษาสารพฤกษเคมี วัตถุประสงค์ของงานวิจัยนี้เพื่อวิเคราะห์ความคงตัวของแกมมาโอรีซานอลในน้ำมันรำข้าวที่ผ่านกระบวนการเอนแคปซูเลชันด้วยวิธีทำแห้งแบบพ่นฝอยสูตรส่วนผสมที่นำมาใช้ในกระบวน การเอนแคปซูเลชันด้วยวิธีสเปรย์ดรายที่ใช้อัตราการไหล 2.5 ml/min และอุณหภูมิเข้า (Inlet temperature) 160 °C ได้แก่ 1)อัตราส่วนของส่วนผสมสารเคลือบระหว่างโซเดียมเคซีนเนต และมอลโตเด็กซ์ตริน ที่ 1:3 1:4 และ 1:5 (w/w) 2) อัตราส่วนระหว่างส่วนผสมสารเคลือบกับน้ำมันรำข้าว ที่ 2:1 1:1 และ 1:2 (w/w) และ 3) ความเข้มข้นอิมัลชันของส่วนผสมทั้งหมดต่อน้ำ ที่ 20 25 และ 30% (w/w) ผลการทดลอง พบว่า สูตรที่เหมาะสมในการรักษาความคงตัวของแกมมาโอรีซานอลในน้ำมันรำข้าว โดยกระบวนการเอนแคปซูลชันด้วยวิธีทำแห้งแบบพ่นฝอยคือ อัตราส่วนของส่วนผสมสารเคลือบระหว่างโซเดียมเคซีนเนต และมอลโตเด็กซ์ตริน ที่ 1:3 อัตราส่วนระหว่างส่วนผสมสารเคลือบกับน้ำมันรำข้าว ที่ 1:2 และความเข้มข้นอิมัลชันของส่วนผสมทั้งหมดต่อน้ำ ที่ 25% โดยมีประสิทธิภาพการห่อหุ้มที่ 42.49% และให้ผลิตภัณฑ์เป็นผงที่มีความชื้นต่ำที่สุด (2.1%) และปริมาณแกมมาโอรีซานอลและผลผลิตสูงที่สุด (0.73% และ 9.45% ตามลำดับ) ดังนั้นงานวิจัยครั้งนี้สามารถเพิ่มความคงสภาพของแกมมาโอรีซานอลใน RBO ที่ผ่านกระบวนการเอนแคปซูเลชันด้วยวิธีสเปรย์ดราย

คำสำคัญ: น้ำมันรำข้าว, แกมมาโอรีซานอล, กระบวนการเอนแคปซูเลชัน

ABSTRACT

Rice bran oil (RBO) is an edible vegetable oil that contains phytochemicals such as tocopherols, tocotrienols, phytosterols and gamma-oryzanol. Although RBO provides a large amount of phytochemicals, it also presents unsaturated fatty acids that cause oxidation. Therefore, encapsulation by spray drying is one of the stabilization techniques to keep RBO in the form of powder in order to prevent or reduce oxidation and retain those phytochemicals. The objective of this study was to determine the stability of gamma-oryzanol in encapsulated rice bran oil powder using a spray dryer. Mixture formula variables preparation for encapsulation by spray dryer using flow rate at 2.5 ml/min and inlet temperature at 160 °C were (1) the ratio of wall material mixture between Sodium Caseinate and Maltodextrin (RSM) 1:3, 1:4 and 1:5 (w/w), (2) the ratio of the wall material mixture and RBO (RWO) 2:1, 1:1 and 1:2 (w/w), and (3) the emulsion concentration of wall material with RBO to water (CWOW) 20, 25 and 30% (w/w). The result showed that the suitable formulae for efficient encapsulating gamma-oryzanol in RBO by spray dryer with the encapsulation efficiency of 42.49% was RSM 1:3, RWO 1:2, and CWOW 25%. This condition provided encapsulated RBO powder with the lowest moisture content (2.1%) and the highest gamma-oryzanol content and percent yield (0.73% and 9.45%, respectively). In conclusion, the encapsulation by a spray dryer was successfully employed to stabilize gamma-oryzanol in RBO.

Keywords: Rice bran oil, Gamma-Oryzanol, Encapsulation

Introduction

Rice bran is the by-product from rice polish industry. In the past, most of the rice bran was used for animal feed. According to the increasing of research related to rice bran value added, many products were developed in the food industry such as rice bran oil (RBO), rice bran cereal, and rice bran flour (Khalid et al, 2015). Moreover, RBO is the richest source of natural phytochemicals such as tocopherol, tocotrienol, phytosterol, and gamma-oryzanol (Vanessa et al, 2012). Especially, gamma-oryzanol is only occurred component in rice bran and provides the beneficial effects on human health (Vanessa et al, 2012). There are global interests in developing methods to separate it from natural sources such as crude RBO, RBO soapstock, rice bran acid oil, or biodiesel residue from RBO (Siti et al, 2009). Although RBO provides many benefits, it can be easily oxidized due to the enzymatic activities. Therefore, there is a need to stabilize rice bran to prevent the oxidation. One of the stabilization methods is encapsulation by using a spray dryer. This technique can be useful for supplementation of foods with polyunsaturated fatty acid (PUFA). Protection of PUFA in edible oil against lipid oxidation is necessary to enhance its shelf life by using an efficient technique of encapsulation Pradeep et al. (2015). The objectives of this study were to find the emulsion formula for encapsulation by using the spray dryer and study the effectiveness of encapsulated on amount of gamma-oryzanol, moisture content, encapsulated efficiency and percent yield.

Materials and methods

Materials included core material (Rice bran oil from King Rice Oil Group), wall materials (Maltodextrin DE 12 from Union science Co., Ltd and Sodium caseinate from S&A Chemical food) and an emulsifier (Lecithin). Variables of this study were (1) the ratio of wall material mixture between Sodium caseinate and Maltodextrin (RSM) 1:3, 1:4 and 1:5 (w/w), (2) the ratio of the wall material mixture and RBO (RWO) 2:1, 1:1 and 1:2 (w/w), and (3) the emulsion concentration of wall material with RBO to water (CWOW) 20, 25 and 30% (w/w). The emulsion formula were shown in Table 1. The Emulsion was prepared by mixing Sodium Caseinate and Maltodextrin, after that dissolve with water and followed by RBO. Then lecithin was added at 1% by weight and the emulsion was homogenized at 11000 rpm for 30 minutes. The emulsion was spray dried using a lab scale spray dryer (Glory Scientific and Engineering (2011) Co.,Ltd, Bangkok). The feed rate was 2.5 ml/min and the inlet drying air temperature was 160 °C (Kalaya et al, 2011). The encapsulated RBO was analyzed for percent yield, moisture content (AOAC, 2005), gamma-oryzanol (CODEX 2015) and encapsulated efficiency (Helena et al, 2013). Duncan's multiple range tests was employed to determine the significance of differences among samples at $p < 0.05$ level, using SPSS for Windows (version 17.0) program.

Result and discussion

Part I: Choosing the emulsion formula for spray drying

Table 2 showed the total emulsion formula carried out in this research. The criteria for selecting formula are (1) powder was produced without sticking to a nozzle, (2) high percent yield and (3) final form of product was powder. There were 9 selected formula as shown in Table 3.

The selected formula included the following treatments;

(1) RSM 1:3 RWO 1:1 CWOW 25%, (2) RSM 1:4 RWO 1:1 CWOW 25%, (3) RSM 1:5 RWO 1:1 CWOW 25%, (4) RSM 1:3 RWO 1:2 CWOW 25%, (5) RSM 1:4 RWO 1:2 CWOW 25%, (6) RSM 1:5 RWO 1:2 CWOW 25%, (7) RSM 1:3 RWO 1:2 CWOW 30%, (8) RSM 1:4 RWO 1:2 CWOW 30%, (9) RSM 1:5 RWO 1:2 CWOW 30%.

These selected formula showed yield percentage between 8.77% and 14.91%. It is important to select appropriate compound for each core material. For example carbohydrates such as maltodextrins, starches, corn syrup solids, and acacia gums have all been widely used as encapsulating agents. However, due to the poor interfacial properties of these wall materials, it must be modified or used in conjunction with a surface active agent to encapsulate oil based materials. In contrast, the amphiphilic character and emulsification properties of proteins such as sodium caseinate would appear to offer the physical and functional characteristics required to encapsulate lipid core materials (Kalaya et al, 2011).

Part II: Encapsulated RBO by using spray dryer

1. Percent yield and weight

The % yield and weight of encapsulated RBO after spray drying of the selected formula were shown in Table 3. The results showed that % yield and weight were 4.79-9.45% and 14.03-27.75g respectively. The formula with the lowest % yield was RSM 1:5, RWO 1:2 and CWOW 30% (4.79%) and the highest % yield was RSM 1:3, RWO 1:2 and CWOW 25% (9.45%). In this result, the % yield was less compared to the % yield shown in Table 2. As low gamma-oryzanol concentration in rice bran oil (2,000 ppm) used in part 1, considerable reduction of gamma-oryzanol concentration was observed, rice bran oil with higher gamma-oryzanol content (6,000 ppm) was then used in part 2 in order to reserve more gamma-oryzanol in sample. This might affect results of the weight and percent yield change.

2. Gamma-Oryzanol and moisture content

The gamma-oryzanol and moisture content of encapsulated RBO was shown in Figure 1. The results showed that gamma-oryzanol and moisture content was between 0.46-0.73% and 2.10-4.09% respectively. The formula with RWO 1:1 contained higher moisture content than those for formula with RWO 1:2. It was noticed that RWO 1:1 contained more wall material compared to RWO 1:2. More wall materials content leaded to more viscous emulsion, resulting in increasing of powder particle size. The larger particle had more moisture content as it was more difficult for evaporation the water inside. Fernanda et al, (2019) observed moisture content (1%) of spray drying powder when mean diameter was 87 μm, whereas moisture content increased to 8% with mean diameter 160 μm and the results agree with information reported by Parthasarathi et al, (2016). Furthermore, the moisture content was inversely proportional to the gamma–oryzanol, whereas oxidation in encapsulated RBO was caused by increasing moisture content as well as the large particle that allow the oxygen into the particle wall (Helena et al., 2013) resulting in gamma-oryzanol decrease. It was noticed that the formula of 1:3, RWO 1:2 and CWOW 25% contained the lowest moisture content and the highest gamma-oryzanol value (2.1% and 0.73% respectively) indicating the good quality of the powder.

3. Encapsulated efficiency (%EE)

The encapsulated efficiency of encapsulated RBO was indicated in Figure 2. It was found that %EE ranged from 30.08-71.16% and chosen formula of RSM 1:3, RWO 1:2 and CWOW 25% exhibited %EE of 42.49%. The three statistically significant highest % EE were formula of RSM 1:3 RWO 1:1 CWOW 25% (69.09%), RSM 1:5 RWO1:1 CWOW 25%(70.90%), and RSM 1:3 RWO 1:2 CWOW 30% (71.16%), and the lowest % EE was RSM 1:5 RWO1:2 CWOW 30% (30.08%). It can be seen that the exact trend of each treatment cannot be determined. This may due to the interaction of these 3 variables (RSM, RWO, and CWOW). Therefore, more study about role of core material of wall materials is recommended for further investigation.

Summary

The suitable formulae for efficient encapsulating gamma-oryzanol in RBO by spray dryer was the ratio of wall material mixture between Sodium caseinate and Maltodextrin (RSM) 1:3, the ratio of the wall material mixture and RBO (RWO) 1:2, and the emulsion concentration of wall material with RBO to water (CWOW) 25% which provided the powder quality with the lowest moisture content (2.1%), the highest gamma-oryzanol content (0.73%), percent yield (9.45%), and encapsulated efficiency (42.49%).

It was recommended that the calculation of the flow rate when feeding emulsion into the spray dryer of each formula should be conducted in order to clearly consider the viscosity of each formula. Consideration of understanding the independent variables regarding interaction of these three variables (RSM, RWO, and CWOW) should also be further studied.

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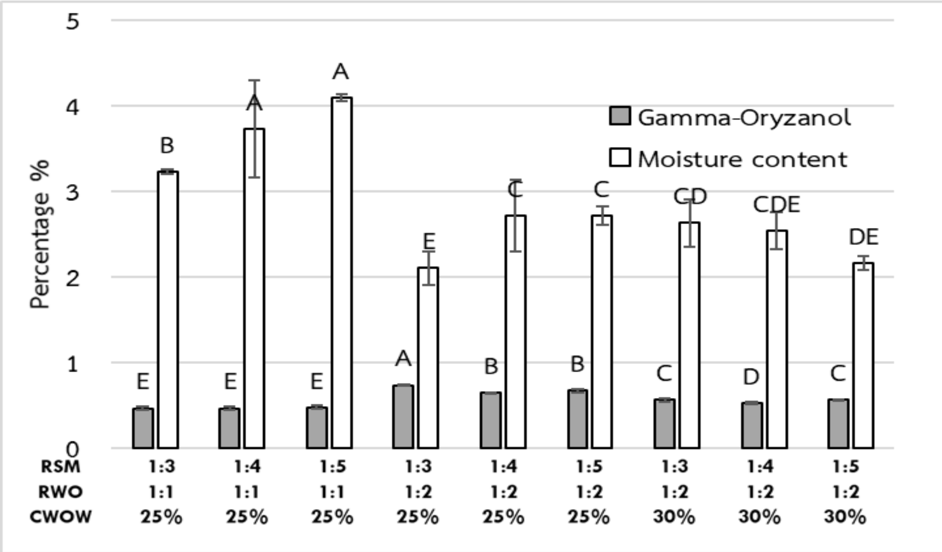

Figure 1 The Gamma-oryzanol and moisture content of encapsulated RBO. Difference superscripts are indicated significantly different with the same parameter (p <0.05).

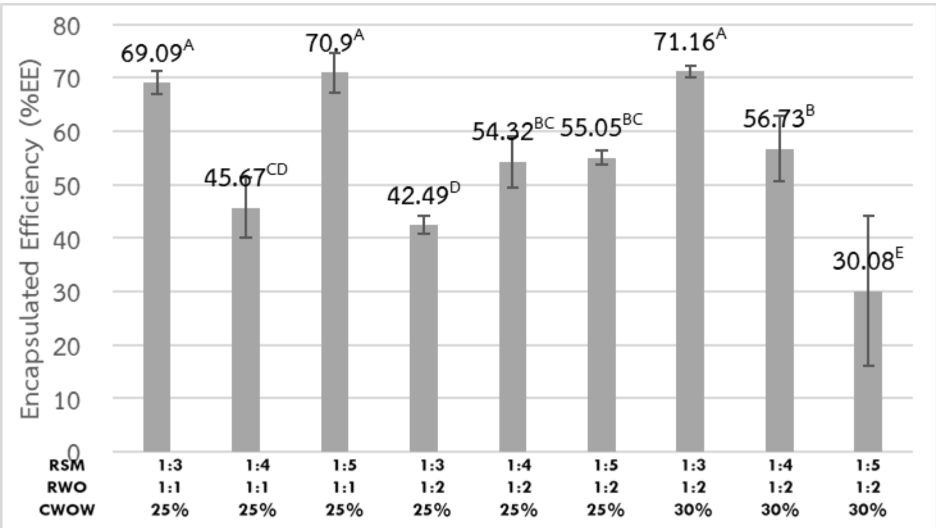

Figure 2 Encapsulated efficiency of encapsulated RBO. Different superscripts indicate significant different (p <0.05).

Table 1 The emulsion formula of the ratio walls material mixture between Sodium Caseinate and Maltodextrin (RSM), the ratio walls material mixture and RBO (RWO) and the emulsion concentration of wall material with RBO to water (CWOW).

CWOW	RWO	RSM		
		1:3	**1:4**	**1:5**
20%	2:1	1	2	3
	1:1	4	5	6
	1:2	7	8	9
25%	2:1	10	11	12
	1:1	13	14	15
	1:2	16	17	18
30%	2:1	19	20	21
	1:1	22	23	24
	1:2	25	26	27

Table 2 The %yield of encapsulated RBO after spray drying of selected formula.

CWOW	RWO	RSM		
		1:3	**1:4**	**1:5**
20%	2:1	3.21	5.22	2.93
	1:1	3.78	3.12	1.49
	1:2	1.61	2.43	1.41
25%	2:1	1.70	0.48	-
	1:1	8.77	14.82	13.60
	1:2	12.37	11.74	9.22
30%	2:1	0.46	-	-
	1:1	-	-	-
	1:2	13.21	11.22	14.91

Table 3 The weight and % yield of encapsulated RBO after spray drying of chosen emulsion formula.

No	RSM	RWO	CWOW	Weight (g)	% Yield
1	1:3	1:1	25%	22.05	7.55
2	1:4	1:1	25%	22.06	7.67
3	1:5	1:1	25%	16.28	5.52
4	1:3	1:2	25%	27.75	9.45
5	1:4	1:2	25%	19.85	6.76
6	1:5	1:2	25%	19.13	6.49
7	1:3	1:2	30%	14.03	4.79
8	1:4	1:2	30%	18.87	6.41
9	1:5	1:2	30%	20.14	6.87