Physicochemical and stability of organic rice bran milk added with hydrocolloids

Utthapon Issara and Saroat Rawdkuen[1,*]

Abstract

The present work was aimed to study the effect of four hydrocolloids on physicochemical and stability of organic rice bran milk (RBM) during refrigerated storage. Guar gum (GUA), xanthan gum (XAN), pectin (PEC), and carrageenan (CAR) at the concentrations of 0, 0.05, 0.1, 0.3 and 0.5% (w/v) were gradually added into the pasteurized RBM before their properties and stability determinations. The results showed that GUA, XAN, and PEC were the most effective substances for pH reduction, while CAR increased the pH of RBM (p<0.05). Total soluble solid (TSS) of RBM added with different hydrocolloids was ranged from 4.3±0.71 to 6.3±0.71°Brix. The viscosity of RBM after 7 days storage at 4°C was 4.05±0.04 to 229.77±1.48cP, which significantly higher than the control (3.05±0.01cP) (p<0.05). The highest stability of RBM was found when XAN at the level >0.3 (w/v) was applied. According to the results, GUA at all concentrations seem to be the most effective hydrocolloid for physicochemical properties improvement, while XAN was provided the good product stability.

Keywords: Rice bran, Organic product, Milk, Hydrocolloids, Stability

1. Introduction

Food hydrocolloids are hydrophilic biopolymer that used as functional ingredients in the food manufacture for control of microstructure, texture, flavor and shelf-life of food products (Dickinson, 2003). The term of hydrocolloids are obtained from embraces all of various polysaccharides that are extracted from plants, seaweed, and microbial sources. Moreover, gums derived from plant exudates and modified biopolymers made by the chemical or enzymatic treatment of starch or cellulose is also included in hydrocolloids. However, big differences in functional properties exist between many types of food biopolymer are depend on chemical structure based and sensitivity to solution conditions (pH, ionic strength, specific ions) (Dickinson, 2003). Food hydrocolloids have been exploited for food systems as thickeners, gelling agents, stabilizer, bulking agents, and emulsifiers (Viebke *et al.,* 2014; Phillips and Williams, 2009). They are widely applied in many of foods such as, beverages (emulsifiers) including carbonated soft drinks (Tan, 2004), confectionery (coating agents & texturizing), dairy based products (stabilizers & thickeners) like an ice-cream (Goff, 1997),

[1] Food Technology Program, School of Agro Industry, Mae Fah Luang University, Chiang Rai, Thailand, 57100

* Corresponding author, e-mail: saroat@mfu.ac.th

bakery product (bulking agents) (Viebke *et al.,* 2014) sauces and dressings (Dickinson, 2009). Moreover, among gum, especially gum arabic (Acacia senegal), modified starches, modified celluloses, some kinds of pectin, and some galactomannans are most widely used in food systems (Dickinson, 2009; Dickinson, 2003; Garti and Reichman, 1993).

Cereal and grain milks are made by disintegration of the plant materials, which means that particle compositions and size are not as uniform. The particle size of the cereals and grains will have a large dependence upon the method by which they are milled (Durand, 2003). In addition, the stability of the emulsified beverage also depends upon droplet size and aggregation. There are some parameters such as particle size and size distribution, which resulting to the quality of food product and the beverage like organic rice bran milk (RBM), especially in terms of stability properties. Generally, almost hydrocolloids are applied with several food products as a plain milk, ice-cream, bread and fruit juice etc. Nevertheless, RBM and its related products have not been reported by using hydrocolloids for quality and/or stability improvement. Therefore, this work was aimed to study the effect of type and concentration of hydrocolloids on physicochemical and stability of pasteurized RBM during refrigerated storage.

2. Materials and Methods

2.1 Organic rice bran preparations and hydrocolloids

Stabilized organic rice bran was obtained from Urmatt Co. Ltd., Chiang Rai, Thailand. The rice bran was dried in the oven at 60°C for 8 h, ground and then passed by sieving machine (Retsch, AS200 Digit) with 35 mesh (500µM) and stored in vacuum plastic bag at -18°C. This sample was used as the starting material for rice bran milk production.

Four types of hydrocolloids included: Guar gum (GUA), Xanthan gum (XAN), Pectin (PEC), and Carrageenan (CAR) were purchased from Union Science Co., Ltd. Chaing Mai, Thailand.

2.2 Organic rice bran milk production

Organic rice bran milk was prepared according to the method of Faccin *et al.,* (2009) with some modification. Concisely, the ratio of rice bran to water 1:15 (w/v) was prepared. Then, the mixture was blended using colloids mill machine (ASAKO, YJTM85D-2P, China) at the speed of 3000 rpm, for 15 min. The obtained suspension was filtered with sheet cloth for 3 times. Then, the filtrate was pasteurized at 72°C, for 15 Sec with pot cookware and referred to “Rice Bran Milk: RBM”. Then, Guar gum (GUA), xanthan gum (XAN), pectin (PEC) and carrageenan (CAR) at the concentrations of 0, 0.05, 0.1, 0.3 and 0.5% (w/v) were gradually added into the pasteurized RBM. After thermal processing, the RBM was cooled and packed in

150 ml polypropylene (PP) plastic bottle and covered with Parafilm® “M” Laboratory Film their properties and stability determination.

2.3 Physicochemical properties determinations

2.3.1 pH determination

pH of RBM was determined using pH meter (pH 510, Eutech Instrument, Singapore) according to method of Sadler (2010). Sample volume of 20ml was poured into 50 ml beaker, and then pH of sample was recorded.

2.3.2 Total soluble solid (TSS) determination

RBM sample was dropped in to the Hand Refractometer (ATago UriconN-Hand held-Refractometer, 0–32%°Brix, ATago Co., Ltd., Taiwan) for TSS measurement, and TSS of all samples was recorded.

2.3.3 Viscosity determination

RBM was evaluated the viscosity according to the method of Faccin *et al.* (2009) with some modification. A Brookfield viscometer Model LDVD-III+ Serial 67844 (Brookfield engineering labs Inc. Middleboro, Ma 02346, U.S.A) and UL spindle (UL-0) No.00 probe with shear rate 110 (1/sec), shear stress 7.00 (Pa) and temperature at 24±1°C were used. Then the viscosity value of RBM samples was recorded until 7 days during storage time (at 4°C).

2.4 Stability monitoring of organic rice bran milk

The stability of organic RBM was measured by coagulation method (Yu and Raghavan, 2009) with some modification. In brief, the RBM was poured into 10 ml cylinder. Then the sample was kept at 4°C (7 days) for stability monitoring. The sample was observed for the precipitate during the 7 days storage time and recorded as following equation:

$$\text{Stability (\%)} = ((10_a - \text{precipitate*}) / 10) \times 100$$

Where: 10_a is volume of RBM sample (control) after production

*The level that indicated in below substances of separation phase

2.5 Statistical analysis

All determinations were performed in triplicate. Statistical analysis of the results was conducted by using the analysis of variance (ANOVA) and the Duncan’s multiple range test at 95% confidence level by using SPSS software (SPSS 16.0 for window, SPSS Inc, Chicago, IL).

3. Results and Discussion

3.1 Physicochemical properties of rice bran milk

The effect of hydrocolloids addition on pH value and total soluble solid (TSS) of pasteurized organic rice bran milk were presented in Table 1. The results showed that GUA, XAN, and PEC were the most effective substances for pH reduction at all concentrations applied, while CAR increased the pH value of RBM with the addition of 0.05 to 0.5% (w/v) (p<0.05). These hydrocolloids have initial different pH value from sources and obtained different extraction process, which affecting to their properties when applied in food products (Dickinson, 2003). Moreover, some polysaccharides like pectin that obtained from citrus fruits extraction is composed galacturonic acid are making up about half of the pectin. Hence, this monosaccharide is promoted to be partially methyl-esterified and presented an acidic pH environment in aqueous systems (Alqahtani *et al.,* 2014). The obtained RBM showed higher pH values than those obtained by Potter *et al.,* (2007) who related studies on syrup composed of rice, soy and blueberry (3.64±0.02 to 3.97±0.11). In addition, the pH of typical organic rice bran beverage (cocoa and strawberry flavor) has been reported for 6.30±0.1 and 6.30±0.2, respectively (Faccin *et al.,* 2009). In this study (Table 1) pH of control RBM was 6.63±0.01; whereas pH of obtained samples after hydrocolloids were applied ranged from 6.65±0.01 in sample with GUA (0.05% w/v) addition to 5.96±0.03 in RBM obtained with 0.5% (w/v) addition of XAN. However, GUA seem to be the most effective hydrocolloid for physicochemical properties of RBM with control sample when compared with other hydrocolloids addition. Considered in pH values of obtained RBM in this study was near neutrality, as a resulting to adequate for reproduction of pathogenic microorganisms (Faccin *et al.,* 2009). As a rule, the increase of pH leads to decrease the functional efficiency of preservatives in the beverage emulsion (Mirhosseini *et al.,* 2008). Thus, the least pH value was considered as an optimum pH region for RBM beverage. Therefore, in terms of food safety especially, the microorganisms should be necessarily to investigated in the further study to be making for consumer safety, even though obtained RBM was passed thermal treatment.

Table 1 Physicochemical properties of rice bran milk

Parameters	Concentrations	Types of hydrocolloids*			
	(w/v)	Guar gum	Xanthan gum	Pectin	Carrageenan
pH	0	6.63 ± 0.01^{aA}	6.63 ± 0.01^{aA}	6.63 ± 0.01^{aA}	6.63 ± 0.01^{aA}
	0.05	6.65 ± 0.01^{aA}	6.30 ± 0.02^{bC}	6.34 ± 0.01^{bB}	6.35 ± 0.01^{cB}
	0.1	6.64 ± 0.00^{aA}	6.30 ± 0.01^{bC}	6.32 ± 0.01^{bC}	6.37 ± 0.01^{cB}
	0.3	6.57 ± 0.01^{bA}	6.12 ± 0.01^{cC}	6.15 ± 0.00^{cC}	6.41 ± 0.01^{bB}
	0.5	6.49 ± 0.04^{cA}	5.96 ± 0.03^{dD}	6.07 ± 0.01^{dC}	6.43 ± 0.01^{bB}
TSS (°Brix)	0	4.3 ± 0.71^{bA}	4.3 ± 0.71^{bA}	4.3 ± 0.71^{bA}	4.3 ± 0.71^{bA}
	0.05	5.3 ± 0.71^{abAB}	5.3 ± 0.71^{abA}	5.3 ± 0.71^{abAB}	4.7 ± 0.00^{abA}
	0.1	5.3 ± 0.71^{abAB}	5.7 ± 0.71^{aA}	5.3 ± 0.00^{abAB}	5.3 ± 0.71^{abAB}
	0.3	5.7 ± 0.71^{aA}	5.7 ± 0.00^{aAB}	5.3 ± 0.71^{abAB}	5.7 ± 0.71^{aAB}
	0.5	6.3 ± 0.71^{aA}	5.7 ± 0.00^{aAB}	5.7 ± 0.71^{aA}	5.7 ± 0.71^{aAB}

Note : * The values are expressed as Mean ± SD (n=3)

Mean with different letter in the same column (a, b, c ,d) and row (A, B, C, D) are significant different at (p<0.05)

Total soluble solid (TSS) of RBM with different hydrocolloids added was ranged from 4.7±0.00 to 6.3±0.71°Brix with the highest value when 0.5% (w/v) of GUA was added (p<0.05), while those control presented in 4.3±0.71°Brix (Table 1). Even though RBM was no sugar added (natural flavor) meanwhile it is presented the small number for increasing of TSS. As a result, increase in TSS value in this work may be caused from particle of rice bran and depend on concentration of hydrocolloids added rather than sugar content in RBM samples. Anyway, it is also possible deliberated from starch content (48.44%) in rice bran which noted by Prakash (1996).

3.2 Viscosity of rice bran milk during storage times

Viscosity is an important parameter of foods that affects the mouth feel and texture of fluids such as beverages (Yu *et al.,* 2007). The RBM is an emulsion with physical characteristics and viscosity that are appealing to consumers. The hydrocolloids have their function in food and beverage manufacture, especially to their rheological and surface properties. Li and Nie (2016) noted that rheological properties are defined as mechanical properties that result in deformation and the flow of material, which including flow behavior (viscosity) and mechanical solid property (texture). Hence, aiming to verify the effect of hydrocolloids applied on viscosity of RBM product during refrigerate storage condition (4°C) was determined. According to the results shown in Table 2, the addition of hydrocolloids resulted in a higher viscosity of all samples as compared with control. The viscosity of RBM after 7 days storage was 4.05±0.04 to 229.77±1.48cP, which significantly higher than the control (3.05±0.01cP) (p<0.05). The results demonstrated that increasing trend of viscosity of RBM depended on concentrations of hydrocolloids added and storage time. However, GUA and XAN were provided in high viscosity for RBM when >0.3% (w/v) was applied. Kolniak *et al.* (2013) reported that the increases of viscosity in samples could be caused by the presence of large particles of hydrocolloids and rice bran particles, especially starch content in rice bran. Also, the presence of temperature for storage time could be affecting the increase of the beverage viscosity. In colloidal suspensions, viscosity is increased by the thickening of the liquid phase ascribable to liquid absorption and resultant swelling of the dispersed colloid (Nussinovitch, 2010). There are various factors to make the viscosity increased of colloidal system with hydrocolloids application such as concentration, temperature, solvation, electrical charge and degree of dispersion etc. (Nussinovitch and Hirashima, 2014). However, the hydrocolloids dispersions prepared with 0.5% (w/v) have different apparent viscosities and may have contributed to the observed differences in emulsion stability (Huang *et al.,* 2001). This property was related with particle size distribution and stability monitoring of RBM due to high viscosity helps particles and/or compositions in RBM were suspension in aqueous system (Faccin *et al.,* 2009).

Table 2 The viscosity value of rice bran milk during storage at 4^{o}C for 7 days

		Viscosity of RBM (cP)*			
Days	**Types of hydrocolloids**	**Concentrations (w/v)**			
		0.05	**0.1**	**0.3**	**0.5**
0	Control	3.05 ± 0.01^{dA}	3.05 ± 0.01^{eA}	3.05 ± 0.01^{dA}	3.05 ± 0.01^{eA}
	Guar gum	4.05 ± 0.04^{aC}	6.17 ± 0.04^{aC}	33.12 ± 0.07^{bB}	121.69 ± 3.36^{bA}
	Xanthan gum	3.81 ± 0.04^{bC}	4.42 ± 0.04^{bC}	175.34 ± 0.39^{aB}	223.93 ± 1.94^{aA}
	Pectin	3.12 ± 0.06^{dD}	3.29 ± 0.04^{dC}	5.89 ± 0.07^{cB}	8.22 ± 0.02^{dA}
	Carrageenan	3.26 ± 0.03^{cD}	3.95 ± 0.02^{cC}	6.22 ± 0.14^{cB}	13.3 ± 0.35^{cA}
7	Control	3.14 ± 0.01^{dA}	3.14 ± 0.01^{dA}	3.14 ± 0.01^{dA}	3.14 ± 0.01^{eA}
	Guar gum	4.17 ± 0.07^{cD}	6.85 ± 0.26^{bC}	36.37 ± 0.19^{bB}	129.60 ± 1.02^{bA}
	Xanthan gum	5.17 ± 0.08^{aC}	7.60 ± 0.05^{aC}	183.63 ± 2.65^{aB}	229.77 ± 1.48^{aA}
	Pectin	4.91 ± 0.15^{bD}	6.94 ± 0.07^{bC}	10.33 ± 0.30^{cB}	15.32 ± 0.40^{dA}
	Carrageenan	5.25 ± 0.08^{aD}	5.93 ± 0.13^{cC}	9.08 ± 0.03^{cB}	18.05 ± 0.06^{cA}

Note: *The values are expressed as Mean±SD (n=3)

Mean with different letter in the same column $^{(a, b, c, d, e)}$ and row $^{(A, B, C, D)}$ are significant different at (p<0.05)

3.3 Stability study of rice bran milk

A beverage emulsion may contain a number of constituents that partition into different phases within the product (McClements, 2005). A separation layer on the beverage is undesirable because it would lead to consumer rejection. RBM is an emulsion with physical characteristics and viscosity that are appealing to the stability. In this case the highest stability at 4°C after 7 days storage time of obtained RBM was found when XAN performed equally well at the level of >0.3 (w/v) was applied (Figure 1). The addition in high amount of hydrocolloids was most affected to stability, which consistent with the results of viscosity. While the stability at a given hydrocolloids addition was largely dependent on the hydrocolloid type and concentration used in the RBM samples. The amount of hydrocolloids added to the sample had little impact on the final stability of the sample. There is some mechanism in particularly gravitational separation lead to a change in the structural organization of the various components within the system (Piorkowski and McClements, 2014; Friberg *et al.,* 2004; McClements, 2005 and Dickinson, 1992). In fact, sugars, polysaccharides, polyphenols, and minerals and among others may cause interact with rice bran compositions, especially protein through a variety of physico-chemical mechanisms (Baccouche *et al.,* 2013).

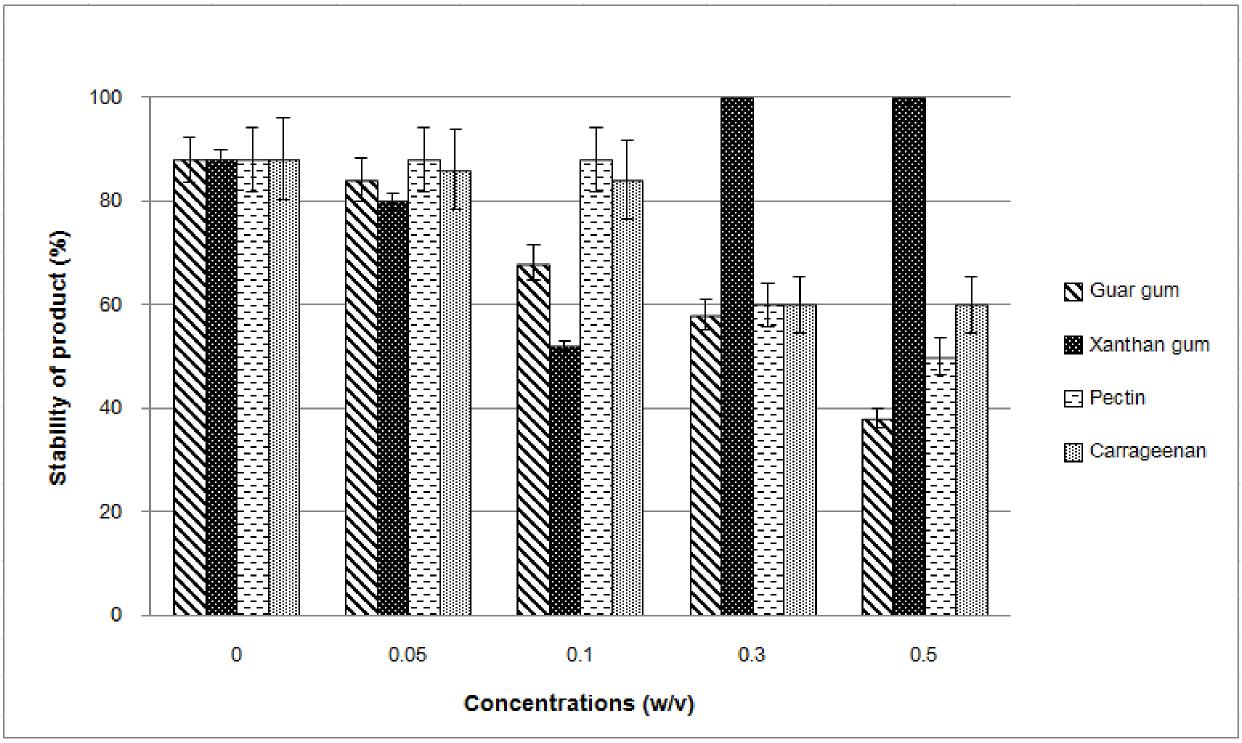

Figure 1 The stability of rice bran milk during storage at 4°C for 7 days

In the case of RBM beverages, these interactions lead to a separation into two phases due to whole rice bran was used. The RBM is thermodynamically unfavorable systems, its separation phase could be undergone by one of two alternative mechanisms: either by complex coacervation (associative phase separation), or by thermodynamic incompatibility (segregative phase separation) (Baccouche *et al.,* 2013). Besides, the chemical structure changes of active components can conduct to changes in physical stability (Piorkowski and McClements, 2014).
Then, understanding of the interactions between the ingredients in the WBP beverages is needed for optimization of these beverages' physical stability. Comparing these results with the viscosity data (Table 2), it did not appear that increased viscosity was responsible for decreased RBM separation. Therefore, the relationship between viscosity and stability is likely due to rheological properties rather than physicochemical interactions (Joyner and Damiano, 2015). These results were expected based on the increase in viscosity of the samples prepared with higher hydrocolloid concentrations. Anyway, this hypothesis should be further studied with other techniques. Indeed, the results demonstrated that viscosity was not only factor affecting to stability, but increased viscosity slows particle and droplet movements in quiescent liquids, slowing the rate of destabilization as a resulting in increased for physical stability of RBM. While some studies have shown that increasing the concentration of xanthan gum, guar gum, and locust bean gum can improve stability of emulsions products were reported by Neirynck *et al.* (2007) and Perrechil and Cunha (2010).

4. Conclusion

The present study demonstrated that the addition of hydrocolloids into RBM resulted to pH, viscosity, and stability properties of RBM. Increasing high amount of hydrocolloids leaded to increase the viscosity. According to the results, GUA at all concentrations seem to be the most effective hydrocolloids for physicochemical properties, while XAN was provided the good product stability. For suggestion, the mixing effective hydrocolloids substance (GUA and XAN) together for application to RBM should be further study, and characterization of RBM properties for requirements to good product quality.

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