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Combination of stabiliser and emulsifier for Pink Guava Juice Drink (PGJD) fortified with Vitamin E

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Abstract

In the beverages industry, the stabilizer and emulsifier were used to enhance the quality of Pink Guava Juice Drink (PGJD) in terms of colour, taste, and texture. Thus, the product is favourable and marketable. This study was conducted to find the best emulsifier combination for PGJD. The combination of six different stabilizers such as Guar gum (GG), Carboxyl methyl cellulose (CMC), Arabic gum (AG), Xanthan gum (XG), Propylene glycol alginate (PGA), and Pectin were applied to PGJD formulation. Meanwhile, about three emulsifiers which are Arabic gum (AG), Polysorbate 80 (P80), and Propylene glycol alginate (PGA) were used to emulsify vitamin E in PGJD. The ratio for both stabilizers and emulsifiers varied accordingly. The most stable and suitable combination of stabilizers and emulsifiers was later added to PGJD. The combination of XG and CMC at the concentration of 70:30 with 0.2% (w/v) was the best stabilizer. Meanwhile, P80 was found to be the best emulsifier at a concentration of 0.8% (w/v) and PGJD fortified with 225 mg of vitamin E was chosen as the most acceptable PGJ among panelists. This finding of the present study can be a guideline for beverage manufacturers in selecting the best stabilizers and emulsifiers.

1. INTRODUCTION

Pink Guava or its scientific name, *Psidium guajava L.* is one of the tropical fruits that is widely planted in Perak, Malaysia. This fruit is originated from Central America and the southern part of Mexico (Suwanwong and Boonpangrak, 2021; Nagarajan et al., 2019; Lamo al., 2019; Ninga et al., 2018; Moon et al., 2018; Garbanzo et al., 2017; Aishah et al., 2016). The fruit is favourable for its pink colour and moderately sweet taste. The pink guava is one of the easiest fruits to process in the food industry as the whole fruit was edible, and its soft structure makes it easier to be converted into a puree. In terms of biochemical nature, this fruit did not prone to pulp browning. From a puree, the product will be reprocessed to produce a Pink Guava Juice Drink or PGJD (Aishah et al., 2016). It has marketable properties, especially in the European country and increased awareness of the consumer about the importance of having a healthy choice of drink instead of common caffeine-containing beverages such as coffee, tea, or carbonated soft drinks. In Malaysia, pink guava juices are marketed with total soluble solid ranging from 9.9°Brix to 10.63°Brix and pH ranging between 3.46 and 3.98 (Silva et al., 2016). Pink guava juice is chosen over ordinary guava juice mainly due to its attractive pink colour originating from lycopene which constitutes more than 80% of its total carotenoid content (Nagarajan et al., 2019; Campoli et al., 2019; Aishah et al., 2016). In the case of fruit juice specifically guava, their thermodynamical systems were generally unstable where it can show signs of rapid separation of juices into two immiscible phases over a period and were stabilized by improving their kinetic stability through the addition of stabilizers (Campoli et al., 2019; Lamo et al., 2019; Ninga et al., 2018; Moon et al., 2018; Garbanzo et al., 2017).

Stabilizers are substances that allow food ingredients, which do not mix well, to remain in a homogenous state after blending. Stabilizers and thickeners are combined with water in food to increase product viscosity, form gel, and prevent product

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crystallization. Starch, pectin, Arabic gum, carrageenan gum, guar gum, and xanthan gum are commonly used to thicken diverse products such as beverages, gravies, dairy products, and puddings. On other hand, an emulsifier is an additive that can blend the ingredients of the food mixtures and then prevent them from separating during processing periods. Emulsifier also produces a stable mixture of food components such as oils, fats, water, carbohydrates, proteins, minerals, flavours, and vitamins (Karp et al., 2019: Sadahira et al., 2016).

Vitamin E is a biological antioxidant, and it was recognized worldwide to be an essential micronutrient. A daily intake of 10 mg vitamin E (tocopherol and tocotrienol) equivalents (or 15 IU/day) is currently advised as adequate levels for healthy men (Whitney et al., 2018). Vitamin E is a potent chain-breaking antioxidant, scavenging oxygen radicals and terminating free-radical chain reactions. Lui et al., (2018) reported that the increment of vitamin E intake in older adults significantly reduced the risk of cognitive impairment (Alzheimer's disease) while Alzoubi et al., (2019) reported that vitamin E may have a neuroprotective effect mediated by its antioxidant activity and prevented memory impairment and alterations in oxidative stress biomarkers. In addition, there is evidence that vitamin E has positive effects on cardiovascular disease, cancer prevention, the immune system, and slowing down the ageing process. The incorporation of vitamin E in fruit juices will therefore greatly enhance the vitamin intake in daily consumption (Fuente et al., 2020).

2. MATERIALS AND METHODS

2.1. Raw materials

The main ingredient, pink guava puree, and flavour enhancer were attained from Golden Hope Food and Beverages Sdn Bhd. Meanwhile the stabilizer, vitamin E was gathered from Sime Darby Bioganic Sdn Bhd. Other materials like food-grade citric acid, food colouring, food preservatives, food stabilizers, and emulsifiers were bought from Meilun Food Chemical Sdn Bhd. while sugar was purchased at a local supermarket.

2.2. Preparation of pink guava juice drink (PGJD)

The sample was prepared by using this formula: pink guava puree (12%), sugar (9%), citric acid (0.15%), food colouring (0.0006%), flavour enhancer (0.046%), preservative (0.015%), water (78.8%), stabilizer (0.2%), vitamin E (0.0075 – 0.03%) and emulsifier (0.1 – 1.0%). The ingredients were homogenized using a laboratory homogenizer at 20,000 rpm for 5 mins and later boiled at 100°C for 5 mins before hot filled in glass bottles. The finishing product immediately cooled to room temperature.

2.3. Determination of the best stabilizers using colloidal stability index (CSI)

The combination of six different stabilizers such as Guar gum (GG), Carboxyl methyl cellulose (CMC), Arabic gum (AG), Xanthan gum (XG), Propylene glycol alginate (PGA), and Pectin was applied to PGJD formulation. The sample was stored for 24 weeks at 28°C. The monitoring test was performed in triplicate samples. Higher colloidal stability was demonstrated by a larger CSI value. The measurement of colloidal stability was performed every 7 days until 24 weeks of storage. Results with CSI below 90% were considered unacceptable.

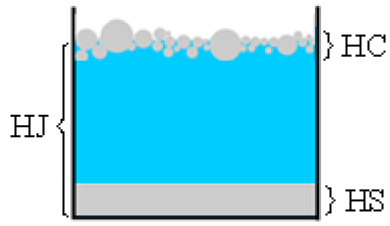

Figure 1: Graphical definition of colloidal stability index (CSI)

Figure 1 showed the graphical definition of colloidal stability index (CSI) and was calculated as a percentage by using the following equation below;

$$CSI = \frac{(HJ - (HC + HS))}{HJ} X\,100 \qquad (1)$$

where, HJ is the height of colloidal / juice in a container; HC is the height of the cream layer; and HS is the height of the sedimentation phase.

2.4. Determination of the best emulsifier using emulsion stability index (ESI)

Three emulsifiers which are Arabic gum (AG), Polysorbate 80 (P80), and Propylene glycol alginate (PGA) were used to emulsify vitamin E in PGJD with the amount of emulsifier added was 0.1 – 1.0 % (w/v). The sample was stored for 24 weeks at 28°C. The monitoring test was performed in triplicate samples. Higher colloidal stability was demonstrated by a larger CSI value. The measurement of colloidal stability was performed every 7 days until 24 weeks of storage. Results with CSI below 90% were considered unacceptable.

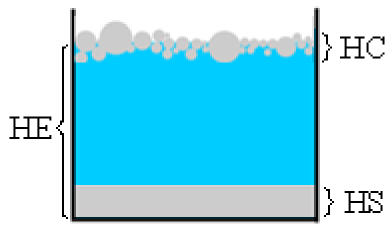

Figure 2: Graphical definition of emulsion stability index (ESI)

Figure 2 showed the graphical definition of emulsion stability index (ESI) and was calculated as a percentage by using the following equation below;

$$ESI = \frac{\left(HE - (HC + HS)\right)}{HE} X\,100 \qquad (2)$$

where, HE is the emulsion height; HC is the height of the cream layer; and HS is the height of the sedimentation phase.

2.5. Determination of the best PGJD fortified with vitamin E using sensory analysis

Sensory evaluation of pink guava juice was conducted to determine the acceptability of pink guava juice fortified with 70 mg, 150 mg, 225 mg, and 300 mg of vitamin E. The samples were evaluated randomly using fifty untrained panellists. The hedonic scaling method was used. Sensory scores for attributes such as colour, mouthfeel, oiliness, taste, and overall acceptability were obtained.

2.6 Statistical analysis

All data obtained were calculated as mean values of triplicate analysis and followed by one-way Analysis of Variance (ANOVA) using SPSS software.

3. RESULT AND DISCUSSION

3.1 Selection of stabilizers using colloidal stability index (CSI)

The combination of guar gum (GG) + pectin, propylene glycol alginate (PGA) + pectin, and guar gum (GG) + propylene glycol alginate (PGA) as shown in Figures 3, 4, and 5, respectively shows the worst result based on the lowest CSI value was recorded.

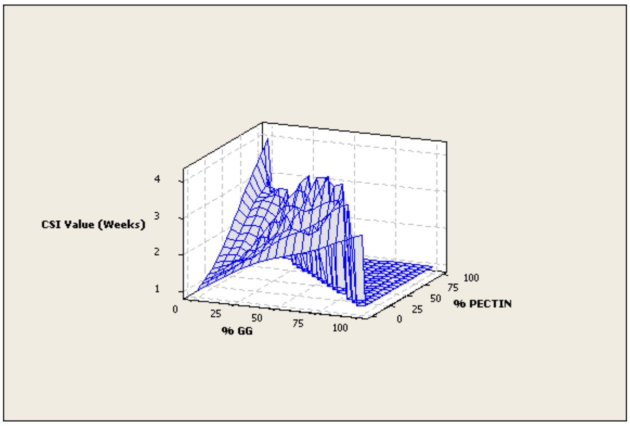

Figure 3: Graphical model of guar gum (GG) and pectin combination.

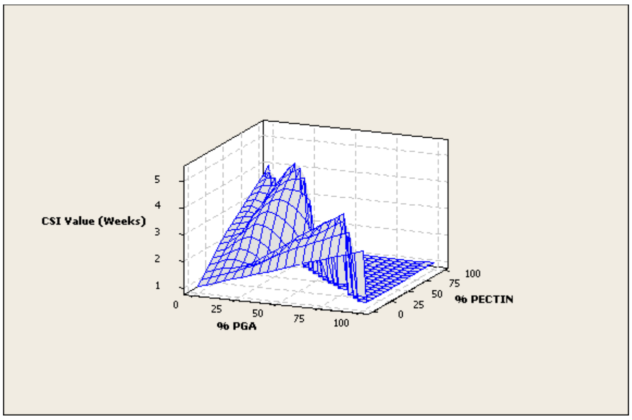

Figure 4: Graphical model of propylene glycol alginate (PGA) and pectin combination.

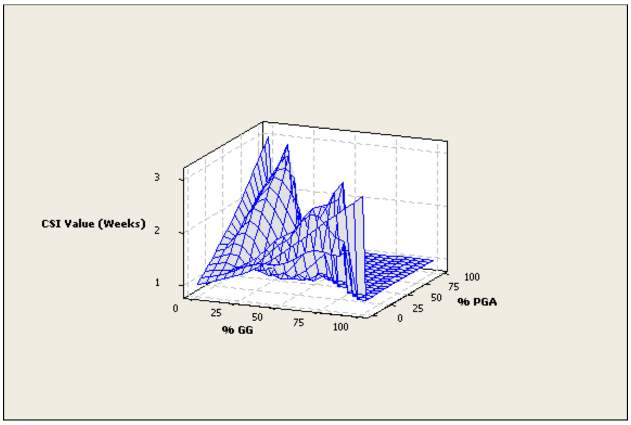

Figure 5: Graphical model of guar gum (GG) and propylene glycol alginate (PGA) combination.

Figures 6, 7, 8, 9, 10, and 11 show the average results which involved the combination of guar gum (GG) + xanthan gum (XG), propylene glycol alginate (PGA) + xanthan gum (XG), pectin + xanthan gum (XG), guar gum (GG) + Arabic gum (AG), propylene glycol alginate (PGA) + Arabic gum (AG) and pectin and Arabic gum (AG), respectively. These figures indicated that by using these stabilizers, PGJD samples were able to maintain their colloidal stability for a maximum of 8 weeks before phase separation occurred during storage. The lowest CSI value (3 weeks) was recorded at a 100:0 mixing ratio and the highest CSI value (13 weeks) was shown by a 0:100 mixing ratio.

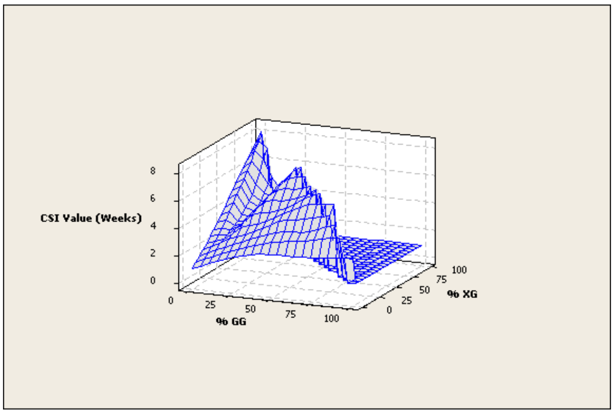

Figure 6: Graphical model of guar gum (GG) and xanthan gum (XG) combination.

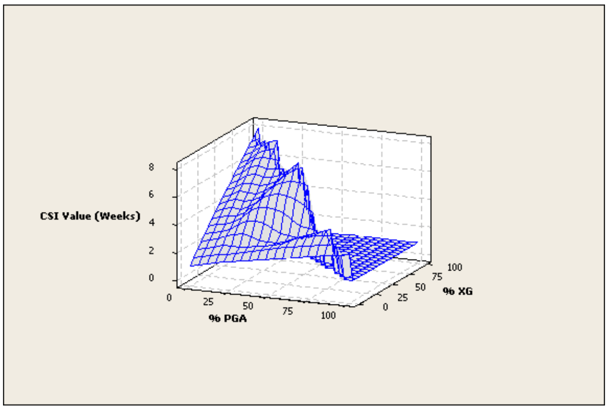

Figure 7: Graphical model of propylene glycol alginate (PGA) and xanthan gum (XG) combination.

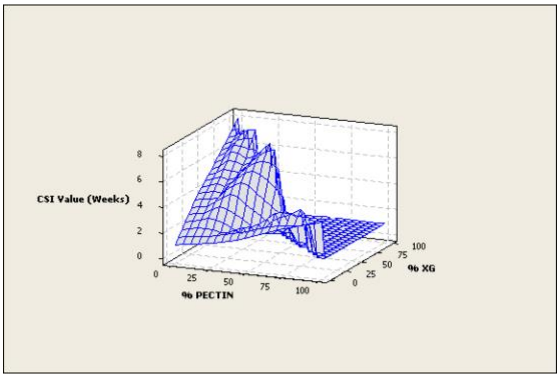

Figure 8: Graphical model of pectin and xanthan gum (XG) combination.

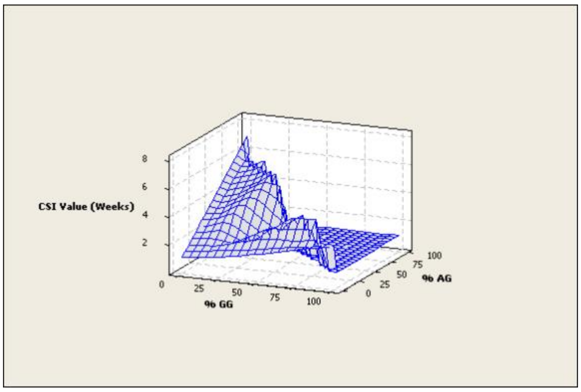

Figure 9: Graphical model of guar gum (GG) and Arabic gum (AG) combination.

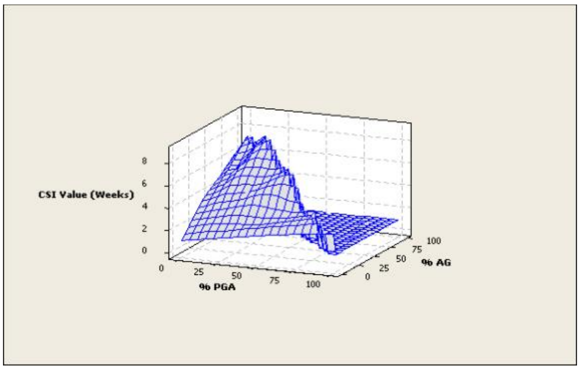

Figure 10: Graphical model of propylene glycol alginate (PGA) and Arabic gum (AG) combination.

It also indicated that PGJD samples that were applied with these stabilizers were able to maintain their colloidal stability for only 4 to 5 weeks before phase separation occurred during storage. Campoli et al. (2006) and Abliz et al., (2021) found that physical destabilization in fruit juice occurred due to several factors such as gravitational separation, flocculation, and Ostwald ripening (partial) coalescence, and phase inversion.

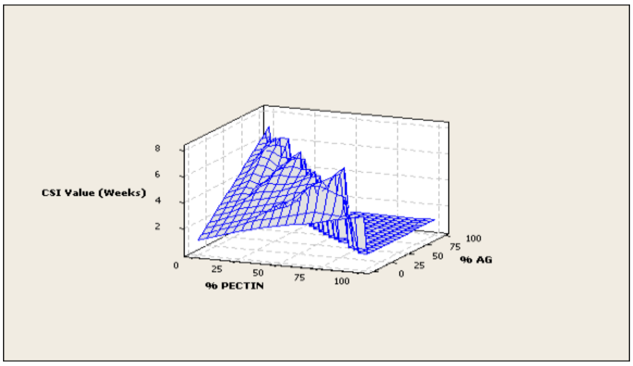

Figure 11: Graphical model of pectin and Arabic gum (AG) combination.

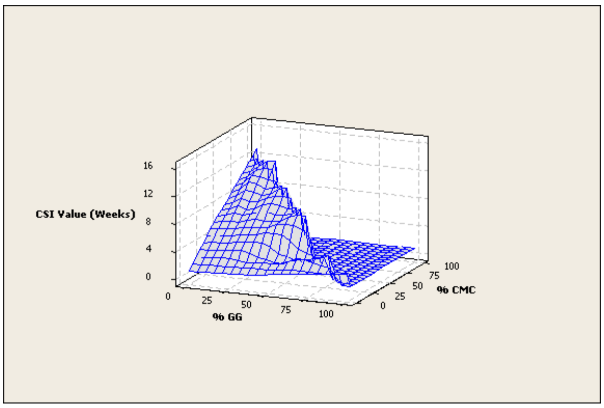

Figure 12: Graphical model of guar gum (GG) and carboxyl methylcellulose (CMC) combination.

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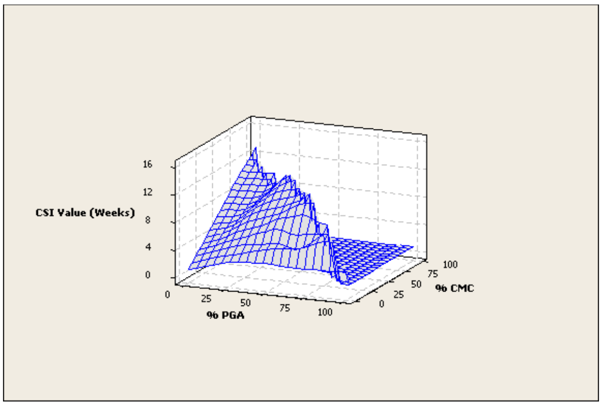

Figure 13: Graphical model of propylene glycol alginate (PGA) and carboxyl methylcellulose (CMC) combination.

The combination of guar gum (GG) + carboxyl methylcellulose (CMC), propylene glycol alginate (PGA) + carboxyl methylcellulose (CMC), pectin + carboxyl methylcellulose (CMC), Arabic gum (AG) + carboxyl methylcellulose (CMC) and Arabic gum (AG) + xanthan gum (XG) is shown in Figures 12, 13, 14, 15 and 17 respectively illustrate good result due to high CSI value achieved. They also indicated that PGJD samples that were applied with these stabilizers were able to maintain their colloidal stability for 13 weeks before phase separation occurred during storage at room temperature (28°C).

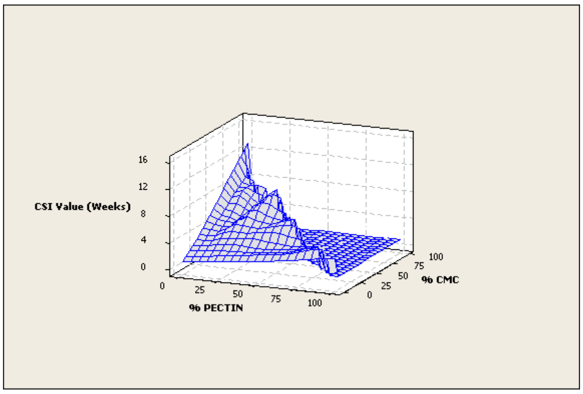

Figure 14: Graphical model of pectin and carboxyl methylcellulose (CMC) combination.

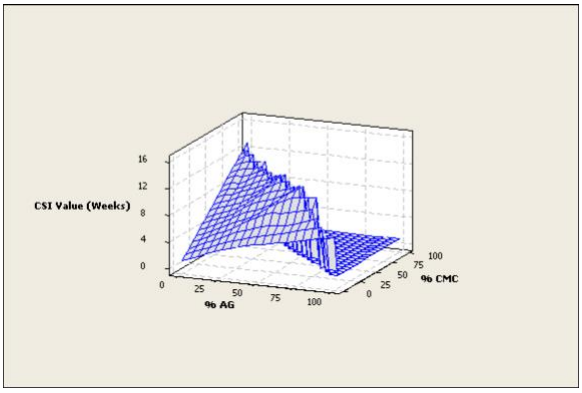

Figure 15: Graphical model of Arabic gum (AG) and carboxyl methylcellulose (CMC) combination.

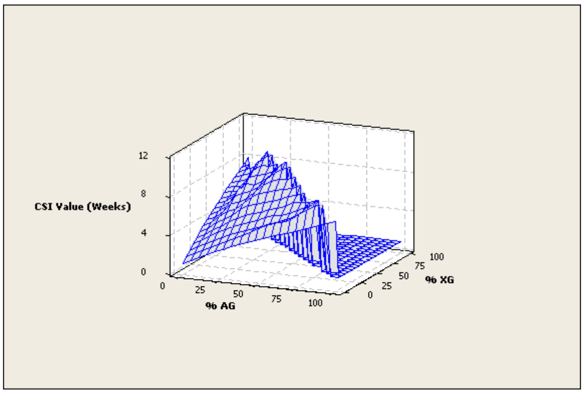

Figure 17: Graphical model of Arabic gum (XG) and carboxyl methylcellulose (CMC) combination.

The result in Figure 16 shows the combination of xanthan gum (XG) + carboxyl methylcellulose (CMC) and found to be the best and highly potential stabilizer due to the highest CSI value recorded at (17 weeks). It also shows that the synergistic effect between these two stabilizers occurred when the 70:30 mixture proportion was administered. The addition of stabilizers such as CMC and XG in the correct proportion will reduce the physical destabilization in PGJD, a direct result caused by the alteration of the electrostatic interaction and van der Waals interaction between molecules (Mirhosseini et al. 2008).

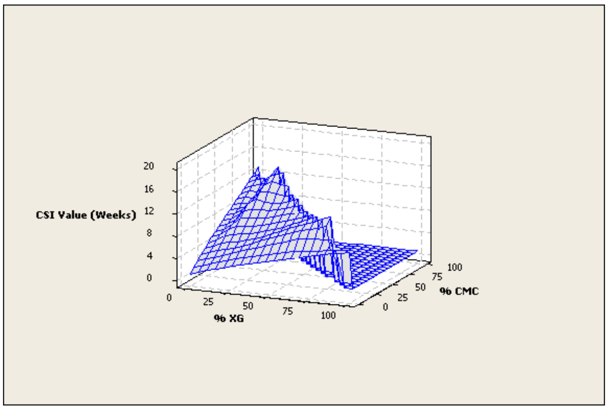

Figure 16: Graphical model of xanthan gum (XG) and carboxyl methylcellulose (CMC) combination.

In addition, all the results shown in Figures 3 to 17 show that without a proper stabilizer, PGJD itself could be very unstable where phase separation occurred in the only first week of storage. The combination of CMC and XG at a 70:30 ratio was able to prolong the CSI value for 17 weeks. Based on this result, CMC and XG were chosen for further analysis in this study.

3.2 Selection of emulsifier using emulsion stability index (ESI)

Based on the result in Figure 18, creaming of vitamin E was observed in the first week of storage for PGJD which had no emulsifier added to it. Results also

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showed that the addition of PGA in all concentrations was unable to stop the creaming of vitamin E from occurring in PGJD even at 19 weeks of storage. AG showed better performance compared to PGA in all concentrations but only at 1.0% (w/v) concentration of AG was sufficient to emulsify 300 mg/l of vitamin E for 24 weeks. Subsequently, P80 was found to be the best emulsifier compared to AG and PGA. P80 was able to completely emulsify vitamin E into PGJD at a minimum 0.8% (w/v) concentration. The concentration form was relatively lower compared to the concentration of AG used to emulsify vitamin E during 24 weeks of storage.

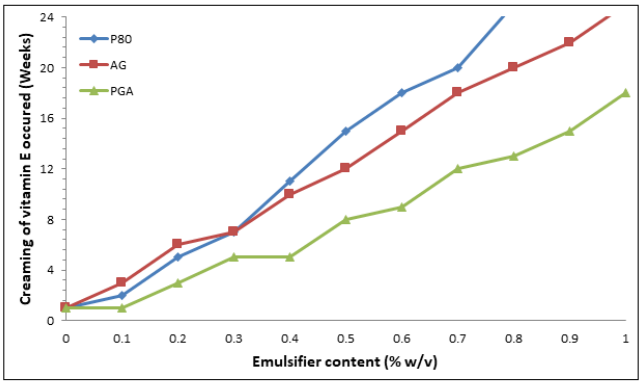
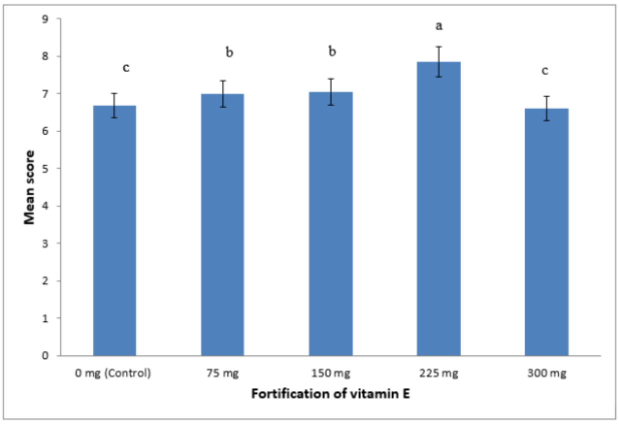


Figure 18: Creaming analysis of emulsifiers applied in PGJD.

According to Roy et al. (2021), P80 inherited several good characteristics such as high solubility in water, dissolved oil in water efficiently, did not alter viscosity, flavour, colour, and taste, produced good stability emulsion, and highly resistant to pH changes and it is also cheaper than AG and PGA. Rodriquez et al. (2021) stated that P80 are amphipathic non-ionic surfactants commonly used as an emulsifier, dispersant, and stabilizer in a wide variety of food, cosmetic and pharmaceutical products. P80 too is normally added to ice cream to facilitate solubilization of poorly soluble materials and to enhance the stability of emulsions. Therefore, based on the result stated above, P80 was chosen as an emulsifier for further analysis in this study.

3.3 Consumer acceptability of vitamin E fortified PGJD

Figure 19 shows that the highest overall acceptability score was recorded on PGJD fortified with 225 mg vitamin E (7.85 ± 1.03) and there are no significant differences ($p < 0.05$) between overall acceptability for PGJD fortified with 75 mg (6.99 ± 0.53) and 150 mg vitamin E (7.05 ± 0.22). Meanwhile, PGJD fortified with 0 mg (6.68 ± 0.21) and 300 mg vitamin E (0.60 ± 0.31) also showed no significant differences ($p < 0.05$) in their overall acceptability value and from the panellists' point of view, the overall acceptance for this two PGJD samples were about the same. Based on the highest values of colour, taste, and overall acceptability results, vitamin E with an amount of 225 mg was chosen as the most suitable vitamin E content to be added to PGJD and will be used for further analysis. The selected amount of 225 mg was still below the Tolerable Upper Intake Level (UL) for children aged 4-8 years old. In addition, PGJD fortified with 225 mg of vitamin E was considered suitable and safe for human consumption from ages 4 years old and above.



Data are mean ± S.D. (n=50)
[a-c] Different letters in the same column indicate a significant difference at $p<0.05$

Figure 19: Sensory score on overall acceptability of PGJD fortified with vitamin E.

4. CONCLUSION

The results obtained from the series of trials derived from the combination of six stabilizers (Guar gum, Carboxymethyl cellulose, Arabic gum, Xanthan gum, Propylene glycol alginate, and Pectin) with three emulsifiers (Arabic gum, Polysorbate 80, and Propylene glycol alginate) showed that Xanthan gum and Carboxymethyl cellulose with 70:30 ratio together with 0.8% w/v of Polysorbate 80 gave the best emulsifying action. Sensory evaluation of the PGJD fortified with different concentrations of vitamin E (0, 75, 150, 225, and 300 mg/L) was performed where PGJD fortified with 225 mg/L vitamin E was most significantly preferred by the untrained panellist. This finding is significant and can be applied by beverage manufacturing industries to decide the best stabilizers and emulsifiers for their business.

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