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Development of Innovative Jelly Ball (hydro bead) to Reduce Dehydration Elderly

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ABSTRACT

Dehydration in the elderly increases the risk of incidence for various diseases, including slow recovery with underlying illnesses since the majority of human body is composed of water. Normally, the elderly received water from food and drinking water. However, increasing ages could make individuals vulnerable to dehydration due to physiological changes in the ageing process. The project aims to develop a complement product to resolve/reduce the elderly dehydration and promote water as well as antioxidants intake and make drinking water more interesting and enjoyable. The technology selected was spherification which is the technique that relies on liquid and gel formation while the taste and quality of the ingredients are still maintained. The ratio of sodium alginate and calcium lactate were evaluated to obtain the optimum product. The best formula of jelly balls for sensory test is orange juice containing jelly ball, which consisted of 3% calcium lactate and 0.5% sodium alginate. The final product was tested for sensory and rehydration evaluations at the two-nursing homes around Mahidol University (Nakhonpathom campus). For the clinical studies, the elderly had three jelly balls every meal for 30 consecutive days. It was found that 70% of the elderly were satisfied with the product. It was apparent that the product helped to alleviate the dry mouth issue, which was present in 66.7% of subjects. The frequency of urine in the elderly after ingesting jelly balls revealed that 30% of the participants had increased urination. The comments included refreshing, good taste, and fruity favour. The outcome shows that jelly ball product can improve dehydration in the elderly.

Keywords: Calcium Lactate/ Sodium Alginate/ Reverse Frozen Spherification/ Jelly Balls/ Encapsulation

Introduction

The ageing population is growing at a rapid pace, and this could result in the primary health issue as health is the mostly deteriorate condition in adult. Illness in the elderly frequently coexists with malnutrition, particularly in conditions that reduce appetite. The diet affects good health, and the nutritional needs of the elderly vary while the water requirements are identical. Water is a crucial ingredient in most of the metabolism in our body. Normally, people fail to consume enough water, and their hunger is reduced which could be due to dehydration. Dehydration is another symptom that can happen when the human body loses more water than it consumes. [Seladi-Schulman J., 2020]. Dehydration is more common as we age because the amount of fluid in our bodies decreases, putting them at a higher risk for complications that include loss of balance, kidney problems, and a lowered thirst response, leading these individuals to not recognize of whether they are thirsty or are drinking water, or have drunk water [Seladi-Schulman J., 2020]. All of these problems have been overlooked for many years and there are many treatments that involve replacing the fluids that have been lost. There are many foods to alleviate dehydration, as well as drinking water or foods that contain high water content, such as juice, broths, or fruits. Thus, innovation is required to prevent and lower dehydration in the elderly. Jelly balls are the hydro bead made from jelly containing water and phytochemicals inside. The viscosity of the liquid should be sticky and varied in size to ensure the elderly can easily hold and swallow it.

The period of time for consume the jelly balls should be consumed is between meals and before bedtime, due to the fact that given during meals, patients would consume less food. To increase acceptance, supplementary food and supplement liquid might need to be in a different form, smell, and flavor, and the color is an additional appealing characteristic that may stimulate hunger. Therefore, jelly balls (hydro bead) can address difficulties and fulfill the demands of the elderly. Therefore, this project aims to develop jelly balls that will not only provide liquids to reduce hydration in elderly but additionally include a combination of dietary fiber and plants phytochemical. The intent use of this jelly ball is that if the elderly become unwell by obtaining sufficient nutrition,

they will recover faster, resulting in a healthy old society, minimizing the cost of treatment and medical care, and improving the well-being of the elderly

Purposes

1. To create an innovation for solving the problem of dehydration in elderly, especially in dementia and bedridden patients.
2. To create long terms and durable health solution for elderly by reducing dehydration which is a factor in maintaining the efficient functioning of the body.
3. To establish the prototype product for develop the product to solve the nutrition problem for elderly by decrease dehydration and increase the appetite, including reducing the incidence of disease or illness which are a cycle of dehydration and malnutrition.

Research Methodology

1. Materials and sample preparation

The chemicals sodium alginate, calcium lactate, and calcium gluconate were purchased from Chemipan Co., Thailand. All the chemicals used in this study were food-grade. Oranges were purchased from the local market. Calcium lactate was mixed in different concentrations with different levels of sodium alginate (0.5, 0.8, and 1% w/v) at different gelling time intervals to study the effect on the size, shape, and wall thickness of the balls. To remove bubbles, sodium alginate was combined with boiling water (70 °C) and processed in a blender, then wrapped and cooled (4 °C) for 2–24 hours [Gaikwad S., Kulthe A., and Suthar T., 2018].

2. Spherification process

To make flavoring water balls, orange juices were mixed with calcium lactate solutions and xanthan gum was added and stirred until dissolved. The mixture was poured into the mold and place it in the freezer (-20 °C) overnight. After that, the frozen juice balls were removed from the mold and soaked in an alginate bath. The jelly balls were rinsed with water and stored at 4 °C prior shipped to nursing home. [Suktanarak, et al., 2021].

3. Spherification jelly ball evaluation

3.1 Setting time

The gelling time is the amount of time it takes for the alginate beads to create gel. Calcium lactate balls were made by dropping the dispersion into a solution of sodium alginate and allowed it to harden for varied time periods (12,16 and 20 minutes) to investigate the time required to create gel [Smardel P, Bogataj M, and Mrhar A., 2008].

3.2 Characterization of jelly ball

The calcium balls were evaluated for their diameter and gel membrane thickness. The diameter and gel membrane thickness of the balls were measured by using vernier caliper, the balls were cut to remove the liquid inside, while the coating membrane was washes with water and its thickness was measured using a vernier caliper [Santhi, K., et al. (2013)].

4. Determination of color

Samples were analyzed color by using ColorFlex EZ Spectrophotometer (HunterLab, USA). Three replicates for each sample were randomly selected for the tests. The standard color scale used was CIELAB with parameters L* (lightness/darkness), a* (+ a = redness, - a = greenness), and b* (+ b = yellowness, - b = blueness) [Bubin, et al., 2019].

5. Chemical quality evaluation

Jelly balls were taken to measure the pH value by a pH meter, pH/Cond meter SevenDirect SD23, Mettler Toledo. Total soluble solid was measured by master refractometer (ATAGO), Tokyo, Japan

6. Sensory evaluation

The jelly water balls were evaluated for sensory attributes by elderly panelists. Semi-untrained judges using a 5-point Hedonic scale system for different parameters such as color, flavor, taste, ease of eating, and overall acceptability. Approximately 30 people were involved in the research and the amount of time was taking to participate in the food tasting test and rate their preferences on the assessment form was about 20 minutes. The 30 mL of jelly ball was served 5 minutes after the meal for breakfast, lunch and dinner . The amount served were 3 balls per meal. [Gaikwad S, Kulthe A, and Suthar T., 2019]. Ethical approved by Mahidol CIRB (2022/191.1207).

7. Clinical evaluation

The measurement of dehydration was self-perceived levels of dry mouth, thirsty, and frequency of urination before and after received jelly balls for 30 days, which were evaluated using a by using a 3-items questionnaire (color of urine, frequently of thirst and dry mouth). (CNAQ; Appendix A) [Wilson, et al., 2005]

Results

1. Final formulation and physical characteristic of Jelly ball

According to the preliminary study "Effect of Guar Gum on the Stability and Physical Properties of Orange Juice," 0.1% guar gum mixed with 0.03% CMC created the optimum formulation for the stability and physical properties of orange juice [Mysweetdelights, 2013]. As a result, these two emulsifiers were likewise being employed in fruit juices. The final juice was orange juice mixed with 0.1% xanthan gum, 0.1% guar gum and 0.03% of CMC, and has modified in the percentages of calcium lactate from 3% to 1% for a better flavor.

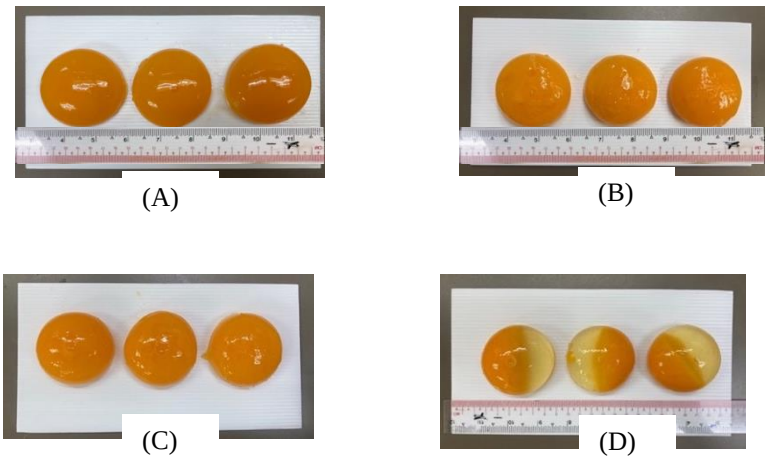

Figure 1. Orange juice balls on Day 0 (A), 1(B), 3(C), 7(D) kept at 4 °C

The jelly ball that are freshly made showed homogenous orang color and well-round shape with flexible texture. After sore for 1and 3 day, the orange color become fader but the homogeneity is maintained. At day 7, the separation phase was occurred. The distingue 2 zones can be seen including clear and orange parts. This could be due to the presence of pectin, fiber in orange juice. This phase separation could be reduced by further separate liquid and solid from the orange juice.

Table 1. Color analysis of jelly balls at different day (day 0,1,3,7).

To further determine the color change in jelly ball which is one of the important factors to increase appetite of elderly. Vibrant color should be maintained.

Day	L*	a*	b*
0	38.04 ± 0.16^{ab}	6.84 ± 0.31	30.30 ± 0.56^{a}
1	38.90 ± 0.40^{bc}	7.64 ± 0.53	30.69 ± 0.82^{a}
3	37.38 ± 0.25^{a}	7.72 ± 0.80	29.07 ± 1.44^{b}
7	40.18 ± 0.86^{c}	8.45 ± 0.80	34.07 ± 1.56^{a}

Values are mean ± SD (n = 3).
Superscript small letters shown the significant difference between day.

From Table 1, the lightness of the jelly significantly increased, while the a* which indicated red and green coordinate was not significantly different while b* which indicated yellow and blue show significantly reduction in yellow. This chemical reaction is due to carotenoid degradation and isomerization reaction which could be prevent by addition food additive to prevent oxidation.

Table 2. Physical property of jelly balls stored at different day (day 0,1,3,7).

It is important to study the shelf life and jelly ball stability as the balls are likely to store for a few days' prior consumption. It is then to ensure that the physical property changes will be acceptable for the elderly.

Day	0	1	3	7
Size (W x L x H)	65.27 ± 0.70^{c} 64.00 ± 0.89^{c} 26.83 ± 1.65	60.93 ± 0.46^{b} 60.37 ± 0.72^{b} 25.77 ± 0.61	61.93 ± 0.78^{b} 59.90 ± 0.70^{b} 26.87 ± 1.61	58.67 ± 1.03^{a} 57.23 ± 1.27^{a} 28.07 ± 0.49
pH	4.16 ± 0.01^{b}	4.15± 0.00^{b}	4.15± 0.01^{b}	4.09± 0.01^{a}
TSS (Total soluble solid)	8.07 ± 0.29	8.05± 0.30	8.43± 0.06	8.43± 0.12
Thickness (mm)	0.30 ± 0.00	0.30 ± 0.00	0.30 ± 0.00	0.30 ± 0.00
Water (mL)	50.00 ± 0.00^{b}	49.33± 0.58^{b}	48.00± 1.73^{ab}	45.67± 1.15^{a}

a. Values are mean ± SD (n = 3).
b. Superscript small letters shown the significant difference between day.

The overall size of the jelly balls was not significantly different from day 0 to day 7. There was also no change in pH and total soluble solid. In addition, the water content inside jelly ball slightly decreased but was not significant different among those days. This is as expected as jelly ball was stored in the liquid solution hence it was considered as close system with same diffusion gradient. Therefore, the jelly ball appearance except colour was stables and suitable for consumption.

2. Clinical evaluation

According to the "jelly ball for the elderly" survey, which had 30 untrained subjects, all of them were from Thailand nursing homes. In the jelly ball for elderly research, we focus on managing elderly dehydration by employing a jelly ball product. After 30 days of clinical studies with 30 individuals, within 53.3% being female and 46.7% being male. The elderly were divided into three age groups: 30% between the ages of 60 and 69, 36.7% between the ages of 70 and 79, and 63.3% over the age of 79. 83.3% of the 30 participants have a congenital disease such as hypertension, dyslipidemia, diabetes mellitus, cerebrovascular accident, or Alzheimer.

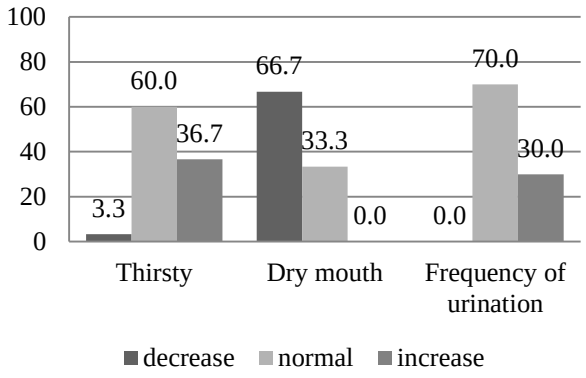

Figure 2. Dehydration test in elderly

After 30 days of clinical studies with 30 individuals, it was discovered that 60% of subjects had normal circumstances in the thirsty portion, 36.7% got thirstier, and only 3.3% decreased. Furthermore, it was apparent that the jelly ball helped to alleviate the dry mouth issue, which was present in 66.7% of subjects. Finally, the frequency of urine in the elderly after ingesting jelly balls revealed that 30% of the participants had increased urination while the other 70% were in normal condition.

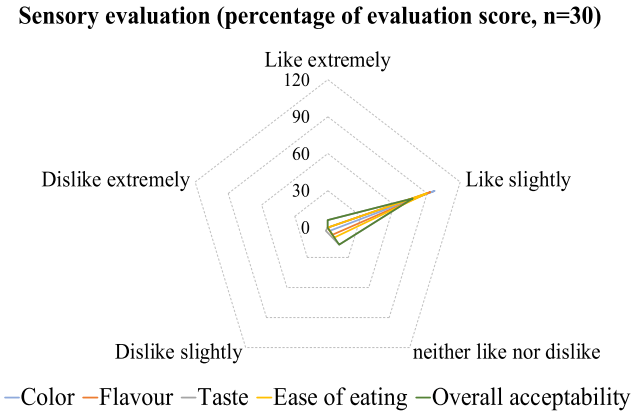

Figure 3. Sensory evaluation of orange jelly balls by spherification method

According to Fig 3, 97% of participants liked the color of the jelly ball slightly, while 3% did not enjoy it at all. Moreover, it is shown that 93% of participants are slightly liking jelly ball flavor, and 7% are neither liking nor disliking it. Out of 30 participants, 77% and 90% showed that they liked the taste of orange jelly balls slightly and that they were comfortable consuming them, respectively. However, 10% and 17% in taste and comfort to consume are neither liked nor disliked. According to the outcomes 6% of customers who dislike the taste of jelly balls. Furthermore, 77% of clients were like a slightly orange jelly ball in terms of overall acceptance. Only 6% of consumers dislike it slightly. In terms of acceptance, 77% of participants approved the product in all characteristics, including color, flavor, taste, eating comfort, and overall acceptability (Figure 3).

Discussion

1. Optimal formulation of jelly ball

According to the result, when increase the concentration of calcium lactate and sodium alginate it also increased the process of gel formation. Furthermore, the ratio of Mannuronic acid to Glucuronic acid, which is a component of sodium alginate, influenced gelation; generally, the calcium concentration controlled the size of the sphere. The increased in gel binding resulted in a decrease in the diameter of the alginate beats. As the calcium concentration increases, the gel constricts more, forcing the sphere size to maintain a more spherical form [Dholvitayakhun and Pumpho, 2018]. It can be concluded that using 3% of calcium lactate provided the good shape when using with 0.5% of sodium alginate. As a final product, the orange jelly balls were reduced in size from large to small. The reduction in sized resulted in reduce of total liquid volume from 50 to 30 mL.

As the result shown (Table 1) that within 7 days water inside slightly leached out, this might be due to the surface tension and consequent form was affected by the density of the flavored liquid and the shape of the bath. It is recommended the density and viscosity of the liquid should be adjusted. If the flavored liquid was too thin, it will not penetrate the thick bath surface, spread and could lose its form. It was not rounding evenly enough to produce an appealing spherical shape if it was too thick. As a result, thickening of the juice is desired to give the right consistency. Xanthan gum is often used to thicken the flavored liquid until it reaches the proper viscosity. A sodium alginate bath was also used to bridge the density gap [Santi, 2012] and it shown that 0.1% of xanthan gum can help the ball retained water up to 7 days. To summarize, the optimal conditions was spheres in 1% sodium alginate with 0.5% sodium alginate in 12 minutes had a perfect condition.

2. Spherification process

Preliminary result will be discussed and followed with the final formulation. At first, herb juice were selected, after using the herb juices with calcium lactate, the main problem with both herb drinks was the color change. It was noticed that after encapsulating herb water, the color changed when exposed to room temperature, This might happened because of the flavonoids in chrysanthemum tea was particularly unstable and oxidized after soaking for an extended period of time [Canavida , 2022]. Other characteristics remain consistent. As a result, the concentration of xanthan gum that should be applied to the jelly ball must be 0.1% since it is close to the viscosity of water combined with xanthan gum. In the following step, fruit juice was selected and the first fruit juice that were used is watermelon juice. Watermelon juice was separated after squeezing the juice and setting it down for a few minutes, this might be due to that watermelons contain water, sugar, electrolytes, and vitamins. Water and sugar separated from the electrolytes and vitamins when watermelon juice is allowed to sit. This is due to the fact of water and sugar contain a higher density than electrolytes and vitamins. Gravity induces the separation of water and sugar from electrolytes and micronutrients.

After all of experiment, the final juice was orange juice which changed from 3% to 1 % of calcium lactate for a better taste and mixed with 0.1% xanthan gum, 0.1% guar gum and 0.03% of CMC. The orange jelly balls that had not been pasteurized had an excellent color and scent, no sediment, and slowly separates but for consumer safety, pasteurization is needed. It may eliminate organisms that decompose and passivate enzymes that can induce chemical changes in orange juice (75°C, 15 minutes in a water bath). The taste of orange juice after pasteurization tastes different; it had a unique taste and flavor change but can still be appealing to consume. This might be due to the duration and processing at high temperatures in pasteurization, which result in a negative impact on flavor, color, and nutrition due to heat induced chemical reaction.

3. Physical and color analysis of final jelly balls

For the color shown on Table 1 on day 7, balls are lighter than on days 0–3, with a greater amount of red and green. On Day 1, the juice inside the balls began to separate slightly, and by Day 7, the juice was completely separated. As seen by the pH value, the pH value decreases during the course of 7 days. These pH drops may be caused by the activity of some bacteria and the conversion of sugar to small amounts of alcohol and acids, or by the sedimentation of some electrolytes during storage [S. Elshehawy, T. M.M.M and H. D.M.A., 2010**].** According to the data (Table 2), size, pH, TSS, thickness, and water levels did not alter substantially during a period of seven days (Figure 1). However, the size of the orange jelly balls was too large for consumption, so the researcher chose to reduce the size from 50 ml balls to 30 ml balls to make them easier to consume and handle.

4. Clinical evaluation

In term of clinical evaluation was discovered that 60% of subjects had normal circumstances in the thirsty portion, 36.7% got thirstier, and only 3.3% decreased (Figure 2) And for sensory evaluation in a jelly ball for the elderly, for like of fresh orange juice jelly ball, a facial 5-point hedonic scale was chosen. Color, flavor, taste, eating comfort, and general acceptability are all factors. In term of sensory, 93% of participants are slightly liking jelly ball flavor. The rise in percentage indicates that the flavor of jelly balls is derived from freshly pressed juice, which provides natural flavor from the fruit. And 90% showed that they liked the taste of orange jelly balls slightly and that they were comfortable consuming due to the small size and proper portion of jelly balls. Pasteurized orange juice had a slightly different flavor than fresh orange juice and 6% of consumers were dislike it slightly. The major reason why some customers dislike the jelly ball was due to the flavor and overview of pasteurized orange juice. To be concluded 77% of participants satisfied with the product in all characteristics.

Conclusions

In accordance with this study, the concentrations of sodium alginate were used at 1% calcium lactate with 0.5% sodium alginate it had a perfect thickness and shape, to increase the density inside the balls, using xanthan gum to reach the appropriate viscosity. The fruit juices had been chosen by adding 0.03% CMC, 0.1%guar gum, 0.02% xanthan gum, and 1% calcium lactate. The orange juice had the greatest results in size, pH, TSS, thickness, and water levels, which did not change much during a period of seven days. Also, the color balls are lighter than on days 0–3. On the sensory part, the survey consisted of 30 participants, all of whom were from Thai nursing homes, with 53.3% being female and 46.7% being male. The elderly were divided into three age groups: 30% between the ages of 60 and 69, 36.7% between the ages of 70 and 79, and 63.3% over the age of 79. 83.3% of the 30 participants have a congenital disease such as hypertension, dyslipidemia, diabetes mellitus, cerebrovascular accident, or Alzheimer's. After 30 days of clinical studies, it was discovered that 60% of subjects had normal circumstances in the thirsty portion, 36.7% got thirstier, and only 3.3% decreased. Furthermore, it was

apparent that the jelly ball helped to alleviate the dry mouth issue, which was present in 66.7% of subjects. Finally, the frequency of urine in the elderly after ingesting jelly balls revealed that 30% of the participants had increased urination while the other 70% were in normal condition. According to the color results shown, 97% of participants liked the color of the jelly ball slightly, while 3% did not enjoy it at all. Moreover, it is shown that 93% of participants are slightly liking jelly ball flavor and 7% are neither liking nor disliking it, and out of 30 participants, 77% and 90% showed that they liked the taste of orange jelly balls slightly and that they were comfortable consuming them, respectively. Pasteurized orange juice had a slightly different flavor than fresh orange juice. According to the outcomes, the jelly ball serving size was appropriate for the elderly due to its small size and proper portion.

Recommendations

This study show the promising Jelly ball (hydro bead) prototypes can be used as an alternative food supplement product to increase water intake of elderly. It is shown that it this jelly ball can effectively reduce dehydration in elderly as well as reduce mouth dryness. Further study such as the effect of long term consumption it 60 days or 90 days and enhance of shelf life are recommended.

References (APA 7th edition)

Bubin, S., Ali, S., Shukri, R., Wan Ibadullah, W. Z., Ramli, N., Mustapha, N. A., & Ismail-Fitry, M. R. (2019). Characterization and stability of pitaya pearls from hydrocolloids by reverse spherification. *International Journal of Food Properties*, *22*, 1353-1364.

Canavida. Little knowledge of fetal chrysanthemum 2022 [Available from: https://canavida.ca/en/blogs/news/%E8%83%8E%E8%8F%8A%E5%B0%8F%E7%9F%A5%E8%AF%86#:~:text=The%20freshly%20brewed%20tea%20is,tea%20will%20be%20greatly%20reduced.

Dholvitayakhun, A., & Pumpho, W. (2018). Mock Pomegranate Seeds Dessert (Tab Tim Grob) Production using Frozen Reverse Spherification Technique. *Journal of Food Technology, Siam University*, *13*(2), 49–59.

Elshehawy S, M.M.M T, D.M.A H. Changes in chemical and nutritional quality during cold storage of some fruit and vegetable juice blends. J of Food & Dairy Sciences, Mansoura University. 2010;1:181-91.

Gaikwad, S., Kulthe, A., & Suthar, T. (2019). Characterization of flavoured sweet water balls prepared by basic spherification technique. *7*, 1714-1718.

MySweetDelights. Molecular gastronomy introduction 2013 [Available from:https://themoleculargastronomyadventure.wordpress.com/2013/12/05/molecular-gastronomy-introduction/.]

Santhi, K., So, D., Ali, A., & Sherina, M. (2013). Formulation and evaluation of Nifedipine microbeads using Guar gum as a release modifier. *International Journal of Pharmaceutical Sciences Review and Research*, *21*, 270-275.

Seladi-Schulman J. The Causes and Symptoms of Dehydration in Older Adults 2020 [Available from: https://www.healthline.com/health/symptoms-of-dehydration-in-elderly.

Smrdel, P., Bogataj, M., & Mrhar, A. (2008). The Influence of Selected Parameters on the Size and Shape of Alginate Beads Prepared by Ionotropic Gelation. *Sci Pharm*, *76*, 77-89.

Suktanarak, S. ., Kajunsri, N. ., Suwantuppa, S. . ., & Waiyapoka , B. . (2021). Producing Bubble Dragon Fruit Peel with Pineapple Juice Using Reverse Spherification Technique. *Rajamangala University of Technology Tawan-Ok Research Journal*, *14*(1), 25–31.

Smrdel, P., Bogataj, M., & Mrhar, A. (2008). The Influence of Selected Parameters on the Size and Shape of Alginate Beads Prepared by Ionotropic Gelation. *Sci Pharm*, *76*, 77-89.

Wilson, M. M., Thomas, D. R., Rubenstein, L. Z., Chibnall, J. T., Anderson, S., Baxi, A., Diebold, M. R., & Morley, J. E. (2005). Appetite assessment: simple appetite questionnaire predicts weight loss in community-dwelling adults and nursing home residents. *The American journal of clinical nutrition*, *82*(5), 1074–1081.