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Research Article

Effect of Incorporating Functional Ingredients on the Physicochemical Properties of Pandan Pudding for the Elderly Population

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Abstract

Background: As the population grows older, it is more important to take initiatives in terms of health care for the older population, as healthy aging is the ultimate goal of aging research and public health strategy. So, based on the study, there is a significant opportunity to expand on innovative ingredients and new product development, which determines the achievability of incorporating functional ingredients in the development of pandan pudding for the elderly population. The effect of including functional ingredients like SCF, astaxanthin, monk fruit sweetener, and different SPI quantities on the developed product's physicochemical properties was studied. **Methodology:** Four formulations of pandan pudding containing 0, 4, 6, and 8% SPI levels and fixed concentrations of SCF, astaxanthin, and monk fruit sweetener were prepared. The physicochemical properties evaluated were pH value, total soluble solids water activity, color, texture, and syneresis. **Results:** The control and F1 showed the highest water activity of 0.98±0.02, and F3 had the highest 8.00±0.00 total soluble solids. Compared with the control, F3(8%SPI) has a pH of 7. In terms of color, the F1, F2, and F3 showed a significant difference. Meanwhile, texture profile analysis of the control showed the highest hardness of 403.5±68.60. **Conclusion:** In conclusion, incorporating F2 (6%SPI) in pandan pudding would effectively develop a nutritious and healthy product for healthy aging.

Keywords: Functional food, Pudding, Soy Protein Isolate, Soluble Corn Fiber, Healthy aging

Introduction

The global population aged above 60 years numbered 962 million in 2017, which is more than twice as large as in 1980, when there were 382 million older persons worldwide. In 2050, the number of older persons will double to almost 2.1 billion. This is due to the decline in fertility and an increase in longevity. Meanwhile, the number of persons aged 80 years or above is projected to increase more than threefold between 2017 and 2050, rising from 137 million to 425 million **(United Nations, 2017)**. It showed that in Malaysia, the number of aged people increased from 10 % in 2018 to 10.3% in 2019. According to the **United Nations (2017),** 35 % to 40 % of the cannot feed daily, and the skipped meal is due to loss of appetite, also known as "Anorexia of aging." About 50% to 70% of the elderly had a risk of malnutrition when they were hospitalized due to decreased appetite, gastrointestinal system diseases, and chronic disease **(Norman et al., 2021).**

Healthy aging is the ultimate goal of aging research and public health strategy **(WHO, 2016)**. As the population grows older, it is more important to take initiatives in terms of health care for the older population. Considering all the negative health aspects of older people, providing a supplement that can improve a healthier life is very important. A balanced and optimal energy supplement would be beneficial for healthy aging. **(Granato et al. 2010).**

Consumers are becoming health conscious of functional foods and superfoods, particularly whole foods with exceptional health benefits. So, plant extracts are used in conventional foods for their functional properties, which have been evident for years due to experience with age-related health issues **(Sabaragamuwa et al., 2018).** Functional foods can be referred to as supplements that result in the enhancement of function and improved health. Consumer awareness of health and wellness is the key driving factor in developing new products for foods such as pudding and desserts **(Guiné et al., 2020).**

The application of soy proteins in this new proposed product is because it is highly nutritious and has desirable functional properties **(Wang et al., 2015)**. It is also important as it can replace animal protein **(Lima et al., 2022).** The soluble corn fiber can increase the fiber content and increase calcium absorption. The absorption greatly enhances calcium utilization and bone strength properties **(Whisner et al., 2014).** Astaxanthin, a carotenoid pigment, is an antioxidant with anti-inflammatory properties and, as such, has potential as a therapeutic agent. Pandan leaves are commonly used to enhance flavor, desserts, sweets, coconut jam, and ice cream. Due to the high chlorophyll content, pandan leaves are a popular green colorant for food and have high antioxidant content **(Ghasemzadeh & Jaafar., 2013)**. Carrageenan is a polysaccharide extracted from certain red seaweed species **(García Tasende & Manriquez-Hernandez, 2016).**

In the food industry, carrageenan is used because of its physical functional properties, such as thickening, gelling, and stabilizing abilities. It is also used to improve cottage cheese's texture and control the viscosity and texture of puddings and dairy desserts **(Pekan & Tari, 2008).** Among the commercially available carrageenans, kappa and elderly iota carrageenans have gel-forming properties. Kappa carrageenan is categorized as a thickener agent, while Iota carrageenans have gelling properties **(Pekan & Tari.,2008)**. Monk fruit sweetener was used medicinally as an expectorant, cough remedy, and for respiratory ailments. It was also utilized for constipation, diabetics, and to clear heat from the body **(Pandey & Chauhan, 2020)**. It contains a mixture of curcurbitane-type triterpenoid saponins known as mogrosides). It is reported that it is 100 to 250 times sweeter than sugar. It also has exhibited antihyperglycemic effects **(Mooradian et al., 2017).** It is also called a non-nutritive sweetener **(Li et al., 2015)**. Low-calorie sweetener indicates that it may reduce body weight **(Miller & Perez, 2014).** Studies also show that mogrosides have antioxidant and anti-inflammatory properties **(Chen et al., 2017).**

In this study, the goal was to create a functional pudding designed to meet the dietary needs of elderly consumers. This was achieved by incorporating soy protein isolate, soluble corn fiber, astaxanthin, pandan, and monk fruit sweetener. So, these ingredients were chosen to enhance the pudding's protein and fiber content while reducing its overall sugar level, providing a healthier alternative for older people.

Materials and Methods

Source

In the preparation of Pandan pudding, the ingredients used were soy protein isolate (SPI) (Aqurate Ingredients), soluble corn fiber (SCF) (Aqurate Ingredients), Astaxanthin (Xi'an DN Biology Co., Ltd), Monk fruit sweetener (Aqurate Ingredients), Fine granulated sugar (MSM Prai Berhad Semenyih), whole milk powder (Promac enterprises Sdn Bhd), Iota carrageenan (Xi'an DN Biology Co., Ltd), Kappa carrageenan (BIS Chemicals Sdn Bhd), Pandan flavoring (Star Brand), Apple green coloring (Star Brand), and water.

Preparation of Pandan Pudding

The production procedures and formulation of pudding preparation were based on **(Ares et al., 2009)**. The dry ingredients, including sugar, carrageenan, and whole milk powder, were weighed individually and then mixed into a beaker containing distilled water and mixed with a magnetic stirrer. To hydrate the carrageenan, the dispersion was left for 10 minutes. Then, the other ingredients, such as soluble corn fiber, soy protein isolate, and astaxanthin, were added. Consequently, the mixture was continuously stirred by heating at 90℃ for 8 minutes in a water bath. If any foam arises, it is removed with a spoon.

All samples were placed into plastic cups (5.5 cm in diameter and 3.5cm in height) covered with lids to avoid dehydration. The puddings were allowed to cool at room temperature (25 °C) and then stored in the refrigerator for 4 °C to 5 °C before the physicochemical and proximate analyses. The control formulation does not have the soluble corn fiber, soy protein, and astaxanthin, and the monk fruit sweetener was replaced with sugar.

Physico-chemical Analysis

Water activity: The water activity of pandan pudding for all the formulations was determined using the water activity meter (AquaLab, Model: AquaLab Pre, USA).

pH value: The pH value of all the pandan samples was measured by blending 10g of the sample in 50 ml of distilled water. The pH meter was calibrated using pH 7, pH 10, and pH 4 buffer solutions based on the operating manual **(Jenway 2013)**. Insert the digital pH meter to record the reading (Jenway, Model: 3505, UK). Before immersing the other samples, the electrode of the pH meter should be cleaned.

Total Soluble Solids (TSS): The total soluble solids content of pandan pudding was measured using a refractometer (Fisher Scientific, Model: 13-946-22, UK) with the scale range from ˚0 to ˚32 and expressed as ˚Brix based on AOAC Method 321.12 **(AOAC 2000)**.

Color Analysis: The color of the pandan pudding was measured in a HunterLab Colorflex EZ. The samples were measured one at a time. Reflected color (specular component excluded, D65 illuminant, 10˚ observer angle) was measured. And the results were expressed based on CIE Lab-scale parameters: L* [lightness, 0 = black, 100 = white], a* [greenness (−), redness (+)] and b* [blueness (−), yellowness (+)] **(Figueroa & Genovese, 2019)**.

Texture Profile Analysis: The texture of pandan pudding was analyzed based on the procedure given by **Korus et al. (2015)** using a Brookfield CT3. Firstly, the TA 5 (12.7 mm D, 35 mm L) cylinder was fixed. The pudding sample was placed on the table of the texture analyzer and was compressed with a cylinder to a penetration depth of 25 mm in diameter with a speed of 1mm/sec. All the experiments were conducted at a room temperature of 20℃. This cycle was performed twice for the same distance and speed. From this, two cycles of compression and de-compression will lead to parameters such as hardness, cohesiveness, springiness, and adhesion.

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Syneresis: Syneresis is the contraction of the gel upon storage and separation of water from the gel. It is more pronounced in gels with a lower concentration of the gelling agent. All the pudding was observed for signs of syneresis at 4℃ for one week **(Prakash et al., 2014).**

Statistical Analysis

Once the data was collected, the results were analyzed using the Minitab 18 statistical software for Windows. The data obtained were expressed in terms of means ± standard deviation of all formulated pandan pudding measurements. The results were analyzed using one-way analysis of variance (ANOVA) and Tukey's honest significant difference test (HSD) to determine the statistical difference among the groups. The considerable differences in analyses were indicated by $P < 0.05$.

Results and Discussion

Water activity

Water activity (aw) is known to be a fundamental parameter for the stability of foods. Water activity measures how efficiently the water present can participate in a chemical (physical) reaction. The overall water activity would be reduced if half the water is so tightly bound to a protein molecule that it could not participate in a hydrolysis reaction **(Rifna et al., 2022)**. Presented in **Table 1** are the water activities of four different pandan pudding samples, including control. Based on the result, the water activity of the pandan pudding samples ranged from 0.96 to 0.98. The pandan pudding sample incorporated with monk fruit, astaxanthin, and 8% Soy Protein Isolate (F3) had the lowest mean water activity value. At the same time, control also had the same mean value as F3.F1 showed the highest mean value of water activity. From the control pandan pudding, all the formulated pandan pudding incorporated with soy protein isolate and soluble corn fiber were significantly different ($p<0.05$).At the same time, control and F1 are not significantly different ($P>0.05$). However, when the amount of soy protein isolate is increased, a decreasing trend in mean value is observed. Hydration capacity, solubility, colloidal stability, gelation, emulsification, foaming, and adhesion/cohesion are the main functional properties of soy proteins. The functional properties of proteins are controlled largely by their chemical and physicochemical properties, which, in turn, are influenced by their composition and processing and storage conditions **(Martins & Netto, 2006)**. On the other hand, due to their excellent ability to form and stabilize O/W emulsions, soy proteins are also widely used as emulsifiers in foods **(Wan et al., 2014)**.

Table 1: Physico-chemical properties of Pandan puddings incorporated with different amounts of SPI

Sample	Mean ± Standard deviation		
	Water activity	pH	Total Soluble Solids
Control	0.98±0.02[a]	6.81±0.03[b]	5.10±0.14[c]
F1	0.98±0.02[a]	6.96±0.07[a]	6.90±0.14[b]
F2	0.97±0.00[b]	6.95±0.07[a]	7.20±0.00[b]
F3	0.96±0.02[c]	7.00±0.02[a]	8.00±0.00[a]

The mean ± standard deviation of triplicate analysis in the same column with different subscript lettersa-c are significantly different at p<0.05 among samples (n=3) using Tukey's test.
Control = Pandan pudding incorporated with 0% soy protein isolate and without soluble corn fiber and monk fruit sweetener.
F1 = Pandan pudding incorporated with 4% soy protein isolate and monk fruit sweetener
F2 = Pandan pudding incorporated with 6% soy protein isolate and monk fruit sweetener
F3 = Pandan pudding incorporated with 8% soy protein isolate and monk fruit sweetener

pH

The Scientific scale for measuring how acidic or basic a substance is when it is dissolved in water is called pH. 0 to 14 is where the pH scale runs from. A measurement of 0 means neither acidic nor basic but right in the middle, like plain water (neutral), and 14 means it is very basic. Monitoring the pH is very important if producing a food product that depends on the acidic components or ingredients to extend shelf life, influencing the quality of food products. Consumer health and acceptability need to ensure such measurements are the best estimates since pH influences two major attributes of food safety and quality **(Vijayakumar & Adedeji, 2017).** The pH value of all pandan pudding samples ranged from 6.81 to 7.00, based on **Table 1.** The results of the control pandan pudding indicated that all the formulated pandan pudding samples fortified with soy protein isolate, soluble corn fiber, and monk fruit sweetener were significantly different ($p<0.05$). The stability of astaxanthin from Pjaffia rhodozyma was studied, and it was found that stability was high at pH 4.0 and a lower temperature **(Ambati et al., 2014)**. This means that the soy protein isolate affected the pH value of the pandan pudding.

Meanwhile, SCF does not adversely affect the pH value.SCF is very stable regarding heat, pH, and processing stresses in food processing **(Tate & Lyle, 2017)**. In a constant temperature oven (100–150˚C) for 4 h, the thermal stability of Monk fruit extract (containing around 30% Mogroside V) has been investigated (changes of sweetness, absorbance, the content of mogroside V and total mogroside) and as 1% solution in boiling water (100˚C) up to 8 h. In those conditions, the content of mogroside V remains stable. At above pH 6, it was reported that monk fruit sweetener is not stable. However, the steadiness of the pudding also depends on other ingredients used, such as milk components, carrageenan, sugar, flavors, and colorants. **(Jideani & Vogt, 2016).**

Total Soluble Solids (TSS)

Either a Brix scale hydrometer or a refractometer can be used to measure TSS and reported as "degrees Brix" (˚Brix), which is equivalent to a percentage (%). The unit ˚Brix, which has been in common use in industry for many years in principle, represents the dry substance content of solutions containing mainly sucrose **(Ball, 2006).** Soluble solids are sugars and acids with small amounts of dissolved vitamins, fructans, proteins, pigments, phenolics, and minerals. In laboratories for research and by industry to determine marketing standards, total soluble solids (TSS) are the most important quality parameters to indicate the sweetness of fresh and processed horticultural food products **(Magwaza & Opara, 2015)**. All the formulated pandan pudding samples added with soy protein isolate and monk fruit sweetener were significantly different ($p<0.05$) from the control pandan pudding based on Table 1, 5.10 to 8.00 ˚brix, where the total soluble solids ranged from. It was incorporated with 8% soy protein isolate, which was highest in pandan pudding and lowest in the control sample with 0% soy protein isolate. As soy protein isolate has a low sugar content, it does not affect the TSS content **(Magwaza and Opara, 2015).**

Additionally, the TSS in commercial mango pudding was determined to be 17.2 ˚brix in the lab, which is higher than the controls. This is probably due to the commercialized mango pudding's higher sugar content. However, sugars are not the only components contributing to the total soluble solids; other soluble components, as mentioned above, also make up the total soluble solids.

Table 2: Color analysis of pandan puddings incorporated with different amounts of SPI.

Samples	Mean ± standard deviation		
	L*	a*	b*
Control	26.32 ± 0.39^{b}	-28.50 ± 0.05^{b}	13.90 ± 0.04^{a}
F1	37.21 ± 0.28^{a}	-38.49 ± 0.60^{a}	13.30 ± 0.08^{b}
F2	37.11 ± 0.18^{a}	-38.71 ± 0.06^{a}	13.25 ± 0.23^{b}
F3	37.59 ± 0.50^{a}	-38.83 ± 0.08^{a}	13.45 ± 0.10^{b}

The mean ± standard deviation of triplicate analysis in the same column with different subscript lettersa-c are significantly different at $p<0.05$ among samples (n=3) using Tukey's test.
Control = Pandan pudding incorporated with 0% soy protein isolate and without soluble corn fiber and monk fruit sweetener
F1 = Pandan pudding incorporated with 4% soy protein isolate and monk fruit sweetener
F2 = Pandan pudding incorporated with 6% soy protein isolate and monk fruit sweetener
F3 = Pandan pudding incorporated with 8% soy protein isolate and monk fruit sweetener

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Color Analysis

Whether or not people decide to buy food depends on the product's appearance, among which the most important factor is color, and seems to have an innate allure that gives people the first impression and the greatest influence on our judgment. The most intuitive feeling for products is the color for consumers. One of the most important practices in food processing is improving and maintaining color stability. To enhance the appeal of foods, colorants are often added to products in the food industry. Because natural pigments are generally considered safe, they are normally not required to be certified before being added to foods. Naturally derived pigments are typically more expensive than certified synthetic colorants and may add unintended flavors to foods. However, because they are less costly, impart an intense, uniform color, and blend more easily in food to create a variety of hues, certified colorants are synthetically produced and are used widely. The levels of colorants added should be monitored to ensure that appropriate regulatory guidance is complied with under these circumstances **(Rustagi, 2020).** From **Table 2,** when compared with the other formulations, all the formulated pandan puddings showed the control has a variance in color. Experimental values of L* ranged from about 26 to 37, values of a* ranged from about -18 to -8, and values of b* ranged from about 13 to 14. The control significantly differs from all the other formulations as $P<0.05$. The observed color was a lighter green when compared to the control pandan pudding sample without soy protein isolate, astaxanthin, soluble corn fiber, and monk fruit sweetener. However, the other formulations include all the ingredients, such as soy protein isolate, soluble corn fiber, astaxanthin, and monk fruit sweetener, but the observed color was dark. SPI and astaxanthin do not affect the pandan pudding's color as SPI is a pale powder color, and astaxanthin was added very little.

Texture Profile Analysis

The texture of the food is its physical and chemical interaction in the mouth and can directly correlate to food rheology. Food texture encompasses hardness, smoothness, thickness, and other mouth-feel characteristics **(Rustagi, 2020)**. Food is constantly evaluated from the initial impression when the product touches the palate until the aftertaste. Physical properties that contribute to the texture of food are now widely used to represent the state and taste of that respective food. Through such properties, the collective expression of food texture at present is measured using mechanics and visual and auditory methods **(Rustagi, 2020).**

Hardness: The hardness is the peak force during the first compression cycle and is related to the strength of the gel structure under compression **(Chandra & Shamasundar, 2015).** The control with no SPI shows a significant difference in the samples as $P<0.05$ when compared with the other samples. Meanwhile, F1 shows no significant difference among the samples, as $P>0.05$, when compared with F2 and F3 ($P= 0.767$, $P=0.531$, $P=0.960$).

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There was a decrease in hardness when there was an increase in soy protein isolate. SPI has been widely used in the food industries to improve textural properties and provide three-dimensional network formation, such as hydrogels **(Li et al., 2022)**. Corresponding to the behavior of soft matter, pure SPI had a weak gel state. High temperatures could intensify the thermal motion of SPI molecules and facilitate the structural transformation during heating up **(Pan et al., 2015)**. In the folded state, the hydrophobic groups of the SPI molecules were exposed, thus reducing the hydrophilic group outside the folded structure. The driving forces for gelation structure formation between the proteins and polysaccharides were the hydrophobic and electrostatic interactions of the components **(Sun et al., 2015)**.

Cohesiveness: The cohesiveness (consistency) indicates the strength of internal bonds making up the body of food and the degree to which a food can be deformed before it ruptures (breaks). Cohesiveness is the positive force area ratio during the second compression to that of the first compression. It may be measured as the rate at which the material is disintegrated under mechanical action. Tensile strength is a manifestation of cohesiveness. The cohesiveness indicates the product's ability to hold together **(Chandra & Shamasundar, 2015).** All the formulations of pandan pudding were significantly different as they didn't have the same mean value from **Table 3** The other formulations showed a gradual decrease in the mean value, whereas the cohesiveness of the control showed the highest value. The body of the product is made up of its strength of internal bond. The result is similar to **Siegwein et al. (2011),** whereby at 50% soy treatment level, cohesiveness was found to be statistically significant. Soy protein can modulate shortness of texture in gelled confections without sacrificing the system's structural integrity.

Springiness: Springiness is a textural parameter related to the sample's elasticity. During the time that elapses between the end of the first bite and the start of the second bite, springiness in TPA is related to the height at which the food recovers. If springiness is high, it requires more mastication energy in the mouth **(Chandra & Shamasundar, 2015).** The springiness of the Pandan Pudding showed significant differences in means. This indicates that higher energy was needed for the disintegration of the product, and it possessed a higher springiness ($p > 0.05$). In the pandan pudding samples, the springiness has been gradually decreased. After cold storage, not many variations were observed for the springiness of puddings.

Adhesion: In **Table 3**, the adhesiveness parameter in TPA analysis for the four gelatin samples is represented. Adhesiveness is defined as the negative force area for the first bite. It represents the work required to overcome the attractive forces between the surface of food and the surface of other materials with which the food comes into contact **(Chandra & Shamasundar, 2015).** From one another, the adhesiveness of the pandan pudding samples was completely different. When considered from control to F3, the adhesiveness of the pandan pudding formulation was increasing drastically.

Thus, the adhesive force will increase as hardness decreases **(Sun et al.,2015)**. The adhesiveness predicts the degree of adhesion of pudding on the teeth and represents the force needed to remove the pudding that adheres to a surface **(Dunnewind et al., 2004).**

Syneresis

Upon product storage, the liquid phase separation from a polymeric gel was visibly detected as syneresis. The detection of syneresis was based on the quantitative observation method **(Gilbert et al., 2020).**

The syneresis was monitored by observation method, and the pandan pudding samples were refrigerated for 1 week at 4˚C. The obtained results were the control, and F1 showed the most syneresis in the pandan pudding; total solids content and milk composition were considered the main reason for affecting the syneresis. At the same time, the other samples do not exhibit much of the liquid. Further heating at 90 or 95˚C, gels became stiffer, which was explained by further incorporation of protein in the network and, at pH 7 and 7.6, by the occurrence of rearrangements in the network structure. At pH > 5, less protein (mainly acidic polypeptides) participated in network formation than at lower pH values **(Renkema, 2001).**

Conclusion

In conclusion, the results showed that the pudding incorporated with soy protein isolate, soluble corn fiber, and monk fruit sweetener increased its nutritional content and reduced the sugar level in the end product. There was an increase in total soluble solids content in the pandan pudding. The texture analysis showed that the hardness had decreased when the soy protein isolate content was increased. The color analysis does not depict much color change among all the formulations except for the control. Syneresis was observed higher in the control and lower in the F3. More studies can be performed by incorporating soy protein isolate, monk fruit sweetener, and soluble corn fiber in various forms of food products.

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Conflict of Interest

The authors declare no conflict of interest from preparation to publication of this manuscript.

Ethics Approval

This study does not require any ethical approval.

Participant Consent

This study did not require consent from any human participants.

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