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# Pandan Pudding Reimagined: Nutritional and Antioxidant Fortification with Soy Protein Isolate, Soluble Corn Fiber, and Astaxanthin for Improved Elderly Health

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## Abstract

**Background**:

Aim: The global demographic shift towards an aging population underscores the necessity for food products that cater to the nutritional needs of the elderly. This study explores the development of pandan pudding enriched with soy protein isolate (SPI), soluble corn fiber (SCF), and other functional ingredients, aiming to assess its nutritional and antioxidant properties. Methodology: Pandan pudding was formulated with varying levels of SPI (0%, 4%, 6%, and 8%) and sweetened with monk fruit. The proximate composition (moisture, protein, ash, fat, fiber, and carbohydrate content) and antioxidant properties of the pudding were analyzed using standard AOAC methods and the ABTS radical scavenging assay. Statistical analyses were conducted to determine significant differences between the formulations, including ANOVA and Tukey's test. Result: The addition of SPI, SCF, and monk fruit sweetener significantly increased protein, fiber, and ash content compared to the control pudding. Specifically, protein content ranged from 0.70% in the control to 7.09% in the 8% SPI formulation. Moisture content slightly decreased with increasing SPI, while fat content showed a minor increase. Carbohydrate content decreased as protein and fiber levels increased. Antioxidant analysis revealed that formulations with functional ingredients exhibited higher antioxidant activity, attributed to the bioactive compounds in pandan leaves and astaxanthin. Conclusion: The enriched pandan pudding demonstrated enhanced nutritional quality, making it a viable option for the elderly seeking healthful, protein-rich, and fiber-rich foods.

**Keywords:** Pandan pudding, Functional foods, Antioxidant properties, Nutritional composition, Elderly nutrition.

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## Introduction

In developing countries, the number of elderly people is increasing worldwide **(Azidah et al., 2012).** By 2050, the aged population of 60 years and older is expected to be a total of 2 billion, from 900 million in 2015. Today, people aged 80 years or older are 125 million, and this will be almost many (120 million) living in China alone, and 434 million people in this age group worldwide (WHO, 2018). The aging population around the world is increasing drastically. The shift in population distribution towards older ages is known as population aging. This has started in high-income countries like Japan, which already has 30% of the population over 60 years old. Low- and middle-income countries are experiencing great change (WHO, 2018).

Our knowledge of the relationship between food components and health is now being used to improve food. Most foods can be considered "functional," wherein the foods and components have been demonstrated to provide specific health benefits beyond essential nutrition. Foods consumed on a regular diet offer bioactive compounds ahead of essential nutrients, impact positive health, and are classified as functional foods **(Bultosa, 2016)**.

Food industry expectations are high in food products that meet consumers' demand for a healthy lifestyle. Functional foods play a specific role as they are not intended only to satisfy hunger and provide nutrients but also to prevent nutrition-related diseases and increase consumers' physical and mental well-being **(Menrad, 2013).** Hence, due to the population's socioeconomic changes and demographic trends, functional food is a good option to improve the quality of life of an individual **(Menrad, 2013).**

The soy protein foods have attracted interest worldwide related to health claims as these foods reduce the risk of cardiovascular and heart diseases, lower cholesterol levels, and prevent certain cancers **(Zhao et al., 2020).** The traditional food additive is rich in essential amino acids such as lysine and glutamic. Soluble Corn Fibre is a glucose polymer partially hydrolyzed starch made of glucose syrup. SCF provides a minimum of 85% dietary fiber, contains less than 2% sugar, and scientific data support a caloric content of 1.2 kcal/g **(Wallace et al., 2017)**. Astaxanthin (AST) is a lipid-soluble, red-orange oxy-carotenoid pigment **(Fakhri et al., 2018)**. It is a potent antioxidant to terminate the induction of inflammation in biological systems. It acts against inflammation. The strong antioxidant properties are recognized in therapeutic applications, immune-stimulating, anti-inflammatory, anti-tumor, anti-diabetic, cardio-protective, and neuroprotective qualities **(Martínez et al., 2019).** Carrageenans have been broadly utilized as food additives for their ultimate physicochemical and functional properties, including thickening, gelling, and emulsifying properties in food products, pharmaceutical applications, and cosmetics **(Tang et al., 2019)**. Carrageenans are widely used in non-food products such as pharmaceuticals, cosmetics, printing, and textile industries **(Prajapati et al., 2014).**

In this study, we aim to explore the development of pandan pudding and focus on its proximate composition and antioxidant properties of this product. This investigation seeks to contribute to the growing body of knowledge on functional foods and their potential benefits in enhancing quality of life.

## Materials and Methods

### Source and Preparation of Pandan Pudding

The production procedures and formulation of pudding preparation were based on (Padmanabhan & Lean, 2024).

### Antioxidant Analysis

### 2,2′-Azino-bis-(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) radical scavenging assay

2,2-azino-bis-(3-ethylbenzothiazoline-6- sulphonic acid) (ABTS) radical scavenging assay was evaluated according to Sim et al.,(2019). Potassium persulfate $(K_2O_8S_2)$ 2.45 mM and ABTS (7 mM) were mixed in an amber bottle and kept dark at room temperature for 12–16 hours for activation. Then, 1 mL of the pandan pudding sample was added with 50 ml of ethanol. The activated mixture was then adjusted with ethanol at 734 nm to 0.7 ( ± 0.02). Next, 50 µL of the sample was added with 1950 µL of ABTS and kept in the dark for 3 min. After 3 min, the absorbance was measured against a reagent blank at 734 nm using a UV–vis spectrophotometer (Secoman, France). The radical scavenging assays for all the samples were expressed as a percentage of the initial ABTS radical using the equation.

$$ABTS\ Scavenging\ Effect\ (\%) = \frac{A_0 - A_1}{A_0} \times 100$$

Where A0 is the absorbance of the ABTS solution without sample, A1 is the absorbance of
ABTS solution with sample.

### Proximate analysis

### Moisture Content

The determination of moisture content of all pandan pudding formulation was determined by the oven drying method based on AOAC Official Method 934.06 (**AOAC 2000).** The calculation for the percentages of moisture content for each pandan pudding sample was then done via the loss in weight of the sample during the drying process based on the equation.

$$Moisture\ content\ (\%) = \frac{W_1 - W_2}{W_1 - W_0} \times 100$$

Where W0= Weight of dried crucible with lids (g); W1= Weight of dried crucible with lids and samples before drying (g); W2= Weight of dried crucible with lids and samples after drying (g)

**Protein Content**

The Kjeldahl method was used to determine the protein content of all the formulated pandan pudding samples based on AOAC Official Method 920.152 (2000). Digestion, neutralization, distillation, and titration are the division of the four key steps of the procedures of the Kjeldahl method. The calculation was done based on the equation.

$$Nitrogen\ (\%) = \frac{V_s - V_b}{Weight\ of\ the\ sample} \times \frac{14.007g}{mol} \times Molarity\ of\ HCl \times 100\%$$

Where Vs. = Volume of titre of HCl for sample (mL); Vb = Volume of titre of HCl for blank (mL)

$$Protein\ (\%) = Nitrogen\ \% \times 6.25$$

(6.25 is the conversion factor for converting nitrogen percentage into protein).

**Total Ash Content**

By using AOAC Official Method 940.26 (AOAC 2000), the ash content of all formulated pandan pudding samples was determined. Based on the equation, the ash content of the pandan pudding samples was calculated.

$$Ash\ (\%) = \frac{W_2 - W_0}{W_1 - W_0} \times 100$$

Where W0= weight of crucible (g); W1=weight of crucible and pandan pudding samples (g); W2= weight of crucible and white ash (g).

**Crude Fat Content**

The soxhlet extraction method was used to determine the fat content of all formulated pandan pudding based on AOAC Official Method 948.22 (AOAC 2000). The percentage of the fat content of the pandan pudding sample was calculated based on an equation.

$$Fat\ (\%) = \frac{W_3 - W_2}{W_1} \times 100$$

Where W1 = Weight of initial sample (g); W2 =Weight of round bottom flask with few boiling chips (g); W3 = Weight of round bottom flask with extracted fat (g).

**Crude Fibre Content**

Based on AOAC Method 920.169 (AOAC 2000), the determination of crude fibre content of pandan pudding samples for all formulations was determined using the acid and alkali digestion method. The percentage of crude fibre for the pandan pudding samples was calculated based on the equation.

$$Crude\ fibre\ (\%) = \frac{W_2 - W_3}{W_1} \times 100$$

Where W1 = Weight of sample (g); W2 =Weight of crucible with lid and dried sample(g); W3 = Weight of crucible with lid and ash (g).

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### Carbohydrate Content by Difference

All pandan pudding samples' total and available carbohydrate content was estimated using the difference method. Once the proximate analysis has been performed all fractions were determined by (MoH, 2017). The percentage of carbohydrates was calculated based on the equation

$$Carbohydrate\ content\ by\ difference(\%) = 100 - [Moisture\ (5) + Protein\ (\%) + Fat(\%) + Ash$$

### Calorific Value

The calorific value of all formulations of pandan pudding was projected by summing up themultiplied values of protein, fat, carbohydrates, and fiber with their factor of 4,9,4, and 2,respectively. The calorific value was expressed as kcal/100g of pandan pudding. It wascalculated based on the equation.

## STATISTICAL ANALYSIS

Once the data collections were completed, the results were analyzed using the Minitab 18statistical software. The data obtained were expressed in terms of means ± standard deviationof all formulated pandan pudding measurements. The results were analyzed by using a one-way analysis of variance (ANOVA) and Tukey's honest significant difference test (HSD) wasconducted to determine the statistical difference among the groups. The significantdifferences in analyses were indicated by p<0.05.

## Results and Discussion

### Antioxidant analysis by ABTS assay

**Table 1:** Antioxidant analysis of pandan puddings incorporated with different amounts of SPI

| | Mean ± standard deviation | | | |
|---|---|---|---|---|
| | Control | F1 | F2 | F3 |
| Antioxidant (%) | 58.42 ± 1.61[b] | 98.30 ± 0.72[a] | 98.13 ± 0.73[a] | 98.05 ±0.79[a] |

The mean ± standard deviation of triplicate analysis in the same row with different subscript lettera-b 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 with 4% soy protein isolate and monk fruit sweetener.
F2 = Pandan pudding with 6% soy protein isolate and monk fruit sweetener.
F3 = Pandan pudding with 8% soy protein isolate and monk fruit sweetener.

 

When compared with F1, F2, and F3, the control is significantly different p<0.05. whereas F1, F2, and F3 are not significantly different as p>0.05. The F2, when compared with F1, showed a p-value of 0.998 (greater than 0.05), and F3, in comparison with F1, showed a p-value of 0.995 (greater than 0.05). As control doesn't have the pandan and astaxanthin in it. It does not exhibit higher antioxidant content. Meanwhile, all the other pandan formulations showed the availability of antioxidant content in the sample. In addition to its high amount of chlorophyll, the pandan leaf also has antioxidant properties, which could increase food stability (Lilis Suryani et al., 2020). Furthermore, higher amounts of chlorophyll increased antioxidant activity because chlorophyll derivatives could break the radical chains due to chlorophyll being an electron donor (Lilis Suryani et al., 2020). It is well known that its antioxidant capacity is greater than that shown by other carotenoid compounds (Muller & Bohm, 2011). Free radicals produced in the body may cause cancer and other chronic diseases and can damage organic molecules, the major reason for several health problems. Therefore, dietary antioxidants originating in legumes could be consumed to reduce the risk of several life-threatening diseases and aging. Thus, it is important to evaluate the antioxidant capacities of food products (Lobo et al., 2010). It may be a good natural alternative to synthetic antioxidants in the food industry (Nor et al., 2008).

## Proximate analysis

### Moisture

**Table 2:** Proximate composition of pandan puddings incorporate with different amount of SPI

| Sample | Mean ± Standard deviation | | | | | |
|---|---|---|---|---|---|---|
| | Moisture (%) | Protein (%) | Ash (%) | Fat (%) | Crude fibre (%) | Carbohydrates (%) |
| Control | 48.50±0.71$^{a}$ | 0.70±0.00$^{d}$ | 0.49±0.13$^{b}$ | 2.48±0.21$^{c}$ | 0.48±0.01$^{c}$ | 47.34 ± 1.04$^{a}$ |
| F1 | 46.90±0.14$^{ab}$ | 5.16±0.12$^{c}$ | 0.79±0.01$^{a}$ | 2.17±0.23$^{b}$ | 0.93±0.03$^{b}$ | 46.03 ± 0.07$^{ab}$ |
| F2 | 46.25±0.21$^{b}$ | 6.21±0.12$^{b}$ | 0.91±0.01$^{a}$ | 2.77±0.16$^{a}$ | 1.29±0.06$^{a}$ | 45.39 ± 0.38$^{ab}$ |
| F3 | 45.55±0.35$^{b}$ | 7.09±0.13$^{a}$ | 0.96±0.02$^{a}$ | 2.27±0.09$^{b}$ | 1.39±0.02$^{a}$ | 44.18 ± 0.10$^{b}$ |

Mean ± standard deviation of triplicate analysis in the same column with different subscript lettera-d 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 fibre and monk fruit sweetener

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F1 = Pandan pudding with 4% soy protein isolate and monk fruit sweetener.
F2 = Pandan pudding with 6% soy protein isolate and monk fruit sweetener.
F3 = Pandan pudding with 8% soy protein isolate and monk fruit sweetener

Moisture determination is one of the foremost important and most generally used measurements within the processing and testing of foods. Food's moisture (or total solids) content is vital to food manufacturers for various reasons. Moisture is a crucial thing about food quality, preservation, and resistance to deterioration **(Nielsen, 2010)**.

The results for the moisture content of the pandan pudding are shown in Table 2. It was observed that the pandan pudding with the addition of soy protein isolate, SCF, and monk fruit sweetener resulted in a slightly lower value of moisture in comparison to the control. This is because SPI replaces water to make up the same weight. The soy protein isolate has a moisture content of 4.8 % ± 0.32. So, the increase in SPI will lower the moisture content. This might be because soy protein isolate contains more solid matter with high emulsifying properties than corn flour **(Wang et al., 2021).** Compared with F1 there is no significant difference among them as $p>0.05$. However, other formulations, such as F2 and F3, significantly differ as $p<0.05$. Meanwhile, the other differences among the formulations showed that they are not significantly different as they exhibit the p-values are higher than 0.05.

In sugar-based confections, the water content is generally governed by the boiling point relationship of the sugars in the formulation. The final water content significantly impacts texture and shelf life, with lower moisture content leading to harder confections that typically have a longer shelf life. A high level of sucrose was more effective than a low level in lowering moisture content **(Chen et al., 2007).** This is because most yeast and bacteria favor and multiply highly in high moisture conditions **(Ghoddusi et al.,2013; Wiley, 2017)**. Here the moisture content of the pandan pudding means values were nearer to the custard pudding.

Marina and Nurul Azizah (2014) incorporated different milk products into custard puddings, and the custard pudding's moisture content ranged from 54.25% to 61.88%. With moisture content around this range, it helps to ensure the springiness and cohesiveness characteristics in puddings. Indeed, the moisture content is a very important aspect to determine the quality and shelf life of products with high sugar content. Hence, refrigeration or heat treatment is required to inhibit the growth and proliferation of microorganisms, which could cause a deterioration reaction to the puddings **(Ghoddusi et al., 2013; Wiley, 2017).**

**Protein**

Inadequate intake of dietary proteins containing essential amino acids leads to increased turnover of muscular proteins, resulting in reduced growth and loss of muscle mass as all the formulated pandan pudding shows that the mean values are significantly different from one another as the $P<0.05$. The protein content has a mean value ranging from 0.70% to 7.09%. Control has a very low value of protein content (0.70%) compared with the other formulations. Meanwhile, there was a gradual increase in the other

formulations; F3 showed the highest protein content of 7.09% in the pandan pudding. There is an increase in soy protein isolates. The protein value in the pandan pudding sample also increased. The main storage protein of soy protein isolate is globulins, which contain almost 90% of soybean protein **(Wang et al., 2021).** The resulting protein isolates were high in protein, free of glucosinolates, and low in phytates. It was found that at pH values below 11, protein extractability reduced significantly while operating above pH 11 was impractical due to the highly corrosive nature of the mixture and, more importantly, the instability of the ultrafiltration membrane above pH 11. Based on the Food Regulation 1985, the food contains a source of protein not less than 5 g per 100 g or 2.5 g per 100 ml, which means that the developed pandan pudding is enriched with protein which can be claimed as a "Source of Protein".

**Total ash content**

By analyzing the Tukey Simultaneous tests for Difference of Means, the formulated pandan pudding showed that the control compared with F1, F2, and F3 they are significantly different from one another as $p<0.05$. At the same time, F1, F2, and F3 are not significantly different from each other as $p>0.05$. The formulated pandan pudding showed mean values ranging from 0.49% to 5.27%. Meanwhile, the control showed a lower mean value (0.49%) of ash content than the other formulated pandan pudding. F3 showed the highest mean value of 5.27% from other pandan puddings. So, an increase in soy protein isolate will increase the total ash content. Soy protein isolate also showed the highest ash content (5.4%) **(Poulin et al., 2011).** The ash content increased with an increasing level of soy protein isolate in rice pudding **(Wang et al., 2021).** In contrast with prior studies, the ash content of milk pudding (0.50%) and chocolate pudding (0.04%), whereas the pandan pudding has ash content ranged from 0.49 to 0.96%. This indicated that the ash content of the pandan pudding is superior to other types of pudding in the literature.

**Crude fat**

Table 2 showed that the fat content of the formulated pandan pudding showed a mean ranging from 2.48% to 2.77% of fat content. During this, the control showed the littlest amount means the value of two 0.48%, as there is no soy protein isolate and soluble corn fiber. The other formulation showed a slight increase in the fat content. It was found that the fat content of soy bread samples was quite that of the control bread sample, and thus, the fat content increased with the increasing level of soybean flour **(Wang et al., 2021)**. The fat crystals' melting profile plays a key role in determining properties like texture, stability, spreadability, and mouthfeel. The fat has a higher caloric density than that of most nutrients in foods **(Rios et al., 2014).** For consumers, textural attributes of fats that arise from their molecular states are of primary importance. Food texture is affected by fats by forming structures of crystalline networks and by disruption of a structure by interfering with non-fat networks **(Rios et al., 2014).**

**Crude fibre**

From Table 2, the formulated pandan pudding showed a mean from 0.48% to 1.79 %. The Tukey simultaneous test showed that $p<0.05$ suggests that each of the formulated pandan puddings is significantly different from the others. Control showed the smallest value of 0.48% from the formulated pandan pudding, whereas F3 showed the best mean of 1.79%. Enriching the fiber content of food products with low fiber content natively is an extended practice in the industry (refined flour, bakery, drinks, beverages, dairy, and meat products) because it improves nutritional input, provides high-value products, and contributes to competitiveness. These products should be labeled as 'source of fiber foods' if they contain 3 g of fiber per 100 g and 'high fiber content foods' if they contain 6 g per 100 g (Regulation (EC) No 1924/2006).

**Carbohydrate by Difference**

Carbohydrates are significant in food because carbohydrates provide energy, enhance immune function, and support cellular communications. Carbohydrates are converted into energy to allow our cells to function **("Nutrition for Dummies," 2006).** The purpose of carbohydrates is one of the most frequently required analyses in the food analysis laboratory and has considerable application in nutritional and biochemical studies **(Wang et al., 2015).** The carbohydrate content by difference excludes moisture, protein fat, ash, and fibre contained in foods to determine the amounts of energy provided by foods. Table 2 shows that the pandan pudding has a carbohydrate value of 47.34% to 44.18%. In this, the control showed the highest value of 47.34%, and F3 showed the lowest value of 44.18%. Compared with the other formulations, the control showed they were significantly different as $p<0.05$.

Meanwhile, F1, F2, and F3 depict that the $p>0.05$ means they are not significantly different.

However, a decreasing trend was observed in the formulated pandan pudding as the addition of Soy protein isolate and SCF had significantly increased the ash, protein, and fiber content, lowering the carbohydrate value. Dietary fiber is a carbohydrate from plant or fruit sources; it is indigestible as the digestive enzyme in the body cannot break down fiber **(Macagnan et al., 2016).** Thus, it does not contribute energy to the diet by being indigested when it passes through the intestinal tract. SCF's fiber content had increased; therefore, the pandan pudding with SCF contains the lowest carbohydrate value.

**Calorific value**

The energy value, also known as the calorie value of a food, is often referred to as calorific value, and it is normally used to determine the chemical energy between the organic constituents bonding, such as proteins, carbohydrates, and fats. Tukey simultaneous Tests for differences of means analyzed the calorific content of the pandan pudding. From the analysis, when compared with other formulations, control showed that they are significantly differentfrom one another as $p<0.05$. However, F2 and F3 showed they are not significantly different as $p>0.05$. The F3 illustrates that the highest mean value of 255.08 .

kcal compared with the other formulations and control, showed the least value of 215.4 kcal. An earlier study reported that the calorific value for milk pudding is 221.57 kcal/100g **(Marina & Nurul, 2014),** and from a product label, commercial mango pudding contains 82.40 kcal/100g. The calorific value of the formulated pandan pudding is higher than the calories found in commercial mango pudding. This is due to the low protein and carbohydrate content found in commercial mango pudding, as it only contains 0.30% protein and 18.50% carbohydrate, while the formulated pandan pudding incorporated with 8% SPI contains 7.09% protein and 46.03% carbohydrate **(Van Kleef et al., 2008)**. Hence, there may be more moisture content in the commercial pudding, which then resulted in a lower calorific value in commercial mango pudding (82.40 kcal/g) when compared to the pandan pudding incorporated with SPI (153.22kcal/g). Calories are the most broadly used nutritional indicator and the best-recognized notion among consumers. Additionally to nutrient quality, the amount of calories present in individual foods is a critical piece of information for the consumers to facilitate them to make informed choices in their diet. A key challenge for nutrition labeling is to find accurate yet simple representations of the caloric information in a format that is appealing, easy to process, and easy to understand for consumers **(Van Kleef et al., 2008).**

## Conclusion

The results showed that the pudding incorporated with soy protein isolate, soluble corn fibre, and monk fruit sweetener increased its nutritional content and reduced the sugar level in the end product. Furthermore, the proximate analysis showed a significant increment in protein, ash content, moisture, and the crude fiber content of the pandan pudding samples in terms of increasing amounts of soy protein isolate and the addition of soluble corn fiber. Meanwhile, the fat content showed an increasing trend in the sample, while carbohydrates showed a decreased value. The effect of the increased protein content with the incorporation of soy protein isolate, soluble corn fiber, and monk fruit sweetener in pandan pudding showed that this product might be a good choice for the elderly population as they are more concerned about their daily nutritional requirements intake. The pandan pudding also showed a certain amount of antioxidant content present in it. In conclusion, the outcome of the present study showed that the pandan pudding incorporated with soy protein isolate, soluble corn fiber, astaxanthin, and monk fruit sweetener is enriched with protein, fiber, and antioxidant content. At the same time, this product can be claimed as a protein source and high fibre. Thus, the developed product could be more convenient and suitable for the elderly.

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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 has undergone ethical approval.

## Participant Consent

It ensures that individuals voluntarily agree to participate in a study with a full understanding of what it entails.

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