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ADDITION OF VEGETABLES IN THE EXTRUSION OF RICE PUFFED SNACKS TO INCREASE VEGETABLES CONSUMPTION IN CHILDREN

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ABSTRACT

11 Children's low consumption of fruit and vegetables have been a concern in Indonesia. Even until recently, Indonesia still cannot fulfil the recommended fruit and vegetables consumption per capita. A survey done in four elementary schools in Central Java revealed that approximately 45,6% of the children do not consume vegetables daily and approximately 1,6% students has never eaten vegetables. This may lead to a lot of health problems. To overcome this problem, innovations are needed. One of the innovations that can be done is the addition of vegetables into extruded snack products which are children's favorite snacks. Extruded snacks from rice and vegetables were made with different vegetables concentrations (0%, 5%, 10%, 15% and 20%). Vegetables used were carrot and cassava leaves which is a rich source of beta-carotenes. Based on the results, as the concentration of vegetables increased, the physical quality, such as texture and color of the extrudates decreased. Based on the physical characteristics and the beta-carotene content of the extrudates, it can be concluded that the optimum concentration for carrot and cassava leaves addition was 15% and 10%, respectively. With the addition of 15% carrot and 10% cassava leaves, the beta-carotene increased 13 times and 22 times, respectively, without significantly altered the physical characteristics of the extrudates. The amount of beta-carotene in 100 grams of 15% carrot extrudates fulfil 18% of vitamin A RDI and 100 grams of 10% cassava-leaves extrudates fulfil 29% of vitamin A RDI.

Keywords*:* vegetable, rice, extrusion, children, snack

1 INTRODUCTION

The low consumption level of fruits and vegetables especially in children has always been a concern. Low consumption of vegetables has long been associated with various health problems such as cardiovascular diseases [1], lung problem [2] and various other non-communicable diseases [3]. Therefore WHO and FAO recommends to consume fruits and vegetables more than 400 g/day [4].

Attempts to increase the consumption level had been done through various approach such as education through school, parents, peer and media [3], [5]. Some approach may be more effective than the others. In order to asses children's vegetable consumption level and factors which may affect the vegetables consumption, specifically in Central Java, Indonesia, a survey was done to four elementary schools in Central Java as a preliminary study.

In order to increase children vegetable consumption, products development may also be done to the snacks that children usually consume, for example extrudates. Usually extrudates is made from corn with addition of flavoring. Vegetable flakes can be added to the extrudates in order to increase the intake of vegetables in children.

This research aims to study the effects of vegetables flakes addition to the physicochemical characteristics of the extrudates. Hopefully with the addition of vegetables to puffed snacks that children enjoy may increase children inclination to consume vegetables.

2 MATERIALS AND METHODS

2.1 Materials

The rice used in this study is local white rice variety C4 obtained in the local market. The chantenay carrot and the cassava leaves were both obtained from the local market.

2.2 Preliminary Study

A survey was done to study children's vegetable consumption. The survey is done at four elementary school in central Java, two school represented middle-high-income family and two school represented low-middle-income family. All the four school is located in Central Java Province but in different cities. Two questionnaires were used to obtain information about the vegetable consumption frequency, types of vegetable consumed and factors that may affect children's consumption. The questionnaires were directed to the children and their mother. The total respondent were 246 pairs of children and mothers.

2.3 Extrusion process

The extrusion process was done using a single screw extruder with white rice only. The addition of vegetables substituted the weight of rice for 5%, 10%, 15%, and 20%. After extrusion process, the extrudates were dried in a cabinet drier in 60°C for 4 hours.

2.4 Physical Characteristic Analysis

2.4.1 Expansion Ratio

Radial expansion ratio was measured as the ratio (in %) between extrudates diameter and the die diameter. Longitudinal expansion ratio was measured as the length of each extrudates that was cut using rotating knives with a constant speed.

2.4.2 Specific Density

Specific density was measured as the ratio between the mass of one piece of extrudates and its volume. The volume of the extrudates was measured by seed displacement method.

2.4.3 Hardness and Crispness

Hardness and crispness of the extrudates were measured using Lloyd Texture Analyzer with cylinder probe, test speed 1 mm/s, depression limit 8 mm. Hardness was expressed as the maximum force and crispness was expressed as the number of peaks in the force-deformation graph.

2.5 Beta-carotene Content Analysis

Beta-carotene from 5 gram of grounded extrudates was extracted with acetone, hexane and $MgCO_3$ for 18 hours. The extract was then filtered using chromatography column consist of filter cloth, celite powder, MgO powder and Na_2SO_4. The absorbance of the filtrate was then measured using spectrophometer at 436 nm. The concentration of beta carotene was calculated using standard curves and was expressed in mg/100 g.

2.6 Data analysis

The data obtained from the extrudates physicochemical analysis were then statisticaly analyzed using One Way Anova with Duncan test.

3 RESULTS AND DISCUSSION

3.1 Level of Vegetable Consumptions in Children

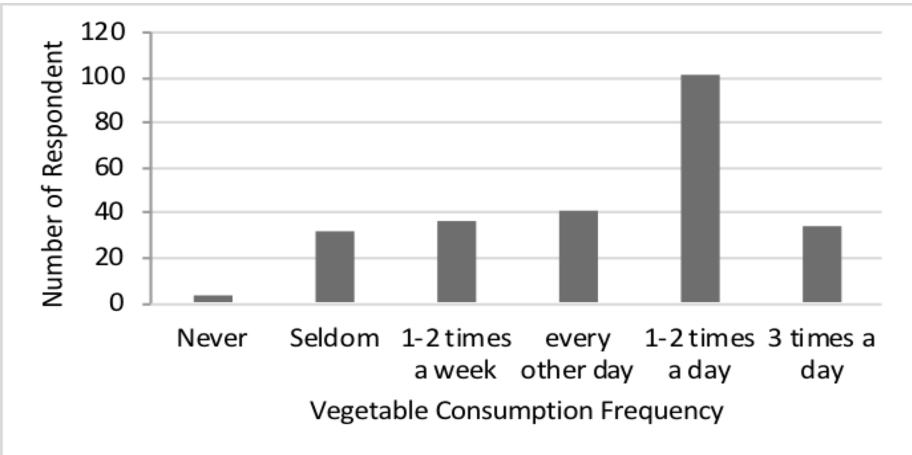

Figure 1: Frequency of Vegetable Consumption in Elementary School Children

From Figure 1, it can be concluded that 1,6% children never even consumed vegetables. As much as 45,6% of the children does not consume vegetable daily which obviously does not meet the requirement of daily fruits and vegetables consumption by the WHO/FAO. Therefore, a strategy is needed to improve children's vegetable consumption in Central Java, Indonesia.

From the survey, significant factors that affect children's vegetable consumption were mother's behavior, i.e. regularly buying vegetables (cor. coef. 0.642), providing children with lunchbox (cor. coef. 0.238), and eating meals together with their children (cor. coef. 0.749). There were also weak significant correlation (cor. coef. 0.283) between mother's perception and children vegetable consumption. Mothers who understand the significance of vegetables to health tend to have children with high vegetable intakes.

The vegetables that are the most familiar to children were spinach and carrots. Meanwhile cassava leaves was the least familiar to children. Carrots and cassava leaves were then selected to be added to the extrudates to increase its nutritional value.

3.2 Physical Characteristics of Rice and Vegetable Extrudates

Table 1: The Expansion Ratios and Density of Rice and Vegetables Extrudates

Formulation	Radial Expansion (%)	Longitudinal Expansion (cm)	Specific Density (g/cm^3)
Rice (control)	276,556±17,003	3,331±0,313	0,078±0,008
Rice +5% CL	241,200±17,413	3,756±0,361	0,084±0,005
Rice +10% CL	227,619±22,859	3,998±0,296	0,092±0,008
Rice +15% CL	196,056±16,219	4,084±0,187	0,094±0,009
Rice +20% CL	188,933±11,800	4,479±0,415	0,126±0,014
Rice +5% CP	246,567±17,306	3,210±0,221	0,084±0,008
Rice +10% CP	229,233±19,552	3,864±0,366	0,086±0,007
Rice +15% CP	222,000±22,182	3,880±0,282	0,103±0,010
Rice +20% CP	204,000±20,219	3,914±0,209	0,112±0,008

Note: CL: cassava leaves; CP: carrot

The addition of vegetable powder, either carrot powder or cassava leaves, caused the radial expansion during the extrusion to decrease. In the melt, the insoluble fiber from the vegetable

flakes tend to exist as filler in the starch and to align parallel to the flow direction of the melt [6], [7]. Thus, decreasing radial expansion as the concentration of the vegetables increased were observed. However, the lack of radial expansion were compensated by the increase in the longitudinal expansion. The more vegetables were added, the higher the longitudinal expansion were during extrusion. This also happened in previous studies where fibrous materials were added into extrusion process [8], [9]. This is due to the fiber in the vegetables which allign with the matrix of the starch to limit the radial expansion, then part of the excessive energy were used to expand longitudinally. However, overall expansion were still decreasing with higher concentration of vegetables added and this caused the specific density of the extrudates to increase which indicated a more compact product with lower porosity.

Due to the increasing density and decreasing radial expansion, increasing hardness were also observed in the extrudates. Decreasing radial expansion also means that the number of pores decreased and the air cell wall thickness increased which caused the reduction in crispness. However, compared to a commercial product which is widely consumed by children with hardness 2210,17±484,74 and crispness 8.88±2,25, the addition of cassava leaves up to 20% and carrot up to 15% still gave an acceptable level of hardness. However, the addition of more than 10% cassava leaves and more than 15% carrot may decrease the crispness into an unacceptable level.

In terms of color, the addition of carrot and cassava leaves gave their natural color to the extrudates. The extrudates with cassava leaves showed a pronounced green color while the extrudates with carrot did not have a significant change in color. The concentration of the vegetables added did not significantly affect the color of the extrudates up to the concentration of 10%.

Table 2: The Texture and Color of Rice and Vegetables Extrudates

Formulation	Hardness (gf)	Crispness	L*	a*	b*
Rice (control)	1423,44±100,02	7,90±0,74	86,61±4,21	-0,24±0,02	11,99±0,45
Rice + 5% CL	1676,93±155,07	7,30±1,42	75,52±3,64	-2,81±0,12	21,42±0,65
Rice + 10% CL	2005,30±105,16	7,10±0,74	71,42±1,11	-2,86±0,13	21,31±0,82
Rice + 15% CL	2063,94±221,42	6,50±0,85	68,53±2,26	-3,08±0,11	21,73±0,93
Rice +20% CL	2185,10±202,70	4,90±0,88	63,82±3,03	-3,43±0,09	21,75±1,01
Rice +5% CP	1502,34±223,49	7,82±1,17	86,73±0,80	-0,25±0,02	19,58±1,40
Rice + 10% CP	2043,44±270,27	7,16±1,43	86,01±0,31	-0,27±0,03	24,22±2,56
Rice + 15% CP	2272,58±380,49	7,05±1,62	83,08±1,26	-0,31±0,03	28,75±1,00
Rice + 20% CP	2443,03±383,87	6,40±1,51	83,09±1,44	-0,35±0,03	31,23±1,38

Note: CL: cassava leaves; CP: carrot

3.2 Beta-carotene Content of Rice and Vegetable Extrudates

The beta-carotene content of the extrudates can be seen in Figure 2 below. As expected, with the increasing concentrations of the vegetables, the beta-carotene content were increased. Extrudates with cassava leaves had a significantly higher beta-carotene content than extrudates with carrot. Compared to the rice extrudates without vegetables addition, the addition of 15% carrot and 10%

cassava leaves increased the beta-carotene 13 times and 22 times, respectively, without significantly altered the physical characteristics of the extrudates.

The amount of beta-carotene in 100 grams of 15% carrot extrudates fulfils 18% of vitamin A RDI and 100 grams of 10% cassava-leaves extrudates fulfils 29% of vitamin A RDI. One commercially available puffed-snack which contain vitamin A has 128 IU of the vitamin. Thus, with the assumption that 1 IU equals to 0.6 μg beta-carotene [10], extrudates with 10% cassava leaves has 11 times more Vitamin A. Extrudates with 15% carrot has 7 times more vitamin A than the commercial products.

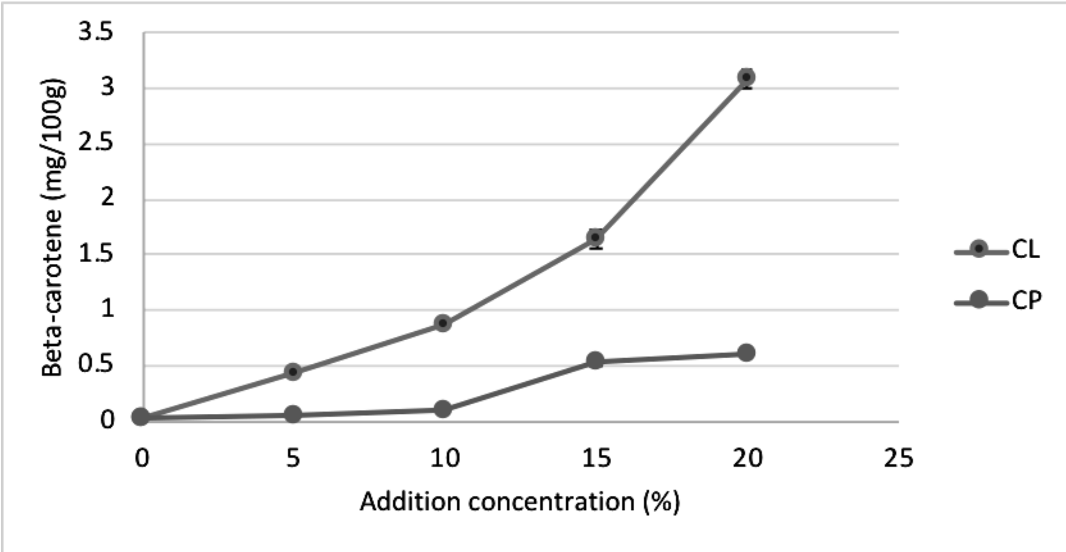

Figure 2: Beta-carotene content in Extrudates with different concentrations of cassava leaves and carrot addition

4 CONCLUSIONS AND FUTURE STUDY

The addition of cassava leaves and carrot powder increases the beta-caroten level of extrudates significantly. This opens an opportunity to improve children's intake of vegetables. However, the vegetable addition may also lead to the degradation of extrudates' physical quality. Conventional
5 extrusion caused significant changes in the physical quality of the extrudates. In order to improve the physical quality, supercritical-fluid extrusion may be used.

Supercritical fluid extrusion uses supercritical CO_2 as the expansion driving force instead of steam during extrusion. This results in a better expansion control and minimum nutrition degradation [11]. Research has been done to extruded milk protein [12] and also with addition of fibrous materials such as fruit pomaces [13].

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