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Physicochemical Characteristics of Sweet Potato (Ipomoea batatas L.) Chips Pre-treated by Commercial and Eggshell Extracted Calcium Chloride

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Abstract. Chips is a snack with thin shape and crispy characteristic because of its low water content. As snack, good quality of chips does not emphasized on its nutritional value, but consumer rather focused on organoleptic properties. Increase the crispiness of sweet potato chips is desirable. This condition can be achieved by soaking chips using calcium solution. Chips found in market is usually soaked using commercial calcium chloride which usually derived from limestone. Other potential source of calcium chloride, which is easily found as food waste, is eggshell. Eggshell contains high amount of calcium. The aim of this research is to investigate the physicochemical properties of sweet potato chips pre-treated by commercial and eggshell extracted calcium chloride. Calcium chloride used in this research is obtained from eggshell extraction and commercial chemical product. The results revealed that each type of the calcium chloride has different purity which are 68,60% for eggshell extracted, and 74% for commercial calcium chloride. Three different concentration of calcium chloride were used (0,25%; 0,50%; 0,75%) to soak the sweet potato. From the research, it is shows that the best treatment is the usage of 0,75% eggshell calcium chloride which resulted in 4,93 % of water content, 2,42 % of ash content, and 20,14 of fat content. Calcium percentage in each pre-treatment process was reduced after each step of processing

Keywords:eggshell, calcium chloride, chips, sweet potato

1. Introduction

Egg is food that commonly consumed in the household. Based on data from Statistic Indonesia (2017), consumption of egg in Indonesia is 0,124 kg per capita per week. Moreover, numerous food industries are also using egg as one of their main ingredient, especially for bread and other bakery products. The enormous utilization of egg in individual level or food industries could give beneficial condition in terms of protein intake which can increase by consuming egg in daily basis. On the other hand problem is also arise due to the number of eggshell as waste as the result of egg utilization.

Eggshell to date are only ended as waste which can be composted. Few other are used to make handycraft. Based on report by [1] the major content of eggshell is calcium carbonate ($CaCO_3$) which contribute to 94% of the total weight of eggshell, other components are calcium phosphate, magnesium carbonate, and other organic compounds in trace amount. Based on those facts, eggshell could be used as potential source of calcium.

Calcium has long been known to play a key role in mantaining the cell wall interity of food product, thus responsible for the firmness and chrispness of several food products [2]. Calcium in the native form is always bond with minerals or other elements. In eggshell, most calcium is in the form of calcium carbonate. By extraction process using acid such as hydrochloric acid, calcium from eggshell could be utilized in the form of calcium chloride. Research by [3] reported the optimization of extraction of eggshell using hydrochloric acid as solvent in various concentration and extraction time.

Calcium chloride can be applied in food processing to maintain the firmness of canned fruits and vegetables. Usually thermal process of food will result in the decrease of firmness of products. This could be due to the changes of cell permeability, changes of pectin, and the effect of sugar in the soaking media. Calcium can be used as soaking agent to increase the hardness of products such as canned papaya, pear, apple, and also the chrispness food products such as chips and flakes.

The aims of this research were to extract the calcium chloride from chicken eggshell, and to investigate the effect of soaking using commercial and chicken eggshell extracted calcium chloride on the physicochemical characteristic of sweet potato chips.

2. Material and Method

In this research, sweet potato was collected from farmer in Malang district East Java province. Meanwhile chicken eggshell were collected from bakery shop in Surabaya, East Java province. Hydrochloride acid (HCl) (Merck, Germany) was used for extraction process, and aquadest for analysis were processed in analytical laboratory, Department of Food Technology, Widya Mandala Catholic University Surabaya. Equipments used for processing were digital balance (Mettler Toledo), slicer, deep fryer, glassware, hot plate, and centrifuge.

2.1. Calcium extraction from eggshell

Calcium chloride can be extracted from eggshell by initiating chemical reaction of calcium carbonate ($CaCO_3$) of eggshell with 2,5% HCl solution [3]. Briefly, 1 grams of eggshell were mixed with 25 mL of 2,5% HCl in a beaker glass and stirred occasionally until no air bubbles were found. The mixtures were then heated until 115ºC. The remaining mixtures were dried in a pan until all solutions were evaporated. The dried white powder is the $CaCl_2$ yield.

2.2. Sweet potato chips processing

Sweet potato were sorted and peeled to remove the skin. Then the peeled sweet potato was washed using clean tap water and placed in trays until completely dry. Sweet potato was then sliced using commercial slicer approximately 2 mm width. The sliced sweet potato was soaked in calcium chloride solution. In this research, commercial $CaCl_2$ and eggshell extracted $CaCl_2$ were used. The concentration of $CaCl_2$ soaking solution were 0,25%, 0,50%, and 0,75%. The sliced sweet potato was soaked for 15 minutes. After that, the sliced sweet potato were fried using deep fryer at 150ºC for 3,5 minutes. Then the fried sweet potato were placed in spinner to remove the oil, cooled in the room temperature and immediately stored in a closed container until further analysis.

2.3. The purity of $CaCl_2$ extracted from eggshell

The purity of $CaCl_2$ from chicken eggshell was determined using spectrophotometry. Briefly, 1 g of $CaCl_2$ yield from extraction process was dissolved in 50 mL of aquadest. Then the solution was mixed thoroughly using vortex. After that, 1 mL of solution wasplaced in cuvette and the absorbance was measure in UV Vis spectrophotometer on 455 nm. The result was then plotted in standard curve made from $CaCl_2$ pro analysis standard.

2.4. Moisture content analysis

Moisture content was measured using thermogravimetric methods of which 1 g of eggshell extracted $CaCl_2$ were placed in weighing bottle and stored in the oven. Temperature of the oven was 110ºC. After that, periodically the sample was weigh until the constant weight was obtained.

2.5. Ash content

For ash content, 1 g of sample was placed in porcelain crush and placed in muffle furnace. The temperature was set to 550ºC. After that, periodically the sample was weigh until the constant weight was obtained.

2.6. Calcium analysis in sweet potato chips as $CaCl_2$

Calcium content were analysis on the chips after soaking with $CaCl_2$ solution, and after frying process to measure the changes of $CaCl_2$ content in sweet potato chips. Briefly, 1 g of potato chips powder each for chips after soaking with $CaCl_2$, and after frying process were destructed using 20 mL 37,5% HCl. The mixture was vortexed thoroughly. After that, the mixtures were heated at 100ºC for 10 minutes. If the volume of HCl decreased, then additional HCl was added. After that 1 mL of final solution was placed in 100 mL volumetric flask and filled up with aquadest. Then, 1 mL of solution was placed in cuvette and the absorbance was measure in UV Vis spectrophotometer on 455 nm. The result was then plotted in standard curve made from $CaCl_2$ pro analysis standard.

2.7. Statistical analysis

This research was conducted using Randomized Complete Block Design with one factor and five replications. Data obtained wereanalyzed using ANAVA on5% of alpha. For significance difference analysis, DMRT (*Duncan Multiple Range Test*) were applied. For statistical analysis, SPPS ver. 16 software was used.

3. Result and Discussion

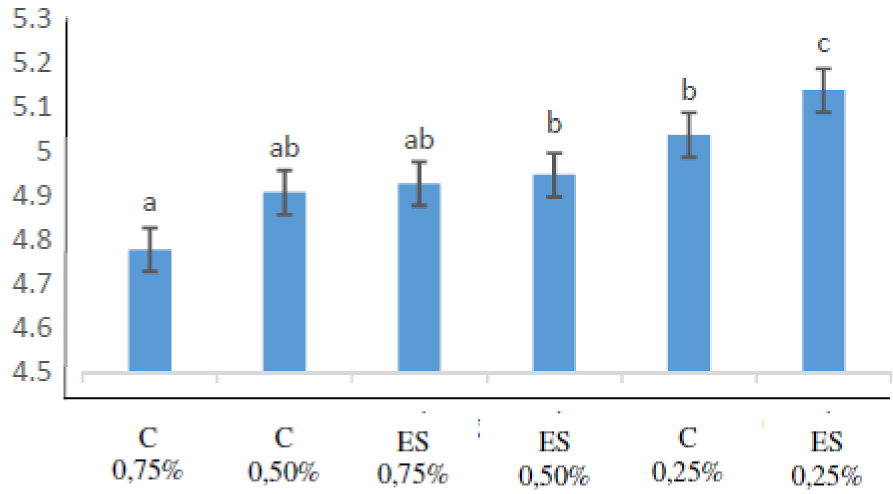
The measurement of purity of eggshell extracted $CaCl_2$ is important because the impurities could affect the functional properties of $CaCl_2$ applied to food or food products. The data of absorbance and concentration of eggshell extracted $CaCl_2$ are shown in Table 1.

Table 1. Data of absorbance and $CaCl_2$ concentration of eggshell extracted $CaCl_2$

Replication	Absorbance (A)	Concentration (ppm)
1	0,231	34,3
2	0,231	34,3
3	0,234	34,4
Average		34,3

The average of concentration was then used to calculate the purity of eggshell extracted $CaCl_2$. From the calculation, the purity was 68,60%. According to Rivera (1999), eggshell consists of 94% of $CaCO_3$. Other mineral found in eggshell is magnesium carbonate. Beside minerals, eggshell also consists of few organic materials such as protein, of which interfere the extraction process thus decrease the yield of $CaCl_2$ obtained. Even though the amount of HCl is sufficient to conduct the extraction, however, the CO_2 as a product of the reaction could also disturb the reaction between HCl and $CaCO_3$. In the form of bubbles, they separate the $CaCO_3$ from acid solution.

Moisture content is the percentage of water in food product. The moisture content measurement of sweet potato chips is important because moisture content will determine the properties and characteristics of chips. The moisture content of sweet potato chips can be seen in Figure 1. Calcium chloride itself is hygroscopic material which can be easily to bond with water. According to [4], $CaCl_2$ are often found in the form of hydrate. $CaCl_2$ is not directly responsible for the moisture content of sweet potato chips, however, the soaking process of sweet potato chips with $CaCl_2$ solution playing a very important role on the formation of calcium pectate in sweet potato which also have pectin content [5]. Ca^{2+} ion will form a bond with pectinic acid [6] in sweet potato resulted in crosslinking formation among Ca^{2+} ion. The crosslinking bond create calcium pectate an insoluble substance [7] which responsible for the crispness of sweet potato chips. The chrispness of sweet potato chips is due to the movement of water inside the chips caused by the calcium pectate molecule. The movement of water creating space inside the chips resulted in low water content and increase the crispness of sweet potato chips.

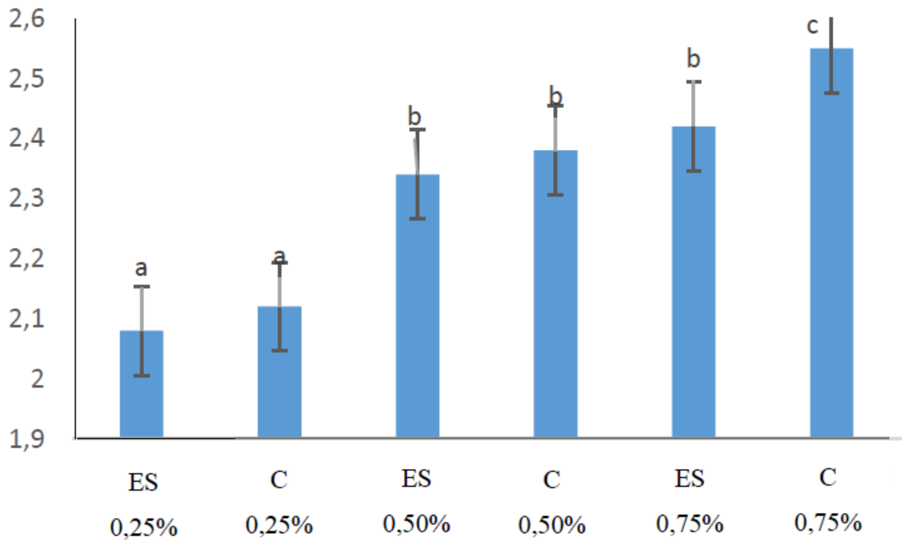


C: commercial; ES: eggshell

Figure 1. The moisture content of sweet potato chips treated with commercial and eggshell extracted calcium chloride

From Figure 2, it can be seen that the increase of $CaCl_2$ concentration will leads to the decrease of moisture content. This could be due to the increase of Ca^{2+} ion which then could form more of calcium pectate complex [8] that could decrease the moisture content of sweet potato chips. The result could also imply that the utilisation of $CaCl_2$ from eggshell is able to substitute the use of commercial $CaCl_2$, in a higher concentration due to the differences of purity level. The moisture content of all samples can fulfil the standard requirement of sweet potato chips products which is 6%.

The ash content in food samples shows the number of minerals in the samples. In this research, measurement of ash content is important because there are soaking procedure of sweet potato chips using $CaCl_2$ solution. The result as seen in Figure 2 revealed that the ash content of sweet potato chips are between 2,08 to 2,55% (w/w).



C: commercial; ES: eggshell

Figure 2. The ash content of sweet potato chips treated with commercial and eggshell extracted calcium chloride

According to [9] sweet potato has 30 mg/100g sample of calcium. Meanwhile the increase of ash content in line with the raise of concentration of $CaCl_2$ soaking solution. The higher concentration of soaking solution leads to the accumulation of Ca2+ ion that will difuse to the matrix of sweet potato and bonding with pectinic acid to form calcium pectate network that will boost the opportunity of Ca^{2+} ion to enter the matrix.

The average of ash content from commercial $CaCl_2$ soaking solution group is higher compared to eggshell $CaCl_2$ group. This could be due to its higher purity. Moreover, in $CaCl_2$ from eggshell there are protein [10] which are not soluble because of denaturation process by acid and heat. Therefore, it decrease the $CaCl_2$ absorbtion by sweet potato chips, resulted in the lower ash content measured in eggshell $CaCl_2$ treated sweet potato chips.

The $CaCl_2$ content were also evaluated after soaking process and after frying. Data of $CaCl_2$ contents can be seen in Table 2.

Table 2. $CaCl_2$ content of sweet potato chips before and after soaking and after drying

Treatment	Concentration (ppm)		
	Before soaking	After soaking	After frying
Eggshell 0,25%	50,06	61,18	62,84
Eggshell 0,50%	47,97	69,94	72,08
Eggshell 0,75%	46,44	84,39	86,81
Commercial 0,25%	47,56	59,24	60,98
Commercial 0,50%	51,03	74,56	76,82
Commercial 0,75%	47,42	86,77	89,72

It can be seen from Table 2 that after soaking the $CaCl_2$ content of sweet potato slice is increased significantly. The soaking process enven thogugh only for 15 minutes provides sufficient time for $CaCl_2$ to difuse inside the matrix of sweet potato slice network, resulted in the raise of $CaCl_2$ concentration measured [11]. The commercial $CaCl_2$ have the stronger ability to penetrate the matrix wall of sweet potato slice and therefore gave a higher content of $CaCl_2$ in comercial treated sweet potato slice. This could be due to the level of purity and absence of interfering substances such as protein.

Menawhile, frying process could also increase the $CaCl_2$ content however the data were not significantly different. Even though the frying process will leads to the evaporation of moisture content and retain the calcium content. In this research there are no significant difference meaning that probably the absorbtion of $CaCl_2$ in the soaking process is effective, thus were not change after fring process. According to [12] the calcium could decrease the oil uptake of frying food products.

4. Conclusion

Eggshell could be a potential source of calcium chloride ($CaCl_2$) and can be applied in sweet potato chips by soaking process. The pre-treatment of $CaCl_2$ can decrease the moisture content of sweet potato chips, increase the ash content, and raise the calcium content of sweet potato chips. Even though, the purity the effectiveness as soaking agent is lower than commercial $CaCl_2$, eggshell $CaCl_2$ is a promising material as substitute with additional benefit in reducing food waste.

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