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Iodine Retention of Potassium Iodate Fortified Modified Cassava Flour (Mocaf) in Various Types of Package during Storage

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Abstract:
Modified cassava flour (mocaf) fortified with potassium iodate (KIO_3) was prepared as food alternative for iodine deficiency disorders (IDD) intervention. This present study aimed to evaluate iodine retention of mocaf fortified with KIO_3, moisture content, and swelling power during storage at various KIO_3 concentrations and package types, conducted in experimental research design. Fortification was performed at KIO_3 concentrations of 0 (non-fortification), 10, 20, 30, and 40 ppm. The products were then stored in polyethylene (PE), polypropylene (PP), and aluminium foil package, at room temperature for 0, 1, 2, 3, and 4 months. Results showed that after 4 months' storage, iodine retention was decrease in all treatments. The highest percentage of iodine retention of 74.93% was obtained by 40 ppm KIO_3fortified flour packed in aluminium foil, which also had the lowest difference between initial and final retention among all samples. Retention pattern showed increasing percentage was obtained with higher KIO_3 concentration in dose dependent manner, followed by increasing moisture content to 18.54% and swelling power to 45.66%. Significant difference was found between storage period and iodine retention, moisture content, and swelling power.

Keywords: *iodine fortification, modified cassava flour (mocaf), package, storage*

1. Introduction

Iodine deficiency disorders (IDD) is the result of lack iodine consumption. Basic Health Survey by Indonesian Ministry of Health in 2013 reported that iodine deficiency occurs in children aged 6-12 years old was 14.9%, while in fertile-age women was 22.1% (Balitbangkes, 2013). In several region in Indonesia, such as Ponorogo district, high incidence of hypothyroid was reported occur in fertile-age women and school-age children of 20.7% and 21.5%, respectively (Supadmi *et al*., 2012). Iodine deficiency is the open door for various health problems such as stunted growth and mental development, hypothyroid, and cretinism, which can be occurred in all ages since baby, neonatus, children, to teenager, and adult (WHO, 2007).

Fortification can be defined as addition of one or more nutrient to increase the nutrient consumption into food, in order to gain adequate nutritional status. Iodine fortification is widely used as a strategy to eliminate iodine deficiency disorders (Lotfi*et al*., 1996; Clifton *et al*., 2013) due to its important role as component of thyroid hormone family thyroxin (T4) and triiodothyronine (T3) regulating several enzyme and metabolism. Potassium iodate (KIO_3) with good stability even in high humidity storage is one of the most commonly used compound, particularly for longer product shelf life (Shelswell, 2003). WHO and UNICEF recommend KIO_3as fortification in salt due to its stability in high temperature and humidity (Sinawat, 1997). However, several previous researches reported various limitation of salt-based iodine fortification such as low salt consumption in household diet due to health reason. It indicated that research on iodine vehicle in other kind of food product is still necessary.

Cassava has high potential to support food security, in form of modified cassava flour. To increase cassava flour consumption and its product diversification, cassava flour quality need to be increased (Haryadi, 2011). Previous research reported that cassava starch modification resulted better functional properties (Gunorubon*et al*., 2012). Mocaf can be used as main ingredientin food product, or as substitution for wheat flour, tapioca, rice/sticky rice, and improveragent (Subagio, 2013). As it contains high level of amylose, the flour can bind iodine, thus iodine can be used as biofortification to prevent iodine deficiency (Mottiar *et al*., 2011). Iodinecan bind to both amylose, with linier α-1-4glycosidicbond, andamylopectinwith α-1-4-glycosidic chainbranched in α-1-6-glycosidic bond (Jane, 2009). However, moisture-contained air diffusion into food package in high humidity storage can lead to iodinerelease (Diosady*et al*., 1997). Moreover, swelling emerges due to hygroscopic property of starch where water become trapped inside starch molecules. This present research was focused on KIO_3 fortification into mocaf aimed to evaluate iodine retention, moisture content, and swelling power during storage at various KIO_3 concentrations and different packages.

2. Material and Methods

2.1. Design and Location

Experimental design was used, conducted in Laboratory Universitas Gadjah Mada Yogyakarta, Indonesia and IDD Research and Development Center of Ministry of Health, Magelang, Indonesia.

2.2. Materials and Instruments

Mocaf was obtained from processing plant in Gunung Kidul district, Yogyakarta, Indonesia. Potassium iodate (KIO_3) in form of white crystal powder was obtained from Merck (Germany). Samples were then put into package made from polyethylene (PE) and polypropylene (PP)0.8 mm thick, 20 cm x 35 cm, and aluminium foil 0.6 micron thick, 20 cm x 32 cm, all at 1.000 g capacity.

2.3. Mocaf Fortification

In dry mixing method, mocaf flour premix was initially made and added with KIO_3 at several concentrations, of 0 (non-fortifications control), 10,20, 30, and 40 ppm. Samples were then prepared in 10 ppm (10 mg KIO_3/1.000 g flour), 20 ppm (20 mg KIO_3/1.000 g flour), 30 ppm (30 mg KIO_3/1.000 g flour), and 40 ppm (40 mg KIO_3/1.000 g flour).

2.4. Mocaf Storage and Sampling

Samples were stored at room temperature 28.29^{0}C, RH 77.42% in open rack which avoid direct sunlight. Sampling was done at initial period (0 month), then 1, 2, 3, and 4 months. Sample as much as 225 packs according to five KIO_3 concentrations and 3 package types: polyethylene, polypropylene, and aluminium foil. In 0 months, 45 packs were evaluated, and repeated in every sampling period. Analysis was done in triplicate.

2.5. Iodine Retention

Retention of iodine is a measure of the proportion of iodine remaining in the food in relation to the amount of iodine initial and stated in the form of percent (Longvah*et al*., 2013). Determination of iodine a method used spectrophotometer, then the retention of iodine was calculated following the formula:

$$\frac{\text{Iodine content of mocaf after storage X 100\%}}{\text{Iodine content of mocaf before storage}}$$

2.6. Moisture Content Analysis

Based on oven method by AOAC (2005), sample was dried at 105^{o}C – 110^{o}C and after cooling in desiccator for 20 minutes, samples were weighed. The process was repeated until constant weight.

2.7. Swelling Power Analysis

A method proposed by Leach *et al*. (1959) was used. In 1 g sample, 50 ml distilled water was added, inside 50 ml valcon tube. After homogenization and heating at 90^{0}C for 30 minutes, mixture was cooled and centrifuged for 20 minutes. Supernatant and natant was separated by filtration, and the later was weighed until constant. Ratio of swelling mass from initial mass was quantified, expressed as g/g.

2.8. Statistical Analysis

distribution normality measurement using Kolmogorov-Smirov. Data were analyzed using one-way analysis of variance (ANOVA) followed by Duncan's multiple range test (DMRT).Statistical analysis was performed using SPSS version 18.0 Software Program.

3. Results and Discussion

3.1. Iodine Retention during Storage

Iodine in iodate form has limitation due to evaporation loss (Diosady*et al*., 2006).Iodine retention (%) of modified cassava flour fortified with potassium iodate during 4 months' storage in various type of packages is presented in figure 1.

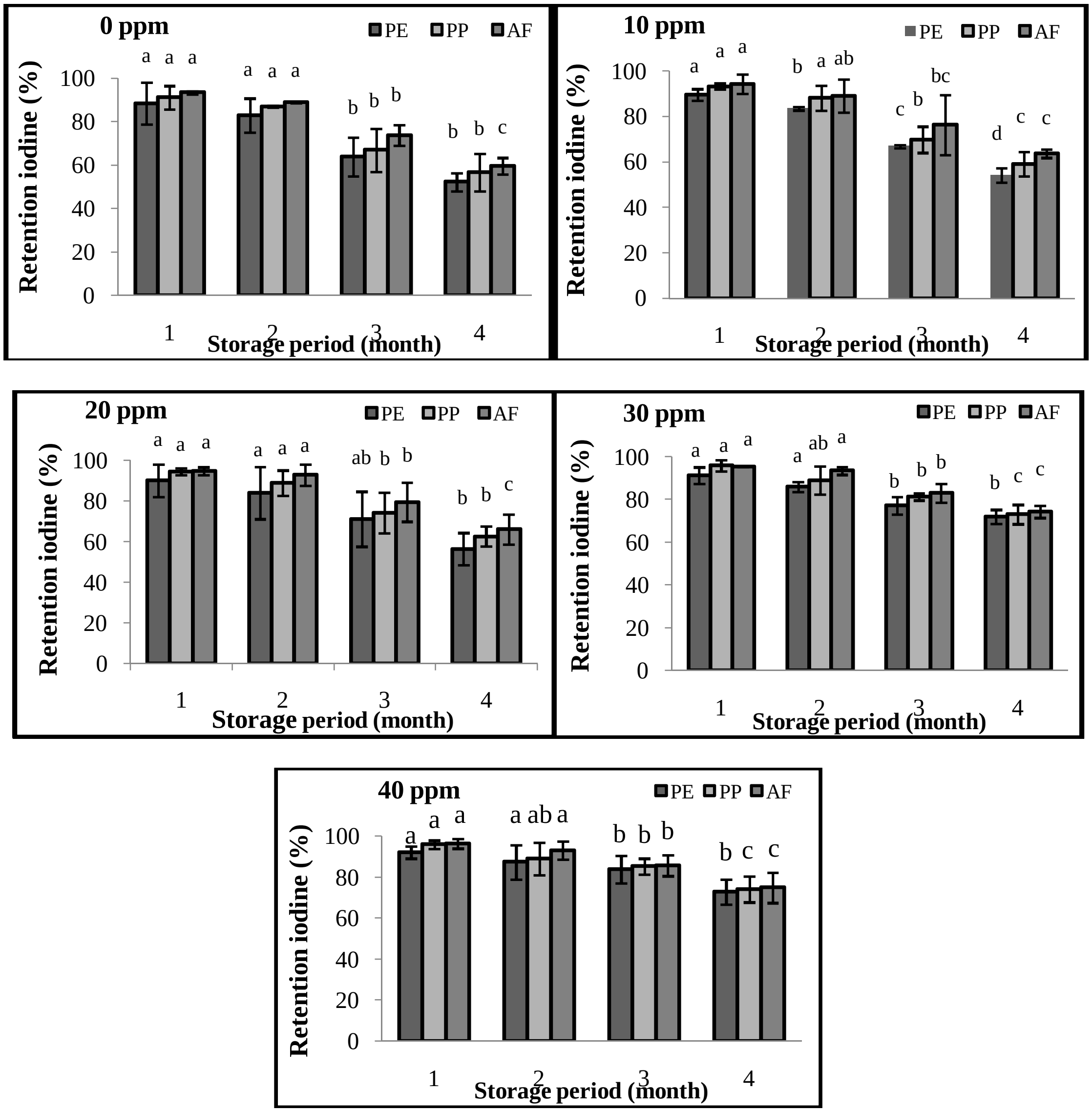

Figure 1: Iodine retention (%) of modified cassava flour fortified with potassium iodate during 4 months' storage in various type of packages.

Values represent mean±standard deviation (n=3, taken at average temperature and humidity of 28.29^0C and 77.42%, respectively). Data with same superscript in a row do not differ significantly (p>0.05).
PE: polyethylene, PP: polypropylene, AF: aluminium foil.

Storage until 3 month at room temperature (average temperature and relative humidity of 28.29^0Cand 77.42%, respectively), iodine retention remained high (68.23 – 84.99%), similar to previous result obtained by Diosady*et al*. (2006). However, after 4 months, retention percentage was decreased in all samples. Iodine retention for 0-40 ppm from each package ranged at 52.3 –72.94% (polyethylene), 56.62 – 74.22% (polypropylene), and 59.67 – 74.93% (aluminium foil). Regardless of package, the pattern indicated that higher retention can be obtained with higher KIO_3 concentration in dose dependent manner. Retention decrease pattern during all storage period also indicated that the loss tends to increase with lower KIO_3 concentration.

Indicated that aluminium foil resulted better iodine retention than polyethylene and polypropylene. Mentioned in another research, aluminium foil can be used for food preparation package (Bassioni*et al*., 2012)andas a barrier to the migration of moisture, oxygen, gas, and light(Lamberti*et al*., 2007), while polyethylene is known to protect food from adverse effect of humidity (Diosady*et al*., 2006).Statistically, storage period significantly affect ediodineloss (p=0.00), with higher loss in longer storage period. Overall, regardless of package and iodate concentration, iodine retention pattern started to change at two months' storage, with significant change at 4 month. There was significant effect of KIO_3 concentrations on iodine content of mocaf, in dose dependent manner, with no significant difference found among package types.

Iodine retention after 3monthsstorage was considered high, Shen*et al* (2013) noted 2 bonds iodine– amylopectin interaction, external and internal iodine complex chain. Jane (2009) also mentioned that iodinebound to 20 % pure amylase in defatted tapioca starch was 23.5%. The results found in this study suggested that iodine retention can be preserved with addition of higher KIO_3concentration, which probably compensate iodine loss during storage.

3.2. Moisture Content

The analysis is one of critical measurement in food industry (Mathlouth, 2001), and it was indicated that storage affected mocaf moisture content. Storage period 4 month, moisture content was13.49±0.09% (wb), 18.54% higher than its initial level. Aluminium foil package had the least increasing of 13.42% (wb).

Statistically, significant difference (p=0.00) was found among moisture content with longer storage period. After two months' storage, moisture content was slightly different, while the pattern of samples packed in polyethylene, polypropylene, and aluminium foil was relatively similar. Significant difference was found among different KIO_3 concentrations. During storage, iodate and iodineredoxreaction generates water molecule. Higher level of iodate conversion into iodine produces more water molecule subsequently contributes to higher moisture content (Liu *et al*., 1988). In the other hand, iodine has low water solubility of 0.34 g/lat 25^0C (Fawellet al., 2003), hence moisture content might influence iodine retention with longer storage period. All results at various KIO_3 concentrations and package types are presented in Table 1.

Package	**KIO_3concentration (ppm)**	**Storage period (month)**				
		0	1	2	3	4
PE	0	11.33±0.22^c	11.40±0.33^c	12.41±0.06^b	12.44±0.03^b	13.14±0.04^a
	10	11.51±0.09^c	12.28±0.32^b	12.44±0.05^b	12.48±0.11^b	13.30±0.04^a
	20	11.53±0.05^c	12.62±0.04^b	12.64±0.15^b	12.74±0.15^b	13.51±0.04^a
	30	11.57±0.05^c	12.69±0.09^b	12.84±0.02^b	12.88±0.10^b	13.53±0.17^a
	40	11.62±0.15^c	13.27±0.24^b	13.34±0.07^b	13.51±0.41^b	14.26±0.04^a
PP	0	11.04±0.47^b	11.35±0.10^b	12.28±0.03^a	12.34±0.04^a	12.72±0.41^a
	10	11.24±0.06^c	12.23±0.53^b	12.38±0.04^b	12.40±0.10^b	13.17±0.06^a
	20	11.48±0.38^c	12.49±0.10^b	12.61±0.11^b	12.72±0.09^b	13.53±0.07^a
	30	11.53±0.18^c	12.62±0.09^b	12.75±0.08^b	12.84±0.16^b	13.92±0.04^a
	40	11.59±0.04^c	13.04±0.37^b	13.30±0.02^b	13.48±0.35^b	14.20±0.07^a
AF	0	10.85±0.07^c	11.00±0.20^c	12.14±0.06^b	12.27±0.12^b	12.62±0.16^a
	10	11.25±0.04^c	11.33±0.06^c	12.26±0.01^b	12.30±0.11^b	13.06±0.05^a
	20	11.30±0.16^c	12.44±0.06^b	12.55±0.07^b	12.56±0.37^b	13.57±0.11^a
	30	11.34±0.18^c	12.54±0.24^b	12.63±0.02^b	12.70±0.07^b	13.75±0.01^a
	40	11.57±0.07^c	13.02±0.16^b	13.10±0.07^b	13.26±0.20^b	14.12±0.09^a

Table 1: Moisture content of modified cassava flour fortified with potassium iodate during 4 months storagein various type of packages

Values represent mean±standard deviation (n=3, taken at average temperature and humidity of 28.29^0C and 77.42%, respectively). Data with same superscript in a row do not differ significantly (p>0.05).
PE: polyethylene, PP: polypropylene, AF: aluminium foil.

3.3. Swelling power (SP)

Swelling power during storage from various KIO_3 concentrations and packages is presented in Table 2. The analysis was done to measure swelling rate of starch granule. Starch swelling mechanism is caused by starch ability to absorb water and low hydrogen bond bind to amylose and amylopectin molecules. Swelling power increased with longer storage period, up to 20.64±2.12% after 4months.Similar swelling power was observed in all package type, but regardless of packages, 10 ppm iodates showed better result with lowest swelling power. Statistically, swelling power was significantly affected by storage period (p=0.00). However, no significant difference was found among package types and KIO_3concentrations. Aluminium foil package had the least increasing of 43.29%.

Package	**KIO_3 concentration (ppm)**	**Storage period (month)**				
		0	1	2	3	4
PE	0	14.38±0.60^c	14.74±0.05^{bc}	14.88±0.18^b	15.75±0.79^a	18.67±2.50^a
	10	14.48±0.20^c	14.89±2.09^{bc}	15.11±0.14^{bc}	17.09±0.75^b	19.62±1.35^a
	20	14.53±0.52^c	14.91±0.74^c	15.46±0.21^c	19.56±0.80^b	22.15±1.80^a
	30	14.56±0.58^c	14.96±0.76^c	17.69±0.67^{bc}	20.55±1.45^{ab}	22.73±3.24^a
	40	14.73±0.76^c	15.40±0.63^{bc}	18.11±1.18^b	21.82±0.74^a	23.05±3.42^a
PP	0	13.42±0.44^c	13.88±0.36^{bc}	14.36±0.59^b	15.18±0.27^a	18.60±0.44^a
	10	13.90±0.35^b	14.27±0.71^b	14.81±0.62^b	16.08±2.47^b	19.17±0.69^a
	20	14.00±0.81^b	14.66±0.53^b	15.20±0.65^b	16.31±1.24^b	21.52±4.53^a
	30	14.14±0.27^b	14.98±0.54^b	16.10±0.50^b	17.75±4.00^b	21.53±1.13^a
	40	14.80±0.19^c	15.33±0.90^{bc}	17.60±1.50^b	20.95±0.95^a	22.78±2.54^a
AF	0	13.70±0.61^b	13,91±0.50^b	14.23±0.72^b	15.05±1.25^a	18.39±2.77^a
	10	13.73±0.39^b	14.32±0.45^b	14.71±0.36^b	15.89±1.27^b	18.85±2.56^a
	20	13.90±0.55^c	14.64±0.27^c	15.16±0.44^{bc}	15.99±0.75^b	19.06±1.03^a
	30	14.14±0.42^c	14.65±0.63^c	15.48±1.06^c	17.67±0.92^b	21.48±0.87^a
	40	14.18±0.98^b	15.08±0.08^b	16.29±0.78^b	20.14±0.67^a	22.04±3.00^a

Table 2: Swelling power of modified cassava flour fortified with potassium iodateduring 4 months storagein various typeof packages

Values represent mean±standard deviation (n=3, taken at average temperature and humidity of 28.29^{0}C and 77.42%, respectively). Data with same superscript in a row do not differ significantly (p>0.05).
PE: polyethylene, PP: polypropylene, AF: aluminium foil.

4. Conclusion

Longer storage period resulted in iodine loss, higher moisture content and swelling power, evaluated once a month. Iodine retention remained relatively high up to 3months storage, with the best retention obtained by flour fortified with 40 ppm KIO_3 packed in aluminium foil. There was significant effect of storage period on iodine retention, moisture content, and swelling power, while KIO_3 concentration only had significant effect on iodine retention and moisture content. In the other hand, package type had no significant effect on iodine retention, moisture content, and swelling power. Polyethylene, polypropylene, and aluminium foil ability to protect mocaf flour was relatively similar, but aluminium foil had better result.

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