Research Article

ความปลอดภัยในการบริโภคลำไยที่ได้รับการกระตุ้นการออกดอกนอกฤดูกาล

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บทคัดย่อ

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รับบทความ : 13 กันยายน 2561 **แก้ไขบทความ:** 15 กุมภาพันธ์ 2562 **ตอบรับ:** 18 กุมภาพันธ์ 2562

ปัจจุบันประเทศไทยมีการผลิตลำไยนอกฤดูกาลโดยการใช้สารโพแตสเซียมคลอเรตกระตุ้นการออกดอกนอกฤดูกาล ซึ่งสารโพแตสเซียมคลอเรตถูกประกาศไม่ให้มีในอาหาร งานวิจัยนี้จึงมีวัตถุประสงค์ในการประเมินความเสี่ยงจากการบริโภคลำไยที่ได้รับการกระตุ้นการออกดอกนอกฤดูกาล **วิธีดำเนินงานวิจัย:** ทำการศึกษาการใช้สารโพแตสเซียมคลอเรตที่ปริมาณการใช้แตกต่างกัน 3 ขนาด เป็นการกระตุ้นต้นลำไยทางราก 3 กลุ่ม (n=5 ต้น) เปรียบเทียบกับกลุ่มควบคุม (n=2 ต้น) หลังการกระตุ้น 210 วัน (ผลลำไยพร้อมรับประทาน) ทำการเก็บตัวอย่างลำไยมาสกัดด้วยน้ำกลั่น แล้วทำปฏิกิริยากับสารละลาย Indigo carmine และกรดไฮโดรคลอริกเข้มข้น 6 โมลาร์ เพื่อวิเคราะห์ปริมาณสารคลอเรตด้วยเครื่อง UV-Spectrophotometer ที่ความยาวคลื่น 610 นาโนเมตร แล้วนำค่าที่ได้ไปใช้ในการคำนวณความเสี่ยงทางสุขภาพจากการบริโภคด้วยค่า Margin of safety (MOS) **ผลการวิจัย:** ผลลำไยกลุ่ม 3 (ที่ได้รับปริมาณสารโพแตสเซียมคลอเรตกระตุ้น 960 กรัมต่อต้น) มีความเข้มข้นของสารคลอเรตสะสมในเนื้อลำไยสูงสุด คือ 0.2254±0.0004 µg/g และกลุ่มควบคุมมีปริมาณสารคลอเรตสะสมต่ำสุดคือ 0.0326±0.0001 µg/g ผลการประเมินความเสี่ยงจากการบริโภคเนื้อลำไยของทุกกลุ่มที่อัตราการบริโภค 10 ผลต่อวัน 500 กรัมต่อวัน และ 1 กิโลกรัมต่อวัน พบค่า MOS (Margin of safety) มากกว่า 1 ทั้งหมด แสดงว่าการบริโภคเนื้อลำไยที่ได้รับการกระตุ้นการออกดอกนอกฤดูกาลด้วยสารโพแตสซียมคลอเรตไม่น่าจะต้องกังวลด้านผลต่อสุขภาพจากสารคลอเรตตกค้างในเนื้อลำไยสำหรับผู้บริโภคโดยทั่วไป

Keywords: ลำไย, นอกฤดูกาล, ความปลอดภัย, การประเมินความเสี่ยง, โพแตสเซียมคลอเรต

Safety of out-of-season longan consumption

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Abstract

Safety of out-of-season longan consumption

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Nowadays, out-of-season longan production in Thailand was generally stimulated by potassium chlorate. As the chemical is prohibited in food, this study was aimed to assess the health risk from consumption of these longan fruits. **Materials and Methodology:** Three different doses of potassium chlorate were applied on longan trees via root (each dose, n=5), and a control group (n=2). After 210 days of application, the longan fruits samples (ready-to-eat fruits) were collected. After extraction with water, the extracts reacted with indigo carmine and 6M HCl were analyzed for chlorate residues using UV-Spectrophotometer at 610 nm. Then, assessment of the health risk by Margin of Safety (MOS) was performed. **Results:** The highest concentration of chlorate residues in longan fruits was found in group 3 (960 g potassium chlorate/tree) at 0.2254±0.0004 µg/g and the lowest concentration was in control group at 0.0326±0.0001 µg/g. The risk assessment found that consumption of 10 fruits/day, 500 and 1,000 g/day of all treated fruits were safe as Margins of Safety were all higher than 1. Therefore, no adverse effects on health should be worried from consumption of out-of-season longan fruits in general population.

Keywords: Longan, Out-of-season, Safety, Risk assessment, Potassium chlorate

1. Introduction

Out-of-season longan production in Thailand was stimulated by potassium chlorate ($KClO_3$). The applied doses were independently chosen by users while some of them followed recommended dose from Office of Agricultural Research and Development Region 1, Department of Agriculture (Surapol Thongtaing, 2009). The application of potassium chlorate could be either via roots or leaves. Chlorate (ClO_3) compounds with oxidizing property can produce adverse effects on human body such as methemoglobinemia, cyanosis, kidney failure, liver damage

and nervous system impairment (JML Safety Data Sheet, 2002). According to present regulations in Thailand, $KClO_3$ is prohibited in food as announcement from Ministry of Public Health on 1993, issue no. 15 (Mari Asami, *et al*., 2003) and the possession of the chemical is strictly controlled by Infantry Division, Department of Military Industry, Ministry of Defense (Potassium chlorate, n.d.).

The tests for toxicity of $KClO_3$ from animal studies found LD_{50} in rat, rabbit, and dog at 1,500, 2,000 and 1,200 mg/kg, respectively (JML Safety Data Sheet, 2002). A case report on human health of American soldiers who ate matchstick heads (containing mixture of $KClO_3$) for 0.28 g/month during 6 months' fieldwork to prevent insect bite were found adverse effects on urine excretion and immune system (Bernardo EO, *et al*., 2015). Another case was a pregnant woman of 29 years old, she ate cinders of matchsticks for 4 weeks (>400 pieces). The baby was born with Apgar score 8-9, but had hyperbilirubinemia and hemolytic anemia. The mother had atherosclerosis to kidney (Bernardo EO, *et al*., 2015).

Therefore, this study was aimed to evaluate for health risk from chlorate residues in the fruits from consumption of out-of-season longan stimulated by different doses of $KClO_3$.

2. Materials and Methodology

2.1 Longan tree samples and $KClO_3$ dosages

Three groups of longan trees (n=5) were treated with different doses of $KClO_3$ and 1 group was for control (n=2). Group 1 was treated with 125 g/tree (farmer's own dose), group 2 was 640 g/tree (recommended dose from Office of Agricultural Research and Development Region 1, Department of Agriculture (Surapol Thongtaing, 2009), group 3 was 960 g/tree (150% recommended dose from the Office (Surapol Thongtaing, 2009)). All trees were treated via root by dissolving $KClO_3$ in water before applying on the soil under the bush near the tree's trunk.

2.2 Chemicals and instruments

$KClO_3$ 99.9% commercial grade (The Sun, China) was used for out-of-season longan stimulation. The other analysis chemicals were $KClO_3$ 99.5% AR (Univar, APS Ajax Finechem, Australia), Indigo carmine AR (Loba, Italy), Hydrochloric acid 12 M AR (RCI Labscan, Indonesia). Analysis instrument was UV-Spectrophotometer (PharmaSpace UV-1700, Shimadzu).

2.3 Chlorate residues analysis

Longan fruits samples were collected at 210 days after application (ready-to-eat fruits). The ground longan flesh was extracted with milli-Q water (1:10 w/v) for 30 mins at room temperature. After extraction, lyophilization, and reinstitution, the extracted samples were reacted with indigocarmine solution 0.0133 mM and HCl 6 M, incubated in water bath at 45-50 degree Celsius for 10 min, let cooled down at room temperature for 15 minutes before detection using UV-Spectrophotometer at 610 nm (Chiswell B and Keller-Lehmann B, 1993) and calculation for chlorate (ClO_3^-) residues in the samples by comparing with standard graph of ClO_3^- concentrations ranging between 0.001-2 ppm.

2.4 Risk assessment

Risk assessment for ingestion of out-of-season longans was estimated from 3 ingestion rates, i.e., 10 fruits/day (90-105 g), 500 g/day and 1,000 g/day of longan flesh and these ingestion rates were used to calculate for 3 daily ingestion doses (DDs) of chlorate residues for male and female population. Body weight of male was assumed at 60 Kg, of female 50 Kg. The reference dose (RfD) of chlorate was using 30 µg/kg/day (Mari Asami, *et al*., 2003). The result of risk assessment is presented by Margin of safety (MOS). MOS = RfD/DD. The criterion of MOS is defined as MOS>1 means the consumption of the longan fruits having no adverse effects on consumer health and MOS<1 means a probability of adverse effects (Environmental Protection Agency (US.EPA), 2017).

3. Results

The ClO_3 residues after 210 days of $KClO_3$ application found that the lowest concentration was found in longan flesh of control group (0.0326±0.0001 µg/g) and the highest was in group 3 (0.2254±0.0004 µg/g) as presented in Table 1.

Risk assessment for safety from out- of- season longan consumption was calculated up to 1 kg/day of longan flesh assumed for longan lovers who may consume up to 1 kg/day averagely. The results as shown in Table 2-3, found that at all consumption doses from all treated groups for both men and women, the MOSs were >>1. Even for the consumption of longan fruits from group 3, the highest $KClO_3$ dose used in this experiment, MOS was found at 9 for women and 11 for men (due to higher body weight of the male population).

Table 1 Chlorate concentrations in longan flesh after 210 days application of potassium chlorate

Sample group	Longan flesh (µg ClO_3/g)
Group 1	0.1488±0.0003*
Group 2	0.0466±0.0002*
Group 3	0.2254±0.0004*
Control group	0.0326±0.0001*

Group1: $KClO_3$ stimulation in farmer's own dose, via root (125 g/tree)

Group2: $KClO_3$ stimulation in recommended dose from Office of Agricultural Research and Development Region 1, Department of Agriculture, via root (640 g/tree)

Group3: $KClO_3$ stimulation in 150% recommended dose from Office of Agricultural Research and Development Region 1, Department of Agriculture, via root (960 g/tree)

Control group: without $KClO_3$ stimulation in the present experiment

* ClO_3 concentration of every group was significantly different from each other at $p<0.05$ (Two way ANOVA)

Table 2 Risk assessment for out-of-season longan consumption for men (60 kg-body weight) shown by Margin of Safety (MOS)

IR	Value	ClO_3^1 (µg/d)	DD^1 (µg/kg-d)	MOS^1	ClO_3^2 (µg/d)	DD^2 (µg/kg-d)	MOS^2	ClO_3^3 (µg/d)	DD^3 (µg/kg-d)	MOS^3	ClO_3^c (µg/d)	DD^c (µg/kg-d)	MOS^c
IR_1	10 fruits/day	11.55	0.19	156	2.72	0.05	662	15.15	0.25	119	1.69	0.03	1,065
IR_2	500 g/day	55.79	0.93	32	13.19	0.22	137	83.59	1.39	22	11.64	0.19	155
IR_3	1,000 g/day	111.57	1.86	16	26.37	0.44	68	167.17	2.79	11	23.29	0.39	77

IR_1=Ingestion rate of 10 longan fruits/day

IR_2=Ingestion rate of 500 g longan fruits/day

IR_3=Ingestion rate of 1,000 g longan fruits/day

[1]ClO_3 residues consumed, Daily ingestion dose (DD) and Margin of safety (MOS) of longan fruits consumption of group 1 sample

[2]ClO_3 residues consumed, Daily ingestion dose (DD) and Margin of safety (MOS) of longan fruits consumption of group 2 sample

[3]ClO_3 residues consumed, Daily ingestion dose (DD) and Margin of safety (MOS) of longan fruits consumption of group 3 sample

[c]ClO_3 residues consumed, Daily ingestion dose (DD) and Margin of safety (MOS) of longan fruits consumption of control sample

Table 3 Risk assessment for out-of-season longan consumption for women (50 kg-body weight) shown by Margin of Safety (MOS)

IR	Value	ClO_3[1] (µg/d)	DD[1] (µg/kg-d)	MOS[1]	ClO_3[2] (µg/d)	DD[2] (µg/kg-d)	MOS[2]	ClO_3[3] (µg/d)	DD[3] (µg/kg-d)	MOS[3]	ClO_3[c] (µg/d)	DD[c] (µg/kg-d)	MOS[c]
IR_1	10 fruits/day	11.55	0.23	130	2.72	0.05	552	15.15	0.30	99	1.69	0.03	888
IR_2	500 g/day	55.79	1.12	27	13.19	0.26	114	83.59	1.67	18	11.64	0.23	129
IR_3	1,000 g/day	111.57	2.23	13	26.37	0.53	57	167.17	3.34	9	23.29	0.47	64

IR_1=Ingestion rate of 10 longan fruits/day

IR_2=Ingestion rate of 500 g longan fruits /day

IR_3=Ingestion rate of 1,000 g longan fruits/day

[1]ClO_3 residues consumed, Daily ingestion dose (DD) and Margin of safety (MOS) of longan fruits consumption of group 1 sample

[2]ClO_3 residues consumed, Daily ingestion dose (DD) and Margin of safety (MOS) of longan fruits consumption of group 2 sample

[3]ClO_3 residues consumed, Daily ingestion dose (DD) and Margin of safety (MOS) of longan fruits consumption of group 3 sample

[C]ClO_3 residues consumed, Daily ingestion dose (DD) and Margin of safety (MOS) of longan fruits consumption of control sample

4. Discussion and Conclusion

The analysis for ClO_3 residues in longan flesh found that when increased the dose of $KClO_3$ stimulation, higher ClO_3 residues were found in the longan flesh, as group 3 where the highest dose of $KClO_3$ used gave the highest residue (Table 1) although the higher residues found in the flesh were not proportional to the higher dose of $KClO_3$ used. However, as group 2 (the second highest dose of $KClO_3$ used) was not found the second highest residue and the control group (no $KClO_3$ used) was also found ClO_3 residue, these findings may have reflected that there may have been many factors other than $KClO_3$ doses used involving in accumulation of ClO_3 residues in the longan flesh. It could have been that ClO_3 residues may have remained in the soil from previous use (before this application) for much longer time than expected, or the migration of ClO_3 from applied area of treated groups somewhere far away had contaminated the control trees (much farther than expected), thus resulted in ClO_3 residue finding in the control group. The half-life of ClO_3 residue in soil after treatment was reported 75-365 days (Soradech Chantiang, 2013). The lesser ClO_3 residue found in sample group 2 than group 1 despite higher application dose may also have been due to errors in application techniques. For example, the application area of group 2 may have covered with pile of remained and dry old leaves much more than other application areas. Therefore, $KClO_3$ applied may have reached the roots of group 2 lesser than expected since some of the applied $KClO_3$ left on the dry old leaves could have lost or decomposed by environmental conditions without reaching the roots. The application area of group 2 may have been steeper slope than that for group 1, so the chemical run-off from the applied area by rains or watering shower may have washed away the chemical much more than expected. Different compositions of the soil in the area may have contained different bio-chemical factors which may have affected $KClO_3$ applied. For example, different amount of bacterial colonies reducing ClO_3 (bacterium reductase) (Srikanjana Klayraung, 2012) in the soil, or

different adsorption of ClO_3 on the dry old leaves or soil. However, the trend of increasing $KClO_3$ use resulted in the more ClO_3 residues was still confirmed in this study as control group was found the lowest and the highest dose used was found the highest residues.

Nevertheless, the worries of health effects from consumption of out-of-season longan fruits were minimized from this study findings. The risk assessment for consumption of out-of-season longan fruits stimulated by $KClO_3$ for all treated groups was calculated up to 1,000 g/day (1 kg of longan flesh). The results showed that male and female were all safe from the consumption of these longan fruits stimulated by $KClO_3$ up to 150% recommended dose from Office of Agricultural Research and Development Region 1, Department of Agriculture (Surapol Thongtaing, 2009).

As referred to the reference dose (RfD) of chlorate at 30 µg/kg/day (Mari Asami, *et al*., 2003), the maximum daily ingestion dose (DD) as high as approximately 10 kg of longan flesh per day was still safe for average Thai male and female even when calculated for consumption of group 3 sample, the highest ClO_3 residues group.

However, for individual consumers with personal health problems such as anemia, chronic kidney disease (CKD), heart disease, diabetes mellitus (DM) and hypertension (HT), this Margin of Safety might not be applied. The abnormalities of blood concentration or hematocrit, waste excretion (creatinine clearance), transportation of O_2 and other co-factors of individuals are of concerns. Symptoms such as cyanosis from lack of O_2 supply to tissue and peripheral nerves fatigue, aphthous ulcer (mouth ulcer), irritation in gastrointestinal tract and methemoglobinemia, if noticed should advise physician.

Finally, this study confirmed that $KClO_3$ could be used to stimulate for out- of- season longan production without problem in general population since only a little residue was left in the products. However, for vulnerable people with health problems, consumption with care should be applied.

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