Variation of Inulin Content in Banana Peels at Different Maturity Stages

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Abstract:

Banana is an inexpensive source of vitamin and dietary fiber. The objective of the present study was to determine inulin content of Kluai Nam Thai (*Musa acuminata*) peel at different maturity stages. The experiment was conducted at the experimental farm of the Faculty of Agricultural Technology, Burapha University, Sakaeo Campus, Sakaeo, Thailand. Banana peels at four maturity stages (light three-quarters, light full three-quarters, full three-quarters and full) were used and arranged in a completely randomized design with three replications. Data were recorded for number of fruits/finger, peel fresh weight/finger, peel dry weight/finger, total fruit (pulp and peel) fresh weight, peel fresh weight/fruit, percentage of peel fresh weight/fruit, total fruit dry weight, peel dry weight/fruit, percentage of peel dry weight/fruit and inulin content. Maturity stages were significantly different ($P < 0.05$) for total fruit fresh and dry weight, percentage of peel fresh and dry weight/fruit and inulin content. Banana peel harvested at light three-quarters stage had the highest inulin content of 0.57% dry weight, whereas banana peel at light full three-quarters stage, full three-quarters stage and full stage had inulin content of 0.39, 0.35 and 0.32% dry weight, respectively. Banana peels at light three-quarters had the highest of percentage of peel fresh and dry weight/fruit of 51.4 and 45.3%, respectively. The results indicated that banana peel at light three-quarters stage had a significant amount of inulin (0.57% dry weight) for use as an alternative source of a raw material for functional food producers and animal feed.

Keywords: Inulin, Prebiotic, Functional food, Banana by-products, Spectrophotometry

Introduction

Banana (*Musa* spp.) is an important fruit crop and cash crop for banana growers in the tropics. However, it is consumed in most parts of the world. Banana is a member of Musaceae family. Banana cultivars originated mainly from intra- and interspecific hybridizations between two diploid wild species, *Musa acuminata* Colla ('A' genome) and *M. balbisiana* Colla ('B' genome) [1]. Banana cultivars and hybrids in Thailand were classified based on morphological descriptors for grouping genomic (AA, AAA, AAB, ABB and BB) [2]. In this study, Kluai Nam Thai is a model of banana genome AA for determination of inulin content in peel because of its sweet taste, aromatic smell and thick peel. Peel is the major by-product of banana industry. Banana peels at different maturity stages were different in nutritional properties, functional properties and morphological traits [3] [4]. Commercially grown bananas are harvested at the green stage with varying degrees of maturity. According to FAO index of maturity based on the fullness of fruit fingers of the banana, four maturity stages of banana are defines as 1) light three-quarters (sharp angles are still present), 2) light full three quarters (the fingers are still angular), 3) full three quarters (the intermediate between "full" and "light three-quarters") and 4) full (finger rounded) [5].

Inulin is a water soluble storage polysaccharide and belongs to a group of fructans (non-digestible carbohydrates) [6]. Inulin is a type of carbohydrate polymers that are neither digested nor absorbed in digastric system. Therefore, they are subjected to bacterial fermentation in the digestive tract and thus impact the ratio and activities of bacterial in stomach. Some dietary fibers can also be classified as prebiotic [7]. Inulin is classified as prebiotic dietary fiber that has beneficial effects on the host by selectively stimulating the growth of good bacteria and reducing number of bad bacteria in the stomach also improves immune system and health and adjusts gut microbiota dysbiosis [8] [9]. Because of its health promoting

properties, inulin is defined as functional food and used in food and pharmaceutical industries [10]. In previous study, total dietary fiber values of banana peels at three different stages of ripeness from six varieties consisting of Grande Naine and Yankambi Km5 (plantain dessert banana, *Musa* AAA), French Clair and Big Ebanga (plantain, *Musa* AAB), Pelipita (cooking banana, *Musa* ABB) and CRBP039 (hybrid, *Musa* AAAB) varied from 32.9 to 51.9% [11]. Inulin is found at high concentrations in root crops and tuber crops such as in chicory and Jerusalem artichoke, which contain 36-48% and 16-20% dry weight, respectively, and it is also found at a traceable amount in raw banana (0.3-0.7%) and raw-dried banana (0.9-2.0%) [12]. Although inulin found in banana peels is low, the amount of peels from the banana industry is abundant.

Numerous studies have been done so far to evaluate fructan, inulin content and dietary fiber in banana fruit, leaf, rhizome and banana blossom (banana male bud) [13] [14] [15]. The information on the variation in inulin content in banana peels is rather limited. A better understanding on the chances in the inulin content at different maturity stages is important for selection of the appropriate harvest times for high inulin content in banana peels. The aim of this study was to evaluate inulin content in peels of Kluai Nam Thai at different maturity stages. The information obtained in this study is important for appropriate utilization of banana peels, which are considered as agricultural waste from banana industry.

Materials and methods

Plant Materials and field experiment

Banana variety Kluai Nam Thai used in this study was planted at the experimental farm of the Faculty of Agricultural Technology, Burapha University, Sakaeo Campus, Sakaeo, Thailand (Lat 13°44´ N, Long 102°17´ W, 87 masl). The experiment was arranged in a completely randomized design with three replications.

Sample collection and preparation

Data of 10 parameters were recorded for number of fruit/finger, peel fresh weight/finger, peel dry weight/finger, total fruit fresh weight, peel fresh weight/fruit, percentage of peel fresh weight/fruit, total fruit dry weight, peel dry weight/fruit, percentage of peel dry weight/fruit and inulin content. The bunches of banana were randomly collected and cut into fingers. Three banana fingers in the same bunches along the length of the bunches were identified as different maturity stages including light three-quarters (maturity 70%), light full three-quarters (maturity 80%), full three-quarters (maturity 90%) and full (maturity 100%) [16] (Table 1). The banana peels were sliced into thin pieces. The samples were oven-dried at 50 ºC for 10 h or until the weight was constant. The dried samples were milled and stored at -20 ºC until inulin extraction.

Extraction procedure

Analysis of inulin content was performed by using the method described previously [17] [18]. The milled samples of each finger were divided into three replications each of which had two grams, and inulin was extracted by reverse osmosis water in a 25 mL flask at 80 ºC for 20 min on a water bath. The samples were shaken well, stored at room temperature to reduce heat and then sieved by filtering the solution through a Whatman no. 1 filter. The extract solution of 2 mL and 750 µL of hydrochloric acid (3% v/v HCl) were added to a 25 mL volumetric flask for hydrolysis. The volume was adjusted with reverse osmosis water to 25 mL and heated at 97 ± 2 ºC for 45 min on a hot plate. The aliquot of extracts kept to cool at room temperature and then stored at 4 ºC in plastic bottles until further analysis.

Analysis of inulin content

Fructose was determined by spectrophotometry using periodate reaction. The reaction was conducted by mixing 4 mL of aliquot of extracts with 5 mL of 70 mmol L^{-1} citrate buffer pH 6.0, 550 µL of reverse osmosis water and 200 µL of 10 mmol L^{-1} sodium periodate reagent. After 5 min, 250 µL of 100 mmol L^{-1} potassium iodide was added, and the mixture was left for an additional 5 min. The solution absorbance was subsequently measured at 390 nm using a UV-Vis spectrophotometer. The concentration of free fructose was deduced from calibration curve of standard fructose.

Statistical Analysis

Data for all parameters were analyzed statistically according to a completely randomized design using computer software STATISTIX8. Means were separated by least significant difference (LSD) at 0.05 probability level.

Table 1 Cross sections of fruits, fruits and peels of Kluai Nam Thai at different maturity stages

Maturity stages	Cross section of fruits	Finger 1	Finger 2	Finger 3	Banana peels
Light three-quarters					
Light full three-quarters					
Full three-quarters					
Full					

Results and discussion

Fruit maturity stages were not significantly different for number of fruits/finger, peel fresh weight/finger, peel dry weight/finger, peel fresh weight/fruit and peel dry weight/fruit (Table 2). However, they were significantly different ($P < 0.05$) for total fruit fresh weight, percentage of peel fresh weight/fruit, total dry fruit weight, percentage of peel dry weight/fruit and inulin content (Table 2). The results indicated that fruit maturity stage is an important postharvest criterion for quantity and quality of pulps and peels of banana. Harvest at mature stage and over mature stage can result in low inulin content in peels.

Table 2 Mean squares for number of fruits/finger (NF/Fi), peel fresh weight/finger (PFW/Fi), peel dry weight/finger (PDW/Fi), total fruit fresh weight (TFFW), peel fresh weight/fruit (PFW/F), percentage of peel fresh weight/fruit (%PFW/F), total fruit dry weight/fruit (TFDW), peel dry weight/fruit (PDW/F), percentage of peel dry weight/fruit (%PDW/F) and inulin content (IC) of Kluai Nam Thai fruits at four maturity stages

Source	df	NF/Fi	PFW/Fi	PDW/Fi	TFFW	PFW/F	%PFW/F	TFDW	PDW/F	%PDW/F	IC
Maturity stages	3	3.6ns	551.4ns	7.8ns	133.4*	1.7ns	273.0**	26.4*	0.04ns	491.1**	0.039**
Error	8	2.3	711.3	16.4	53.5	1.7	37.3	4.6	0.03	52.0	0.002
CV (%)		12.9	17.3	20.0	19.9	9.8	16.0	27.4	10.6	26.7	10.3

ns, *, ** non-significant and significant at $P < 0.05$ and $P < 0.01$ probability levels, respectively

Banana peels at full three-quarters stage had the highest total fruit fresh weight of 41.9 g, whereas banana peels at full stage, light full three-quarters stage and light three-quarters stage had total fruit fresh weights of 40.5, 37.1 and 27.3 g, respectively (Table3). Banana peels at full three-quarters and full stage had the highest total fruit dry weight of 10.2 and 10.0 g, respectively. Banana peels at light full three-quarters stage and light three-quarters stage had total fruit dry weight of 7.4 and 3.8 g, respectively (Table3). In previous report, yield and dry matter content of banana harvested at late fruit developmental stages were higher than banana harvested at early fruit maturity stages because dry matter content of banana slowly increased in opposition to the decrease in fruit moisture content with the development of physiological maturity of the fruits [19].

Table 3. Number of fruits/finger (NF/Fi), peel fresh weight/finger (PFW/Fi), peel dry weight/finger (PDW/Fi), total fruit fresh weight (TFFW), peel fresh weight/fruit (PFW/F), total fruit dry weight (TFDW) and peel dry weight/fruit (PDW/F) of Kluai Nam Thai fruits at four maturity stages

Maturity stages	NF/Fi (fruit)	PFW/Fi (g)	PDW/Fi (g)	TFFW (g)	PFW/F (g)	TFDW (g)	PDW/F (g)
Three-quarters	10	145	18.0	27.3b	14.0	3.8b	1.74
Light Full Three-quarters	13	173	20.7	37.1ab	13.3	7.4ab	1.59
Full Three-quarters	12	156	21.7	41.9a	13.4	10.2a	1.86
Full	12	144	21.0	40.5ab	12.3	10.0a	1.80
F-test	ns	ns	ns	*	ns	*	ns

Means with different letters in the same column are significantly different at $P < 0.05$ by LSD
ns, * non-significant and significant at $P < 0.05$ probability levels, respectively

This study represented pulp to peel ratio by percentage of peel per one fruit. Banana peels at light three-quarters stage had the highest of percentage of peel fresh weight/fruit and percentage of peel dry weight/fruit (51.4 and 45.3%, respectively) (Figure 1). Banana peels at light full three-quarters, full three-quarters and full stages had percentage of peel fresh weight/fruit of 38.8, 31.9 and 30.4%, respectively. Banana peels at light full three-quarters, full three-quarters and full stages had percentage of peel dry weight/fruit of 26.6, 18.3 and 17.9 %, respectively (Figure 1). This finding support with Amin et al. [19] who

reported the increasing trend of pulp to peel ratio with the increase of harvesting days of banana varieties BARI Kola 1 and Sabri Kola.

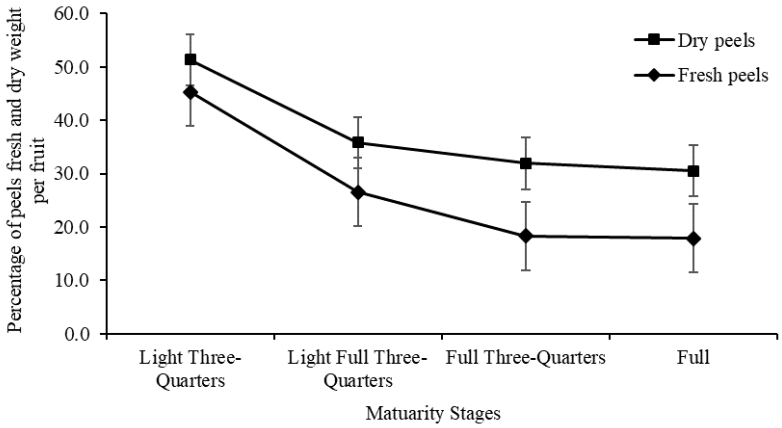

Figure 1 Peal fresh weight percentage and peel dry weight percentage in one fruit of Kluai Nam Thai at different maturity stages. Data are presented as means of three replications ± standard error.

Banana peels at light three-quarters stage had the highest inulin content of 0.57 % dry weight, whereas banana peels at light full three-quarters stage, full three-quarters stage and full stage had inulin contents of 0.39, 0.35 and 0.32 % dry weight, respectively (Fig 2). The results revealed that harvest of the banana at under maturity stage is optimum for height inulin yield because of height inulin content and thick peels.

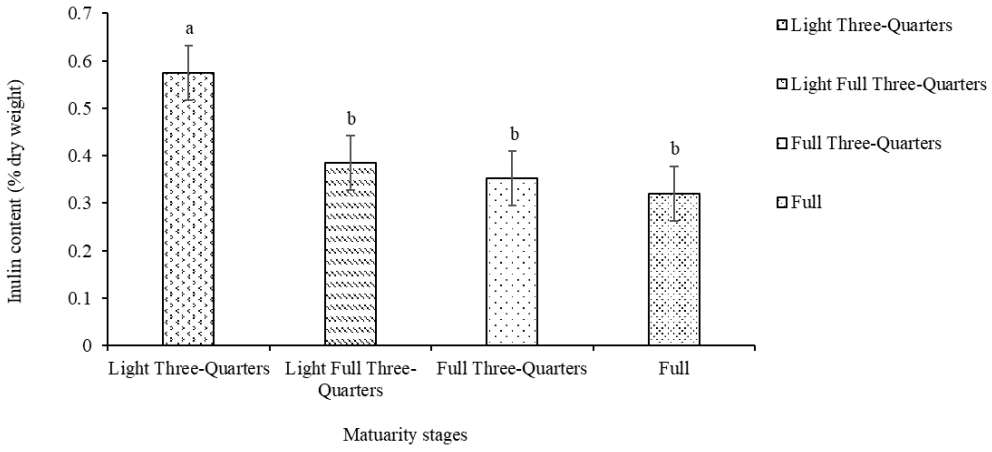

Figure 2 Inulin content in the peels of Kluai Nam Thai harvested at different maturity stages. Data are presented as means of three replications ± standard error.

Conclusions

Kluai Nam Thai peels at light three quarter stage may be used as an alternative source of inulin for use as a raw material for health food products and animal feed, and the use of banana peels can increase the efficiency of banana production. However, this information is limited to one species of banana. Care must be taken to extrapolate the results to other genome groups of banana and further investigations in a wide range of banana genome groups and varieties within genome groups are required in order to obtain more conclusive results

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