Development of A New Banana Processing Product: Banana Starch As A Health Food from Cavendish Banana in Taiwan

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Contents

1. Major component of banana
2. Functionalities of banana major components
3. Functionalities of banana minor components
4. Application of banana
Table 1  Content of starch, dietary fiber and indigestible fraction in the unripe banana mass (UBM) and the unripe banana starch (UBS)

<table>
<thead>
<tr>
<th>Compound (% dw)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>UBM</th>
<th>UBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total starch</td>
<td>61.6±1.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>83.8±2.5&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Resistant starch (RS)</td>
<td>8.2±0.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>67.0±2.3&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Available starch</td>
<td>53.2±1.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.8±0.9&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Total dietary fiber (DF) (without RS)</td>
<td>10.3±0.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.3±0.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Insoluble DF</td>
<td>5.8±0.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.0±0.0&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Soluble DF</td>
<td>4.5±0.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.3±0.1&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Indigestible fraction (IF)</td>
<td>21.0±0.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>69.4±1.5&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Insoluble IF</td>
<td>14.2±0.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>57.7±2.5&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Soluble IF</td>
<td>6.8±0.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.6±0.6&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Results expressed on dry weight (% dw) as mean ± SD of triplicates. Means in row sharing different letters are significantly different (p<0.05)
香蕉澱粉  Banana starch

Pancreatic & Intestinal amylase

alpha-amylase
Mouth

Gelatinized premature
Banana flour

Mature

Premature

Time (min)

Plasma glucose (mg/dl)

0 15 30 45 60 90 120

0 60 120 180

Relative intensity

0 2000 4000 6000 8000 10000 12000

1. CARBOHYDRATES
Starches
Lactose
Sucrose

2. FATS
Pancreas (trypsin,
chymotrypsin,
and carboxypeptidase)

3. PROTEINS
Small intestine
(aminopeptidase
and dipeptides)

Stomach (pepsin)

Pancreas (pancreatic
lipase)

Esophagus

Liver
(bile salts)

Gallbladder,
(bile salts)

Stomach
(HCl)

Small intestine

Galatinized granule.
Prebiotic oligosaccharides & resistant starch

1. Escape from amylase digestion

2. Must be stable under acidic conditions and small gut secretions

3. Must transfer to the colon intact

4. Must have a selective Metabolism

Bifidobacterium
Lactobacterium
Inflammatory response to sterile tissue injury
Response and resistance to infection
Inflammatory pain

Brain morphogenesis
Behavior

Microbiota Composition

Diet
Host genetics
Antibiotics
Hygiene
Other

1000 species
10^{14} cells
10^6 genes
Metabolic complexity of human liver
Table 1. Sugar Levels of Banana Cultivars from Different Genomic Groups Determined at the Full-Ripe Stage

<table>
<thead>
<tr>
<th>cultivar</th>
<th>genomic group</th>
<th>moisture (%)</th>
<th>sucrose (mg/g of DM)</th>
<th>1-kestoseb (µg/g of DM)</th>
<th>nystose (µg/g of DM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ouro</td>
<td>AA</td>
<td>69.2 ± 0.3</td>
<td>190.7 ± 5.7</td>
<td>918 ± 18 g</td>
<td>ND</td>
</tr>
<tr>
<td>Nanicão</td>
<td>AAA</td>
<td>75.9 ± 0.2</td>
<td>354.7 ± 3.1</td>
<td>1016 ± 40 f</td>
<td>ND</td>
</tr>
<tr>
<td>Prata</td>
<td>AAB</td>
<td>71.1 ± 0.2</td>
<td>326.5 ± 18.9</td>
<td>1630 ± 29 e</td>
<td>105 ± 8</td>
</tr>
<tr>
<td>Maçã</td>
<td>AAB</td>
<td>73.1 ± 0.1</td>
<td>224.5 ± 8.4</td>
<td>699 ± 15 d</td>
<td>ND</td>
</tr>
<tr>
<td>Mysore</td>
<td>AAB</td>
<td>76.6 ± 0.2</td>
<td>179.2 ± 3.5</td>
<td>1292 ± 50 c</td>
<td>ND</td>
</tr>
<tr>
<td>Pacovan</td>
<td>AAB</td>
<td>75.1 ± 0.1</td>
<td>274.3 ± 15.7</td>
<td>1097 ± 28 b</td>
<td>ND</td>
</tr>
<tr>
<td>Terra</td>
<td>AAB</td>
<td>61.8 ± 0.2</td>
<td>210.1 ± 2.2</td>
<td>297 ± 13 a</td>
<td>ND</td>
</tr>
<tr>
<td>Figo</td>
<td>ABB</td>
<td>68.7 ± 0.1</td>
<td>180.1 ± 2.0</td>
<td>881 ± 38 g</td>
<td>ND</td>
</tr>
</tbody>
</table>

* Each value is the mean of at least three determinations that are indicated with the standard deviation, respectively. DM, dry matter; ND, not detected. b Different letters indicate statistically significant differences (p > 0.05).
<table>
<thead>
<tr>
<th></th>
<th>Molar proportion$^{a,b}$</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acetate</td>
<td>Propionate</td>
<td>Butyrate</td>
</tr>
<tr>
<td>UBM</td>
<td>57.4±3.1$^a$</td>
<td>23.0±1.4$^a$</td>
<td>19.6±1.8$^a$</td>
</tr>
<tr>
<td>UBS</td>
<td>68.3±1.9$^b$</td>
<td>14.4±0.7$^b$</td>
<td>17.3±1.1$^a$</td>
</tr>
</tbody>
</table>

$^a$Percentage of each SCFA in relation to the sum of acetate, propionate and butyrate. $^b$Results expressed as means ± SD. Means in columns sharing different letters are significantly different ($p<0.05$)
Histological analysis of mice.

A: Colon section from control animals

B: Colon section from inulin-treated animals

C: severe submucosal erosion with edema, ulceration, inflammatory cell infiltration

D: slight inflammatory cell infiltration and no submucosal edema or abnormality of crypt cells
The list of the ligands present in the banana flower initially used are:

Leucocyanin (CID155206), USDA database
Cyanidin (CID128861),
Malvidin (CID159287),
Pelargonidin(CID440832),
Peonidin(CID441773),
Hesperetin (CID 72281),
Naringenin (CID 932),
Hesperetin Triacetate (CID 457809),
The results indicate that few of the flavonoids may be potential activators of IR tyrosine kinase
Hesperetin
Dihydrochalcone ( CID 147608 ),
Naringenin Pelargonidin ( CID439246),
Naringenin Flavanone (CID 25244584),
Hesperetin (Anion) (CID 49859576).
Antidiabetic effect of banana flavonoids

1. Intraperitoneal administration of prunin (naringenin 7-O-β-D-glucoside) produces a significant hypoglycemic effect in diabetic rats. [13].
2. Chronic treatment with hesperitin and naringenin was found to lower the blood glucose level of db/db mice [14].
3. Banana flower extracts are able to promote glucose uptake into the cells, which could be beneficial in diabetes mellitus. It can be hypothesized that consumption of nutraceutical-rich extract of banana flower could replace some amount of insulin being taken for diabetes mellitus [15].
Inhibition of NADPH oxidase leading to reduction of ROS
Antidiabetic effect of banana flavonoids

Hesperetin (CID 72281), Naringenin (CID 932)

- PKC
- c-Src
- IRS-1 Degradation
- IRS-1
- ROS
- ALDOSTERONE
- NADPH OXIDASE
- INDEPENDENT RECEPTOR
- PROPOSED MEMBRANE RECEPTOR
- POKA1
- POKA1

Hesperetin (CID 72281), Naringenin (CID 932)
Banana acetone extract

Peaks: 2, synergic acid; 3, pyrocatechol; 4, catechol acid; 5, gentisic acid; 7, catechin; 8, protocatechuic acid; 9, gallic acid; 11, caffeic acid; 12, chlorogenic acid; 13, ferulic acid; 14, cinnamic acid.


chlorogenic acid
Phytosterols in Banana

<table>
<thead>
<tr>
<th>compound</th>
<th>pulp</th>
<th>peel</th>
</tr>
</thead>
<tbody>
<tr>
<td>sterols</td>
<td></td>
<td></td>
</tr>
<tr>
<td>campesterol</td>
<td>530</td>
<td>10918</td>
</tr>
<tr>
<td>stigmasterol</td>
<td>76</td>
<td>308</td>
</tr>
<tr>
<td>24-methylenepollinastanol</td>
<td>65</td>
<td>633</td>
</tr>
<tr>
<td>31-norcycloclaudenone</td>
<td>&lt;5</td>
<td>ND</td>
</tr>
<tr>
<td>cycloartane</td>
<td>9</td>
<td>2112</td>
</tr>
<tr>
<td>cycloartenol</td>
<td>35</td>
<td>6517</td>
</tr>
<tr>
<td>β-sitosterol</td>
<td>325</td>
<td>650</td>
</tr>
<tr>
<td>n.i. triterpene ketone</td>
<td>ND</td>
<td>367</td>
</tr>
<tr>
<td>isofucosterol</td>
<td>20</td>
<td>ND</td>
</tr>
<tr>
<td>cycloaoeucalenol</td>
<td>ND</td>
<td>100</td>
</tr>
<tr>
<td>cycloartenol</td>
<td>&lt;5</td>
<td>231</td>
</tr>
<tr>
<td>24-methylenecycloartanol</td>
<td>ND</td>
<td>103</td>
</tr>
</tbody>
</table>

Beta-sitosterol

Ordinary cholesterol + an extra ethyl group.

Triglycerides
Free fatty acids
Bile salts
Mixed micelle formation

Phospholipids
Monoglycerides
Capture
Cholesterol from diet
Competition
Phytosterol
Endogenous cholesterol
Monacolin K
Biosynthesis

Increase serum cholesterol level
Chylomicron

FA/LCAA/AC
St
StEa
Dg
StGe

Peel

Pulp

Time (min)
<table>
<thead>
<tr>
<th></th>
<th>1–3</th>
<th>4–6</th>
<th>6–7</th>
<th>7–8</th>
</tr>
</thead>
<tbody>
<tr>
<td>dopamine</td>
<td>865–1940</td>
<td>185–705</td>
<td>80–560</td>
<td>235–930</td>
</tr>
<tr>
<td></td>
<td>(1290 ± 420)</td>
<td>(430 ± 210)</td>
<td>(380 ± 160)</td>
<td>(500 ± 270)</td>
</tr>
<tr>
<td>dopa</td>
<td>14–30</td>
<td>3.5–10</td>
<td>1.1–8.0</td>
<td>2.5–15</td>
</tr>
<tr>
<td>norepinephrine</td>
<td>55–118</td>
<td>8.2–14</td>
<td>ND&lt;sup&gt;c&lt;/sup&gt;–24</td>
<td>38–43</td>
</tr>
<tr>
<td>naringin</td>
<td>120–260</td>
<td>17–120</td>
<td>28–95</td>
<td>42–72</td>
</tr>
<tr>
<td>rutin</td>
<td>16–23</td>
<td>11–14</td>
<td>11–16</td>
<td>15–17</td>
</tr>
<tr>
<td>ascorbic acid&lt;sup&gt;d&lt;/sup&gt;</td>
<td>6.8–8.2</td>
<td>6.6–8.7</td>
<td>5.8–8.0</td>
<td>3.2–7.9</td>
</tr>
<tr>
<td>carotenes&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.43–1.2</td>
<td>0.55–0.87</td>
<td>0.28–0.78</td>
<td>0.11–0.66</td>
</tr>
<tr>
<td>tocopherols&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2.4–2.6</td>
<td>3.2–5.3</td>
<td>1.5–5.8</td>
<td>5.5–7.8</td>
</tr>
</tbody>
</table>
(Ractopamine) beta 2-agonists beta
catecholamines
Epinephrine
Norepinephrine
Dopamine

<table>
<thead>
<tr>
<th>Aromatic Substitution</th>
<th>Category</th>
<th>Example(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-H -OH -H</td>
<td>Phenol</td>
<td>Ractopamine, Ritodrine, Fenoterol, Terbutaline</td>
</tr>
<tr>
<td>-OH -H -OH</td>
<td>Resorcinol</td>
<td>Isoproterenol, Dobutamine, Salbutamol, Salmeterol</td>
</tr>
<tr>
<td>-OH -OH -H</td>
<td>Catechol</td>
<td></td>
</tr>
<tr>
<td>-CH₂OH -OH -H</td>
<td>Saligenin</td>
<td></td>
</tr>
</tbody>
</table>

Tyrosine → DOPA → Dopamine
Tyrosine hydroxylase
5-Adenosylmethionine
S-adenosylmethionine

Epinephrine → Norepinephrine
Phenylethanolamine N-methyltransferase

DOPA decarboxylase
Dopamine β-hydroxylase

CO₂

Dopamine
Inflammatoryy anerg

Inflammation

Microbial killing

Phagocytosis

Inflammatory cytokines

Acetylcholine? Neuropeptides? Catecholamines?

nAChR?
<table>
<thead>
<tr>
<th>Phytochemical</th>
<th>1–3</th>
<th>4–6</th>
<th>6–7</th>
<th>7–8</th>
</tr>
</thead>
<tbody>
<tr>
<td>dopamine</td>
<td>4.7–10</td>
<td>6.1–15</td>
<td>2.5–10</td>
<td>0.72–6.1</td>
</tr>
<tr>
<td></td>
<td>(7.0 ± 2.0)</td>
<td>(9.1 ± 3.1)</td>
<td>(7.3 ± 2.4)</td>
<td>(3.4 ± 2.2)</td>
</tr>
<tr>
<td>dopa</td>
<td>1.3–1.9</td>
<td>1.3–1.9</td>
<td>1.0–1.5</td>
<td>0.95–1.4</td>
</tr>
<tr>
<td>norepinephrine</td>
<td>0.80–1.7</td>
<td>0.84–2.1</td>
<td>0.82–1.6</td>
<td>0.62–1.5</td>
</tr>
<tr>
<td>naringin</td>
<td>ND&lt;sup&gt;c&lt;/sup&gt;–65</td>
<td>ND&lt;sup&gt;c&lt;/sup&gt;</td>
<td>ND&lt;sup&gt;c&lt;/sup&gt;–3.3</td>
<td>ND&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>rutin</td>
<td>ND&lt;sup&gt;c&lt;/sup&gt;–4.8</td>
<td>ND&lt;sup&gt;c&lt;/sup&gt;</td>
<td>ND&lt;sup&gt;c&lt;/sup&gt;</td>
<td>ND&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>ascorbic acid&lt;sup&gt;d&lt;/sup&gt;</td>
<td>12–13</td>
<td>11–13</td>
<td>6.9–11</td>
<td>5.4–10</td>
</tr>
<tr>
<td>carotenes&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.09–0.12</td>
<td>0.06–0.12</td>
<td>0.03–0.12</td>
<td>0.02–0.05</td>
</tr>
<tr>
<td>tocopherols&lt;sup&gt;d&lt;/sup&gt;</td>
<td>ND&lt;sup&gt;c&lt;/sup&gt;</td>
<td>ND&lt;sup&gt;c&lt;/sup&gt;–0.29</td>
<td>ND&lt;sup&gt;c&lt;/sup&gt;</td>
<td>ND&lt;sup&gt;c&lt;/sup&gt;–0.45</td>
</tr>
</tbody>
</table>

<sup>a</sup> Levels determined as described in the text. <sup>b</sup> In Pulp mg/100 g. <sup>c</sup> Not detectable. <sup>d</sup> Data from参考文献.
Thanks for your attention