Effects of Mulberry (*Morus alba*) Fruits on Lipid Profiles, Antioxidant, and Inflammation status in Hypercholesterolemic Subjects

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Presented by
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Introduction and Literature Review
Cardiovascular disease (CVD) is a non-communicable disease, but it is an important public health problem worldwide.

- High cholesterol in blood is an important risk factor of atherosclerosis that various diseases such as coronary heart disease and stroke in the future.
In 2012, an estimated **17.5 million** people died from CVD, mainly from coronary heart disease (7.4 million) and stroke (6.7 million). This number is expected to increase to **23 million** people in 2030.

**Source:** World Health Organization. Global status report on noncommunicable diseases 2014.
Risk factors of cardiovascular disease

**Non-modification**
- Sex
- Age
- Family history of premature CHD

**Modification**
- High blood cholesterol
- High blood pressure
- Diabetes
- Unhealthy diet
- Overweight/obesity
- Cigarette smoking
- Physical inactivity

*Source: World Heart Organization*
The WHO recommends fruits and vegetables intake \textit{400 g/day}, adequate against the occurrence of \textit{chronic diseases}.

Fruits and vegetables are rich in

\begin{itemize}
  \item \textbf{nutrients}
  \item \textbf{fiber}
  \item \textbf{phytochemicals}
  \item \textbf{low in calories}
\end{itemize}
**Introduction**

**Human intervention studies** using berries fruits (fresh, or juice, or freeze-dried), or purified anthocyanin extracts

**Berries** are the best source
- polyphenol
- micronutrients
- fiber

**Improvements** in
- LDL oxidation
- lipid peroxidation
- total plasma antioxidant capacity

**Mulberries:** the best source of...
- polyphenol, especially anthocyanin
- micronutrients
- fiber

*Source: Basu et al, 2010*
Introduction

Lipid profiles:
- High-density lipoprotein cholesterol (HDL-C)
- Low-density lipoprotein cholesterol (LDL-C)
- Triacylglycerol (TAG)
- Total cholesterol (TC)
LDL-C and HDL-C?

Bad vs. Good Cholesterol

**Bad (LDL)**
stores cholesterol in the blood stream

**Good (HDL)**
regulates LDL storage and promotes excretion
LDL-C and HDL-C?

- **LDL-C**: Low Density Lipoprotein (bad cholesterol) is associated with cardiovascular disease.

- **HDL-C**: High Density Lipoprotein (good cholesterol), because it prevents LDL- cholesterol and triglycerides accumulation in the arteries, cause of cardiovascular disease.
## Classification of blood lipids

<table>
<thead>
<tr>
<th>Blood lipids</th>
<th>Concentration (mg/dL)</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total cholesterol</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 200</td>
<td>Desirable</td>
<td></td>
</tr>
<tr>
<td>200-239</td>
<td>Borderline high</td>
<td></td>
</tr>
<tr>
<td>&gt; 240</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td><strong>LDL cholesterol</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 100</td>
<td>Optimal</td>
<td></td>
</tr>
<tr>
<td>100-129</td>
<td>Near or above optimal</td>
<td></td>
</tr>
<tr>
<td>130-159</td>
<td>Borderline high</td>
<td></td>
</tr>
<tr>
<td>160-189</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>&gt; 190</td>
<td>Very high</td>
<td></td>
</tr>
<tr>
<td><strong>HDL cholesterol</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 40</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>≥ 60</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td><strong>Triacylglycerol</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 150</td>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td>150-199</td>
<td>Borderline high</td>
<td></td>
</tr>
<tr>
<td>200-499</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>≥ 500</td>
<td>Very high</td>
<td></td>
</tr>
</tbody>
</table>
Classification

Family: Moraceae
Genus: Morus L.
Species: Morus spp.

There are three common mulberry species:

- Morus alba  (white mulberry)
- Morus nigra  (black mulberry)
- Morus rubra  (red mulberry)
Mulberry Fruit Index

Characteristic of mulberries at degree of maturity

- **Red**
- **Purple-red**
- **Purple-black (ripe)**

β-carotene, vitamin C

Anthocyanin

Sources: Aramwit et al. (2010), Hathaikarn et al. (2008)
Objectives

➢ To compare lipid profiles antioxidant inflammation status in hypercholesterolemic subjects between mulberry and control group.

➢ To compare lipid profiles antioxidant inflammation status in hypercholesterolemic subjects before and after mulberry consumption.
Materials and Methods
Experimental study, a randomized controlled trial

Sample size calculation

Replace a formula

\[
n = \frac{(0.84 + 1.96)^2 \times (0.23 + 0.18)}{(2.54 - 2.19)^2}
\]

\[
n = 26.79
\]

\[
n \sim 27 \text{ persons}
\]

Account for drop outs 10% = 3 persons

Total sample size  30 persons/group (Total  \( n = 60 \))

The reference values for decrease LDL cholesterol, used for calculating sample size

Reference : Alvarez-Suarez JM et al, 2014
Inclusion criteria

- The subjects had hypercholesterolemia, fasting TC ≥ 200 mg/dL, LDL-C ≥ 130 mg/dL.

- Age 30 to 60 years, males and females

- Willing to participate in the study.
Exclusion criteria

- Pre-existing disease (e.g. cardiovascular disease, diabetes mellitus, hypertension, liver, renal, thyroid disorders, cancer)
- Abnormalities in hematology (e.g. hemophilia, anemia)
- Consume antioxidant or lipid-lowering dietary supplements on a regular basis
- Use hormone replacement therapy
Recruitment

Exclusion criteria

- Treatment with lipid-lowering drugs and steroidal medications
- Pregnancy and lactation
- Smoking or drinking alcohol
The freeze-dried mulberry: Chiang Mai variety

- Fresh mulberry are easily bruised.
- Antioxidant and high nutrition value that similar fresh mulberry
In the human study by Qin et al (2009) daily intake 320 mg anthocyanins for 12 weeks showed increased HDL-C and decreased LDL-C concentrations in dyslipidemic subjects.

320 mg anthocyanins ~ 40 g Freeze-dried mulberry
8.31 mg Freeze-dried mulberry

Freeze-dried mulberry has anthocyanins 8.31 mg/g (Pansuwan et al (2010)).
Screening:

- **fast overnight**: TC, LDL-C
- **questionnaire**: general characteristics, nutrition information and lifestyle

Inclusion, Exclusion criteria

N=80

N=60

Experimental design (diagram)
The participants were divided into two groups which each group consisted of 30 participants.

- **Mulberry group** were **consumed** freeze-dried mulberry which contain 45 grams per day for 6 weeks.

- **Control group** that consist of 28 participants **were not consumed** (2 participants were withdrawn).

In order to follow the rules of research (compliance) samples, all participants were continuously observed by telephone and meeting every 2, 4, 6 weeks.
Methods

7 days
Prior to experiment

- Wash-out
  - abstain from consuming anthocyanin rich foods
  - record daily food intake
  - record physical activity patterns

Baseline

Biochemical assessment
- Lipid profiles
  - TC
  - LDL-C
  - HDL-C
  - TAG

Anthropometric assessment

Within 6 weeks

Interventions

The mulberry group: 45 g freeze-dried mulberry fruit per day (320 mg anthocyanins)

Biochemical assessment
- Lipid profiles
- Antioxidants
- Inflammation

Anthropometric assessment

End of study

* during the trial, maintain their usual diet, physical activity, and lifestyle patterns
1. General information and screening questionnaire
2. Three-day food record
3. Physical activity record
Avoid

Foods vegetables and fruits are content rich of anthocyanin.
**Anthropometric assessment:**
- Body weight, Height
- Body fat and visceral fat
- Body mass index (BMI)
- Waist circumference

**Biochemical assessment:**
- Total cholesterol (TC)
- Triacylglycerol (TAG)
- High density lipoprotein cholesterol (HDL-C)
- Low density lipoprotein cholesterol (LDL-C)
- Antioxidant

**Dietary assessment:**
- Three days food record
• **Demographic data**: percentage, mean ± SD

• **Dietary nutrient intakes**:  
  - Between the mulberry group and control group:  
    **Independent samples t - test**  
  - Each group at baseline, week 3, and week 6 of study:  
    **One-way ANOVAs**

• **Lipid profiles Antioxidant and Inflammation status**:  
  - Between the mulberry group and control group:  
    **Independent samples t - test**  
  - Each group (pre-posttest):  
    **Paired samples t – test**

Statistical significance were accepted at a probability value of < 0.05
Results
## General characteristics:

<table>
<thead>
<tr>
<th>General characteristics</th>
<th>Total (N=58)</th>
<th>Mulberry (N=30)</th>
<th>Control (N=28)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>8</td>
<td>13.8</td>
<td>4</td>
<td>13.3</td>
</tr>
<tr>
<td>Female</td>
<td>50</td>
<td>86.2</td>
<td>26</td>
<td>86.7</td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-39</td>
<td>11</td>
<td>19.0</td>
<td>5</td>
<td>16.7</td>
</tr>
<tr>
<td>40-49</td>
<td>21</td>
<td>36.2</td>
<td>9</td>
<td>30.0</td>
</tr>
<tr>
<td>50-60</td>
<td>26</td>
<td>44.8</td>
<td>16</td>
<td>53.3</td>
</tr>
<tr>
<td><strong>Marital status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>26</td>
<td>44.8</td>
<td>14</td>
<td>46.7</td>
</tr>
<tr>
<td>Married</td>
<td>25</td>
<td>43.1</td>
<td>12</td>
<td>40.0</td>
</tr>
<tr>
<td>Separate</td>
<td>7</td>
<td>12.1</td>
<td>4</td>
<td>13.3</td>
</tr>
</tbody>
</table>
General characteristics:

- gender
- age
- Marital status
- behaviors and lifestyles

no significant difference between the two groups
Anthropometry and Blood pressure
### At baseline

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mulberry (N=30)</th>
<th>Control (N=28)</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anthropometry</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>58.67 ± 11.19</td>
<td>62.38 ± 15.67</td>
<td>0.301</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>23.87 ± 3.87</td>
<td>24.80 ± 5.41</td>
<td>0.454</td>
</tr>
<tr>
<td>% body fat</td>
<td>32.44 ± 5.28</td>
<td>31.34 ± 6.14</td>
<td>0.471</td>
</tr>
<tr>
<td>% visceral fat</td>
<td>7.17 ± 4.04</td>
<td>7.99 ± 5.93</td>
<td>0.621</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>81.67 ± 9.87</td>
<td>82.98 ± 12.90</td>
<td>0.667</td>
</tr>
<tr>
<td><strong>Blood pressure</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>118.17 ± 15.18</td>
<td>119.00 ± 16.82</td>
<td>0.844</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>77.37 ± 9.31</td>
<td>76.93 ± 10.62</td>
<td>0.868</td>
</tr>
</tbody>
</table>
## At week 6

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mulberry (N=30)</th>
<th>Control (N=28)</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anthropometry</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>58.60 ± 11.05</td>
<td>62.72 ± 15.48</td>
<td>0.246</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.02 ± 3.86</td>
<td>24.92 ± 5.32</td>
<td>0.464</td>
</tr>
<tr>
<td>% body fat</td>
<td>32.34 ± 5.44</td>
<td>31.09 ± 6.81</td>
<td>0.563</td>
</tr>
<tr>
<td>% visceral fat</td>
<td>6.93 ± 3.92</td>
<td>8.00 ± 5.55</td>
<td>0.433</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>83.22 ± 9.55</td>
<td>85.00 ± 12.06</td>
<td>0.534</td>
</tr>
<tr>
<td><strong>Blood pressure</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>115.77 ± 13.40</td>
<td>116.96 ± 14.55</td>
<td>0.745</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>74.23 ± 10.44</td>
<td>73.79 ± 10.03</td>
<td>0.869</td>
</tr>
</tbody>
</table>
Anthropometry and blood pressure

- mulberry group
- control group

in both before and after the experiment was no difference
The effects of freeze-dried mulberry consumption on lipid profiles, antioxidants and inflammation status in blood.
lipid profiles.
# Changes of lipid profiles

<table>
<thead>
<tr>
<th>Lipid profiles (mg/dL)</th>
<th>Group</th>
<th>Mulberry</th>
<th>Control</th>
<th>p – value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TC</strong>*</td>
<td>Mean change</td>
<td>- 9.23 ± 10.75</td>
<td>7.44 ± 12.13</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>Percent change</td>
<td>- 3.73 ± 3.99</td>
<td>3.33 ± 5.07</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td><strong>LDL-C</strong>*</td>
<td>Mean change</td>
<td>- 11.40 ± 12.04</td>
<td>- 0.11 ± 8.77</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>Percent change</td>
<td>- 6.53 ± 5.93</td>
<td>0.15 ± 4.90</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td><strong>HDL-C</strong></td>
<td>Mean change</td>
<td>1.43 ± 4.96</td>
<td>0.75 ± 7.33</td>
<td>0.681</td>
</tr>
<tr>
<td></td>
<td>Percent change</td>
<td>2.40 ± 8.60</td>
<td>2.11 ± 11.28</td>
<td>0.912</td>
</tr>
<tr>
<td><strong>TAG</strong></td>
<td>Mean change</td>
<td>- 7.76 ± 30.69</td>
<td>- 3.19 ± 25.40</td>
<td>0.549</td>
</tr>
<tr>
<td></td>
<td>Percent change</td>
<td>- 3.90 ± 28.64</td>
<td>- 0.42 ± 25.81</td>
<td>0.638</td>
</tr>
</tbody>
</table>

*Significant differences, p < 0.001 assessed by independent-sample t test*
Percent change of lipid profiles between mulberry group and control group

* Significant differences, $p < 0.001$
This study found that the consumption of freeze-dried mulberry 45 g/day for 6 weeks could significantly decrease the TC 3.73% and LDL-C 6.53%.

no effect on TAG and HDL-C

TC was statistically significant increased

TAG, HDL-C, LDL-C were no statistical significant in Control group
Antioxidant
and
Inflammation status
# Antioxidant and Inflammation status

<table>
<thead>
<tr>
<th></th>
<th>Group</th>
<th>Week0</th>
<th>Week 6</th>
<th>Mean change</th>
<th>Percent change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Antioxidant</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ORAC *</td>
<td>Mulberry</td>
<td>50.49 ± 8.89</td>
<td>55.16 ± 8.92</td>
<td>4.70 ± 4.88</td>
<td>10.27 ± 11.36</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>49.34 ± 11.91</td>
<td>47.25 ± 10.37</td>
<td>-2.09 ± 4.45</td>
<td>-3.16 ± 10.37</td>
</tr>
<tr>
<td>FRAP*</td>
<td>Mulberry</td>
<td>15.45 ± 2.33</td>
<td>17.06 ± 2.11</td>
<td>1.61 ± 1.58</td>
<td>11.39 ± 11.42</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>14.31 ± 2.18</td>
<td>14.06 ± 1.65</td>
<td>-0.25 ± 1.97</td>
<td>-0.09 ± 15.65</td>
</tr>
<tr>
<td><strong>Inflammation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hsCRP (mg/L)</td>
<td>Mulberry</td>
<td>1.75 ± 1.87</td>
<td>1.59 ± 1.84</td>
<td>-0.15 ± 0.77</td>
<td>-6.6 ± 37.49</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>2.30 ± 1.87</td>
<td>2.08 ± 1.76</td>
<td>-0.22 ± 0.87</td>
<td>-4.64 ± 34.69</td>
</tr>
</tbody>
</table>
In mulberry group, the antioxidant resistant value, that was analyzed by **ORAC method**, was significantly increased to 55.16 μM / ml after the 6 weeks consumption. In addition, the results from **FRAP method** was similar.
It is noticeable, in mulberry group, the antioxidant, both **ORAC** and **FRAP**, in blood was significantly increased when compared between at pre- and post-experiment.
Inflammation status between mulberry group and control group in both before and after the experiment was no difference.
Consumption 45 grams freeze-dried mulberry (325 mg anthocyanins, ~ 160 g fresh mulberry) per day for six weeks

- Reduce TC (3.73%) and LDL-C (6.53%), respectively (p < 0.001)
- No change in HDL-C and TAG
- Increase antioxidant activity in hypercholesterolemic subjects

Conclusion
I. Mulberry is a natural source of antioxidants and a good alternative food in order to control lipid profiles to normal levels.

II. A great way to boost the fiber content in dietary intake, which benefits cardiovascular health in humans.

III. Patient’s hypercholesterolemia reduced lipid lowering medications which reduce the expenses and side effects.
THANK YOU
FOR YOUR ATTENTION
Suggestion for further study

◮ Long term effect

◮ Intervention using fresh or juice mulberry in hypercholesterolemia

◮ In hypertension, diabetes mellitus or metabolic syndrome subjects
<table>
<thead>
<tr>
<th>Author, year</th>
<th>Study design</th>
<th>Subjects</th>
<th>Diet</th>
<th>Result</th>
</tr>
</thead>
</table>
| Liu *et al* (2008) | experimental *(in vitro)* 12 weeks | Blood from healthy volunteers | MWEs (22.8 percent of anthocyanins) MACs (88.5 percent of anthocyanins) | **Inhibit** LDL oxidation  
**Inhibit** the death of macrophages  
**Decrease** foam cells formation induced by ox-LDL  
**Prevent** of atherosclerosis |

*MWEs – mulberry water extracts  
MACs – mulberry anthocyaanin-rich extracts*
<table>
<thead>
<tr>
<th>Author, year</th>
<th>Study design</th>
<th>Subjects</th>
<th>Diet</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yang et al. (2010)</td>
<td>experimental (in vivo) 4 weeks</td>
<td>Hyperlipidemia rats</td>
<td>(i) normal diet (ii) normal diet and 5% MFP (iii) normal diet and 10% MFP (iv) high-fat diet, (v) high-fat diet and 5% MFP (vi) high-fat diet and 10% MFP</td>
<td>rats on normal diet and MFP <strong>no significant</strong> change in lipid profile in the serum and liver. rats on high-fat diet and MFP significantly ↓ <strong>reduced</strong> level of serum and liver TG, TC, LDL-C ↓ <strong>reduced</strong> TBARS ↑ <strong>increased</strong> HDL-C ↑ <strong>increased</strong> SOD, GSH-Px</td>
</tr>
</tbody>
</table>

**MFP** - mulberry fruit freeze-dried powder
**TBARS** - Thiobarbituric acid reactive substances
**SOD** – superoxide dismutase
**GSH-Px** – glutathione peroxidase
Literature reviews
LDL-C and HDL-C?

- LDL (bad cholesterol) its low density Lipoprotein is associated with cardiovascular disease is the fat that can cause arteries to harden the fat LDL acts transports cholesterol come from the liver into the blood in the body if cholesterol remains in the bloodstream it accumulated on the walls of blood vessels, causing severe coronary artery stenosis solid long it will cause clogged arteries and high blood pressure as a result of ischemic heart disease kidney failure, paralysis etc.

- HDL stands for High Density Lipoprotein (good cholesterol), HDL high-density cholesterol is good because the arteries prevents cholesterol, triglycerides, and LDL accumulation in the arteries of HDL in the blood, it makes it more likely to be heart disease and stroke.
Literature reviews (cont’)

Harvested during: the months of December to March

Cultivated: the northern and northeast of the Thailand

Consumption: fresh mulberry, mulberry product such as mulberry juice, wine, jam, jelly, ice-cream, candy, canned food and freeze-dried
### Table 3  Nutrient composition of fresh and freeze-dried mulberries (*Morus alba*) values in per 100 grams

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Unit</th>
<th>Ripe mulberries&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Ripe mulberries&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Ripe mulberries&lt;sup&gt;3&lt;/sup&gt;</th>
<th>Freeze-dried mulberries&lt;sup&gt;3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximate composition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>g</td>
<td>72.95</td>
<td>81.72</td>
<td>85-88</td>
<td>3.5-17</td>
</tr>
<tr>
<td>Energy</td>
<td>kcal</td>
<td>96.35</td>
<td>67.36</td>
<td>43</td>
<td>-</td>
</tr>
<tr>
<td>Protein</td>
<td>g</td>
<td>1.68</td>
<td>1.55</td>
<td>0.50-1.40</td>
<td>-</td>
</tr>
<tr>
<td>Lipid</td>
<td>g</td>
<td>0.47</td>
<td>0.48</td>
<td>0.39-0.50</td>
<td>7.54</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>g</td>
<td>21.35</td>
<td>14.21</td>
<td>7.8-9.8</td>
<td>-</td>
</tr>
<tr>
<td>Fiber</td>
<td>g</td>
<td>2.03</td>
<td>1.47</td>
<td>0.9-1.7</td>
<td>24.3</td>
</tr>
<tr>
<td>Sugars</td>
<td>g</td>
<td>-</td>
<td>7.55</td>
<td>1.8-16.2</td>
<td>72.7-80.2</td>
</tr>
</tbody>
</table>

**Sources:**
1. Wasan, 2545
2. Imran, 2010
Table 3 Nutrient composition of fresh freeze-dried mulberries (*Morus alba*) values in per 100 grams (cont')

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Unit</th>
<th>Ripe mulberries&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Ripe mulberries&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Ripe mulberries&lt;sup&gt;3&lt;/sup&gt;</th>
<th>Freeze-dried mulberries&lt;sup&gt;3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium (Ca)</td>
<td>mg</td>
<td>0.21</td>
<td>576</td>
<td>39-443</td>
<td>-</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>mg</td>
<td>-</td>
<td>1,731</td>
<td>194-1,668</td>
<td>-</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>mg</td>
<td>-</td>
<td>280</td>
<td>10-61</td>
<td>-</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>mg</td>
<td>-</td>
<td>240</td>
<td>17-115</td>
<td>-</td>
</tr>
<tr>
<td><strong>Iron (Fe)</strong></td>
<td>mg</td>
<td>43.48</td>
<td>73</td>
<td>1.85-190</td>
<td>48.1</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>mg</td>
<td>0.07</td>
<td>-</td>
<td>35-247</td>
<td>-</td>
</tr>
<tr>
<td><strong>Zinc (Zn)</strong></td>
<td>mg</td>
<td>-</td>
<td>50.20</td>
<td>0.12-3.20</td>
<td>12.1</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>IU</td>
<td>25</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vitamin B1</td>
<td>mg</td>
<td>50.65</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vitamin B2</td>
<td>mg</td>
<td>3.66</td>
<td>0.09</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vitamin B6</td>
<td>mg</td>
<td>930.10</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>mg</td>
<td>4.16</td>
<td>15.20</td>
<td>11-36.40</td>
<td>1.20</td>
</tr>
<tr>
<td>Folic acid</td>
<td>mg</td>
<td>6.87</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Niacin</td>
<td>mg</td>
<td>0.72</td>
<td>3.10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tannin</td>
<td>g</td>
<td>1.06</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Sources: <sup>1</sup> Nuipirom W,2545 <sup>2</sup>Imran, 2010 <sup>3</sup>Mine, 2013
## Table 4 Quality of fresh and freeze-dried mulberries

<table>
<thead>
<tr>
<th>Quality</th>
<th>Fresh</th>
<th>Freeze-dried</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Red</td>
<td>Purple-black (Mature)</td>
</tr>
<tr>
<td>Total polyphenol (µg/g)</td>
<td>1,200.49 ± 55.42</td>
<td>3,716.24 ± 63.83</td>
</tr>
<tr>
<td>Total Anthocyanin (µg/g)</td>
<td>150.40 ± 36.32</td>
<td>2,940.70 ± 60.44</td>
</tr>
<tr>
<td>Quercetin (µg/g)</td>
<td>1.03 ± 0.43</td>
<td>3.08 ± 0.45</td>
</tr>
<tr>
<td>Antioxidant activity</td>
<td>5.66 ± 0.82</td>
<td>8.45 ± 0.95</td>
</tr>
</tbody>
</table>

**Source:** Fresh-Nampanon H *et al.*, 2008
Freeze-dried; Pansuwan S *et al.*, 2007
## Anthocyanin in fruits

### Table 5  Anthocyanin contents in fruits origin

<table>
<thead>
<tr>
<th>Fruits</th>
<th>Anthocyanin content (mg/100 grams fresh weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilberry</td>
<td>300-698</td>
</tr>
<tr>
<td>Blackberry</td>
<td>82.5-325.9</td>
</tr>
<tr>
<td>Blueberry</td>
<td>61.8-299.6</td>
</tr>
<tr>
<td>Cranberry</td>
<td>67-140</td>
</tr>
<tr>
<td>Cherry</td>
<td>2-450</td>
</tr>
<tr>
<td>*Mulberry</td>
<td>294</td>
</tr>
<tr>
<td>Raspberry</td>
<td>20-687</td>
</tr>
<tr>
<td>Strawberry</td>
<td>19-55</td>
</tr>
</tbody>
</table>

**Sources:** *Nampanon H et al, 2008, Sonia de Pascual-Teresa, 2010*
<table>
<thead>
<tr>
<th>Author, year</th>
<th>Study design</th>
<th>Subjects</th>
<th>Diet</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basu <em>et al.</em> (2010)</td>
<td>Intervention study (in human) 8 weeks</td>
<td>Metabolic syndrome subjects (N=27, n= 15 in treatment)</td>
<td>four cups (50 grams freeze-dried strawberry powder) of the strawberry beverage daily (~ 500 g fresh strawberries) or placebo, equivalent amounts of fluids</td>
<td>TC (10 %) ↓ LDL-C (11 %) ↓ small LDL particles (14 %) ↓ TG, HDL-C ↔</td>
</tr>
</tbody>
</table>

**N** - Number  
**CRP** - C-reactive protein  
**TNF**Α - tumour necrosis factor **Α**  
**↓** Decrease  
**↔** No significant change
<table>
<thead>
<tr>
<th>Author, year</th>
<th>Study design</th>
<th>Subjects</th>
<th>Diet</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curtis et al (2009)</td>
<td>Double-blind, randomized, placebo-controlled trial (in human)</td>
<td>Healthy postmenopausal women (N=52)</td>
<td>Anthocyanins derived from elderberry 500 mg/day or placebo</td>
<td>Biomarker of inflammatory (CRP, TNFα)</td>
</tr>
<tr>
<td></td>
<td>12 weeks</td>
<td></td>
<td></td>
<td>Plasma lipids (TC, HDL-C, LDL-C, TG)</td>
</tr>
<tr>
<td>Zhu et al. (2012)</td>
<td>Double-blind, randomized, placebo-controlled trial (in human)</td>
<td>Hypercholesterolemic subjects (N=150)</td>
<td>Pure anthocyanins derived from bilberry and black currant 320 mg/day or placebo</td>
<td>HDL-C (14 %)</td>
</tr>
<tr>
<td></td>
<td>24 weeks</td>
<td></td>
<td></td>
<td>LDL-C (10.4 %)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TC,TG, insulin</td>
</tr>
</tbody>
</table>

N - Number  
TG – Triacylglycerol  
TC – Total cholesterol
### General characteristics (cont’)

<table>
<thead>
<tr>
<th>General characteristics</th>
<th>Total (N=58)</th>
<th>Mulberry (N=30)</th>
<th>Control (N=28)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td><strong>Level of education</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school, Diploma</td>
<td>13</td>
<td>22.4</td>
<td>9</td>
<td>30.0</td>
</tr>
<tr>
<td>Bachelor degree</td>
<td>30</td>
<td>51.7</td>
<td>13</td>
<td>43.3</td>
</tr>
<tr>
<td>Master degree or high</td>
<td>15</td>
<td>25.9</td>
<td>8</td>
<td>26.7</td>
</tr>
<tr>
<td><strong>Characteristics of work</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedentary</td>
<td>38</td>
<td>65.5</td>
<td>19</td>
<td>63.3</td>
</tr>
<tr>
<td>Moderate movement</td>
<td>20</td>
<td>34.5</td>
<td>11</td>
<td>36.7</td>
</tr>
<tr>
<td><strong>Income per month (bath)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 10,000</td>
<td>2</td>
<td>3.4</td>
<td>1</td>
<td>3.3</td>
</tr>
<tr>
<td>10,001 – 20,000</td>
<td>15</td>
<td>25.9</td>
<td>8</td>
<td>26.7</td>
</tr>
<tr>
<td>20,001 – 30,000</td>
<td>21</td>
<td>36.2</td>
<td>11</td>
<td>36.7</td>
</tr>
<tr>
<td>&gt; 30,001</td>
<td>20</td>
<td>34.5</td>
<td>10</td>
<td>33.3</td>
</tr>
</tbody>
</table>
Introduction (cont’)

Figure 1 The prevalence of **borderline high cholesterol** (TC ≥ 200 mg/dL) in Thai people who age upper than 15 years old

Study Design

- Experimental study, a randomized controlled trial

Sample size calculation

This research will calculate using the following formula:

\[ n = \frac{(Z_\beta + Z_{\alpha/2})^2 \left( \sigma_1^2 + \sigma_2^2 \right)}{(\mu_1 - \mu_2)^2} \]

\[ \beta = 0.20 \quad Z_\beta = Z_{0.20} = 0.84 \]

\[ \alpha = 0.05 \quad Z_{\alpha/2} = Z_{0.025} = 1.96 \]
Mulberries on lipid profiles, antioxidant activity, and inflammatory status
### At baseline

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mulberry (N=30)</th>
<th>Control (N=28)</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipid profiles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC (mg/dL)</td>
<td>235.07 ± 28.10</td>
<td>237.26 ± 32.72</td>
<td>0.787</td>
</tr>
<tr>
<td>LDL-C (mg/dL)</td>
<td>167.47 ± 29.32</td>
<td>166.59 ± 34.02</td>
<td>0.917</td>
</tr>
<tr>
<td>HDL-C (mg/dL)</td>
<td>61.13 ± 12.59</td>
<td>65.39 ± 15.86</td>
<td>0.261</td>
</tr>
<tr>
<td>TAG (mg/dL)</td>
<td>117.03 ± 41.21</td>
<td>100.50 ± 31.97</td>
<td>0.105</td>
</tr>
</tbody>
</table>
## At week 6

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mulberry (N=30)</th>
<th>Control (N=28)</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipid profiles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC (mg/dL)</td>
<td>225.83 ± 24.26</td>
<td>244.70 ± 33.12</td>
<td>0.019</td>
</tr>
<tr>
<td>LDL-C (mg/dL)</td>
<td>156.07 ± 24.70</td>
<td>166.48 ± 32.64</td>
<td>0.184</td>
</tr>
<tr>
<td>HDL-C (mg/dL)</td>
<td>62.57 ± 13.66</td>
<td>66.14 ± 15.96</td>
<td>0.362</td>
</tr>
<tr>
<td>TAG (mg/dL)</td>
<td>109.28 ± 43.65</td>
<td>97.31 ± 30.74</td>
<td>0.250</td>
</tr>
</tbody>
</table>
Chapter V
Discussion
## Discussion

<table>
<thead>
<tr>
<th>Author, year</th>
<th>Study design</th>
<th>Subjects</th>
<th>Diet</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present study</td>
<td>randomized, controlled trial (in human) 6 weeks</td>
<td>hypercholesterolemic subjects (N=58)</td>
<td>45 g freeze-dried mulberry per day (325 mg anthocyanins) or control</td>
<td>↓ TC (3.73 %) ↓ LDL-C (6.53 %)</td>
</tr>
<tr>
<td>Qin et al. (2009)</td>
<td>Double-blind, randomized, placebo-controlled trail (in human) 12 weeks</td>
<td>Dyslipidemic subjects (N=120)</td>
<td>Natural purified anthocyanins derived from bilberry and black currant 320 mg / day or placebo</td>
<td>↑ HDL-C (13.7 %) ↓ LDL-C (13.6 %) ↓ CETP activity</td>
</tr>
</tbody>
</table>

CETP – cholesteryl ester transfer protein
<table>
<thead>
<tr>
<th>Author, year</th>
<th>Study design</th>
<th>Subjects</th>
<th>Diet</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ou et al. (2011)</td>
<td>experimental (in vitro) 24 hour</td>
<td>In human hepatoma HepG2 cells</td>
<td>Mulberry water extracts 5.66% ± 1.53 of anthocyanins</td>
<td><strong>Inhibition</strong> lipogenic enzymes (FAS, ACC) <strong>Suppressed</strong> fatty acid synthesis. <strong>Stimulated</strong> fatty acid oxidation</td>
</tr>
</tbody>
</table>

**FAS** - fatty acid synthase  
**ACC** – acetyl-CoA carboxylase
Discussion

AMPK activity↑

Mulberry

SREBP1 ↓

ACC ↓

FAS ↓

GPAT ↓

Triacylglycerol synthesis ↓

PPAR-α ↑

CPT1 ↑

Fatty acid oxidation ↑

SREBP2 ↓

HMGCoAR ↓

Cholesterol synthesis ↓
<table>
<thead>
<tr>
<th>Author, year</th>
<th>Study design</th>
<th>Subjects</th>
<th>Diet</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duangjai <em>et al.</em> (2011)</td>
<td>experimental (in vitro)</td>
<td>Caco-2 cells</td>
<td>Mulberry extracts 100 µg/mL</td>
<td><strong>Blocked</strong> the uptake of cholesterol into Caco-2 cells (about 25% inhibition)</td>
</tr>
</tbody>
</table>
Discussion

Mulberry Fruits

- quercetin (6.9 µg/g dry fruits)
- rutin (41.35 µg/g dry fruits)

Wu et al suggest rutin cloud reduce lipid accumulation by **decreasing the activity of key enzymes** in lipid metabolism, such as ACC, FAS.
Dietary calcium is one mineral

- up-regulate CYP7A1 (the gene of cholesterol-7α- hydroxylase)
- decreased plasma CETP activity

Leading to reduction in the liver and plasma cholesterol level
• The freeze-dried mulberry provide approximately 24.3 grams fiber/100 grams freeze-dried mulberry

• In our study may have been due to the increase in dietary fiber intake from baseline about 10 grams per day during the six weeks
• **Castro et al** following 316 of Japanese-Brazilians subjects in 7 years observed that a decrease of 12.5 mg/dL in the serum TC levels for each increase of 10 grams in the consumption of dietary fiber intake.

• **Streppel et al** found that for every 10 grams per day increment in fiber, there was a 17% reduction in CHD mortality and a 9% reduction in all-cause mortality.
Discussion

The mechanisms of cholesterol-lowering effects of mulberry as follow:

- Blocked the **uptake** of cholesterol into Caco-2 cells
- Inhibited of cholesterol ester transfer protein (CETP) activity
- Stimulating **AMPK** pathway
- Up-regulate the gene of **CYP7A1**
The synergistic effects of Anthocyanins, Polyphenols (e.g. rutin, quercetin), and Fiber in mulberry fruits are possibly the reasons decreasing serum TC, LDL-C levels of hypercholesterolemic subjects.
## Dietary intake (cont’)

### Mulberry group

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Mulberry (N = 30)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Week 0</td>
<td>Week 3</td>
</tr>
<tr>
<td>Energy (kcal/d)</td>
<td>1,265.0 ± 279.1</td>
<td>1,194.7 ± 302.0</td>
</tr>
<tr>
<td>Carbohydrate (g/d)</td>
<td>188.0 ± 47.8</td>
<td>175.8 ± 47.0</td>
</tr>
<tr>
<td>(% of energy)</td>
<td>59.2 ± 8.2</td>
<td>58.8 ± 7.3</td>
</tr>
<tr>
<td>Protein (g/d)</td>
<td>43.1 ± 14.2</td>
<td>41.5 ± 12.7</td>
</tr>
<tr>
<td>(% of energy)</td>
<td>13.7 ± 2.6</td>
<td>14.1 ± 2.3</td>
</tr>
<tr>
<td>Fat (g/d)</td>
<td>38.1 ± 13.3</td>
<td>37.0 ± 14.1</td>
</tr>
<tr>
<td>(% of energy)</td>
<td>26.6 ± 6.6</td>
<td>28.0 ± 9.0</td>
</tr>
<tr>
<td>Cholesterol (mg/d)</td>
<td>202.4 ± 100.2</td>
<td>199.4 ± 118.8</td>
</tr>
<tr>
<td>Fiber (g/d)</td>
<td>10.7 ± 6.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.4 ± 5.9&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
## Dietary intake (cont’)

### Control group

<table>
<thead>
<tr>
<th></th>
<th>Control (N = 28)</th>
<th></th>
<th></th>
<th></th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Week 0</td>
<td>Week 3</td>
<td>Week 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy (kcal/d)</td>
<td>1,243.9 ± 288.6</td>
<td>1,209.7 ± 256.4</td>
<td>1,183.3 ± 230.9</td>
<td>0.702</td>
<td></td>
</tr>
<tr>
<td>Carbohydrate (g/d)</td>
<td>189.0 ± 49.1</td>
<td>181.9 ± 53.0</td>
<td>171.2 ± 44.2</td>
<td>0.422</td>
<td></td>
</tr>
<tr>
<td></td>
<td>58.9 ± 7.4</td>
<td>59.0 ± 8.2</td>
<td>57.7 ± 8.2</td>
<td>0.796</td>
<td></td>
</tr>
<tr>
<td>Protein (g/d)</td>
<td>43.1 ± 12.2</td>
<td>41.9 ± 10.5</td>
<td>41.7 ± 11.8</td>
<td>0.890</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14.0 ± 3.1</td>
<td>14.0 ± 2.9</td>
<td>14.8 ± 4.1</td>
<td>0.650</td>
<td></td>
</tr>
<tr>
<td>Fat (g/d)</td>
<td>36.5 ± 13.0</td>
<td>37.8 ± 12.3</td>
<td>37.2 ± 10.8</td>
<td>0.966</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25.5 ± 6.0</td>
<td>27.2 ± 6.3</td>
<td>28.1 ± 6.1</td>
<td>0.317</td>
<td></td>
</tr>
<tr>
<td>Cholesterol (mg/d)</td>
<td>203.1 ± 94.3</td>
<td>201.6 ± 87.7</td>
<td>195.9 ± 92.8</td>
<td>0.957</td>
<td></td>
</tr>
<tr>
<td>Fiber (g/d)</td>
<td>8.0 ± 4.9</td>
<td>8.3 ± 3.7</td>
<td>7.7 ± 3.8</td>
<td>0.865</td>
<td></td>
</tr>
</tbody>
</table>
## Dietary intake

<table>
<thead>
<tr>
<th></th>
<th>Mulberry</th>
<th>Control</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy (kcal/d)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 0</td>
<td>1,265.0 ± 279.1</td>
<td>1,243.9 ± 288.6</td>
<td>0.783</td>
</tr>
<tr>
<td>Week 6</td>
<td>1,163.7 ± 295.7</td>
<td>1,183.3 ± 230.9</td>
<td>0.785</td>
</tr>
<tr>
<td><strong>Carbohydrate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g/d)</td>
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<tr>
<td>Week 0</td>
<td>188.0 ± 47.8</td>
<td>189.0 ± 49.1</td>
<td>0.939</td>
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<tr>
<td>Week 6</td>
<td>170.1 ± 41.8</td>
<td>171.2 ± 44.2</td>
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<tr>
<td>(% of energy)</td>
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<tr>
<td>Week 0</td>
<td>59.2 ± 8.2</td>
<td>58.9 ± 7.4</td>
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<tr>
<td>Week 6</td>
<td>59.1 ± 8.3</td>
<td>57.7 ± 8.2</td>
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<tr>
<td><strong>Protein</strong></td>
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<tr>
<td>(g/d)</td>
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<tr>
<td>Week 0</td>
<td>43.1 ± 14.2</td>
<td>43.1 ± 12.2</td>
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<td>Week 6</td>
<td>44.1 ± 17.5</td>
<td>41.7 ± 11.8</td>
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<td>(% of energy)</td>
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<tr>
<td>Week 0</td>
<td>13.7 ± 2.6</td>
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<td>Week 6</td>
<td>14.7 ± 2.9</td>
<td>14.8 ± 4.1</td>
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## Dietary intake (cont’)

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<tr>
<th></th>
<th>Mulberry</th>
<th>Control</th>
<th>p - value</th>
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<tbody>
<tr>
<td><strong>Fat</strong></td>
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<tr>
<td>(g/d)</td>
<td>Week 0 38.1 ± 13.3</td>
<td>36.5 ± 13.0</td>
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<td>Week 6 35.4 ± 15.2</td>
<td>37.2 ± 10.8</td>
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<tr>
<td>(% of energy)</td>
<td>Week 0 26.6 ± 6.6</td>
<td>25.5 ± 6.0</td>
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<tr>
<td></td>
<td>Week 6 26.2 ± 6.8</td>
<td>28.1 ± 6.1</td>
<td>0.286</td>
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<tr>
<td><strong>Cholesterol</strong></td>
<td>Week 0 202.4 ± 100.2</td>
<td>203.1 ± 94.3</td>
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<tr>
<td>(mg/d)</td>
<td>Week 6 195.0 ± 118.8</td>
<td>195.9 ± 92.8</td>
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<tr>
<td><strong>Fiber (g/d)</strong></td>
<td>Week 0 10.7 ± 6.9</td>
<td>8.0 ± 4.9</td>
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<td>Week 6 18.4 ± 4.3</td>
<td>7.7 ± 3.8</td>
<td>&lt; 0.001*</td>
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## Behaviors and lifestyles

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<th>Total (N=58)</th>
<th>Mulberry (N=30)</th>
<th>Control (N=28)</th>
<th>p-value</th>
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<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
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<td>Meals per day</td>
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<td>2</td>
<td>7</td>
<td>12.1</td>
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<td>3</td>
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<td>8.6</td>
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<td>Source of meals</td>
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<td>Cooking at home</td>
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<td>8</td>
<td>26.7</td>
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<td>Eating outside</td>
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<td>Ready to eat foods</td>
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<td>Frozen food products</td>
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<td>Exercise</td>
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<tr>
<td>Never</td>
<td>34</td>
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<td>15</td>
<td>50.0</td>
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<tr>
<td>Yes</td>
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<tr>
<td>1-2 time/week</td>
<td>17</td>
<td>29.3</td>
<td>9</td>
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<td>3-4 time/week</td>
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<td>≥ 4 time/week</td>
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<td>1.7</td>
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แบบสอบถามงานวิจัย

เรื่อง "ผลของการบริโภคผลหม่อนต่อระดับไขมันในเลือด ในผู้ที่มีระดับไขมันในเลือดสูง"

คำชี้แจงในการตอบแบบสอบถาม
แบบสอบถามชุดนี้มีทั้งหมด 3 ส่วน คือ

ส่วนที่ 1 ข้อมูลส่วนบุคคลทั่วไป
ส่วนที่ 2 ข้อมูลพฤติกรรมสุขภาพ
ส่วนที่ 3 ข้อมูลการตรวจร่างกายและผลการตรวจทางห้องปฏิบัติการ
2. Three-day food record

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### Table:

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### Code:

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<thead>
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สุภาษิตการบ้านที่กล่าวถึงอาหารบริโภค

การบ้านที่กล่าวถึงอาหารบริโภคในแต่ละวัน จะช่วยให้ท่านทราบถึงกิจวัตรการและรสชาติที่ทานของบริโภคต่างๆได้ ซึ่งจะเป็นเครื่องมือที่ช่วยในการควบคุมการบริโภคอาหารได้ ดังนั้นจึงขอให้ท่านบันทึกรายละเอียดของอาหารที่บริโภค ทั้งชนิดและปริมาณของอาหารที่บริโภคด้วยโรจน์ โดยมีกำหนดใน

1. การบันทึกรายการอาหารของท่านในครั้งนี้ ขอให้ท่านทำกรียนที่หนึ่ง

ทั้งหมด 3 วัน 1 สัปดาห์ (วันธรรมดา 12 วันและวันหยุด 1 วัน)
2. การบันทึกรายการอาหารของท่านในครั้งนี้ ขอให้ท่านทำกรียนที่สอง

ซึ่งต้องการอาหารที่บริโภคในแต่ละวัน หรือแต่ละ

3. การบันทึกรายการอาหารของท่านในครั้งนี้ ขอให้ท่านทำกรียนที่สาม

ซึ่งต้องการอาหารที่บริโภคในแต่ละวัน หรือแต่ละ

4. การบันทึกรายการอาหารของท่านในครั้งนี้ ขอให้ท่านทำกรียนที่สี่

โดยมีกำหนดใน

ทั้งหมด 3 วัน 1 สัปดาห์ (วันธรรมดา 12 วันและวันหยุด 1 วัน)
### 3. Physical activity record

| Time | Activity | Calories
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