Effect of Dietary Energy Density on Increasing Blood Glucose Pattern and Hunger-Satiety Sensation

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Abstract

Background: There was no data how these food density could effect on glucose and visual analog levels based on hunger-filled scales in Indonesian population.

Objective To determine the effect of food energy density on glucose levels and hunger-satiety sensation.

Material and Methods: Seventeen women 18-22 years of age with BMI> 25, were given low energy density breakfast (n = 9) and high energy density (n = 7). The subjects were fasted for 10 hours, fasting blood glucose levels was measured as well as hunger-satiety sensation with a visual analog scale (VAS), prior to treatment. Breakfast was started at 08.00 a.m chew up to 32 times for 15 minutes. Blood glucose levels and VAS measurement were taken back in 2 hours and 4 hours afterward.

Result: There was a significant differences in glucose levels between 4 hours postpandrial and 2 hours postpandrial (p = 0.031) and also between 4 hours postpandrial and fasting state (p = 0.042) in both groups. Analysis of hunger level VAS (p = 0.02) and satiety level VAS (0.04) at 4 hours postpandrial also differ significantly. Correlation analysis between hunger level VAS and blood glucose was different significantly (p = 0.01) with r = -0.59.

Conclusions: The low energy density foods produce a pattern of increasing blood glucose levels were more stable, thus, more able to suppress the sensation of hunger than high energy density.

Keywords: *Energy Density, Blood Glucose Level, VAS, Hunger-Filled Sensation*

Background

Obesity and overweight increased very sharply, almost 35% of the world's adult population has been in this condition. Women are more susceptability into the condition than in men. The obese population is beginning to stabilize in the United States, and its prevalence continues to increase in some countries in Europe and Asia. Obesity is a core component of the metabolic syndrome and includes the top ten health risk factors by WHO that are associated with chronic disease [1].

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The causes of obesity are multifactorial, including genetic, environmental, physiological, cultural, political and socioeconomic factors. Pathophysiologically, obesity occurs when the balance of energy shifts in a positive direction and closely related to high calorie intake. The phenomenon of food that has high energy density also triggers a large caloric intake. Therapy used in limiting caloric intake during this time using sympathomimetic drugs that increase satiety or inhibition of fat absorption so that the caloric intake will decrease. But on the drug has side effects and can not be used in all conditions of the patient [2].

Indonesia has a high of food diversity. For example, the composition of Madura rice, an ethnic food in East Indonesia, has high fiber and low energy density. However, there was no data how these food density could effect on glucose and visual analog levels based on hunger-filled scales [3]. Aim of this study was analyzing effect of energy density of food on blood glucose levels and Visual Analog Scale (VAS). Therefore, it can be used for prevention and therapy in handling an obesity through the influence intake of calories into the body.

Material and Method

The study was conducted with a time series true experimental design under the approval of the Research Ethics Commission of Health Faculty of Universitas Airlangga (No. 284-KEPK). Subjects of the study were 17 people who participated and signed informed consent, BMI >25, women aged 18 to 22 years were given a low energy density breakfast (n = 9) and a high energy density diet (n = 7). Ten hours before breakfast, subjects were not allowed to eat, and measurements of fasting blood glucose and visual analog scale (VAS) were performed before breakfast. Breakfast was done at 08.00 then chewed up to 32 times for 15 minutes. Blood glucose and VAS levels were measured after 2 hours and 4 hours postpandrial [4].

Food Energy Density

Low food energy density is a low-calorie breakfast with a density of <1.6 calories/gram given food in the form of Madura corn rice that consisting of corn rice, pepes fish, fried fish, orem tempe, eggplant sauce, kothok salted fish, vegetable urap and water 200 ml. Madura maize rice used has a mature weight of 320 grams, with food density of 1.4 cal/g, protein 22.18 g (19.47%), fat 16.42 g (32.54%), carbohydrate 56.38g (49,51%), fiber 6,4 g with total energy 455,47 kal [5].

High energy density food is a low-calorie breakfast with a density >2.1 calories/gram given fast food meals consisting of fries, fried chicken flour, tomato sauce and 200 ml water. This food has a density of 2.2 cal/g, with mature weight of 200 g, protein 13.73 g (12.15%), fat 30.29 g (27.644%), carbohydrate 31.22g (27.64%), fiber 1.8 g with a total energy of 451.81 cal [6]. Data were analyzed for distribution normality by Kolmogorov Smirnov test, mean difference test using independent t-test for normal distribution, and Mann Whitney test for abnormal distributed. Data analysis using SPSS version 16 [7].

Results

Seventeen women were enrolled in this study with 18 to 22 year age range, with the distribution that are shown in table 1. Based on IMT, 55.55% of the low energy density group were categorized in BMI 25.0-29.9 whereas 62.5% of high energy density group were categorized in BMI of 30.0-34.9 (table 2).

From figure 2 and 3, it showed that fasting blood glucose levels in low energy density groups are higher than in high energy density groups. The low energy density group obtained a mean of fasting blood glucose by 65.67 ± 13.33 g/dL, 2 hours postpandrial by 81.89 ± 11.11 g/dL, and 4 hours postpandrial by 106.00 ± 56.00 g/dL. Meanwhile, density high energy has mean of fasting blood glucose of 72.00 ± 13.00 g/dL, 2 hours postpandrial of 83.38 ± 10.16 g/dL, and 4 hours postpandrial 96.75 ± 14.38 g/dL.

Figure 1 and 2 showed that low energy density group has higher glucose levels than high energy density group. Even in D2 and DT, there were significant differences between low and high energy density $p < 0.05$, i.e., differences blood glucose levels of postpandrial between 4 hours and 2 hours D2 $p = 0.031$ and DT $p = 0.042$.

Visual Analog Scale is used to assess how hungry, satiety or appetite certain foods in a person. In table 3 we can see how the VAS of each question on fasting conditions, 2 hours postpandrial and 4 hours postpandrial. On examination of normality of data distribution got $p > 0.005$ for all data except at third question at 4 hours postpandrial got $p = 0.037$. To see the average difference was done independent t test got significant difference on VAS number one at 4 hours postpandrial with value $p = 0.02$. A significant difference was also found in the mean VAS number three 4 hours postpandrial using the Mann Whitney test, value $p = 0.037$.

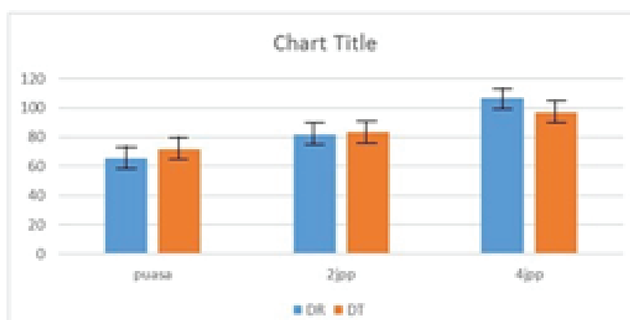
On the answer to question VAS number one is to assess how hungry the research subjects and the third question how much satisfied is obtained significant difference is done the correlation test on glucose levels in 4 hours postpandrial. The results can be seen in table 4. Additionally, from table 4 are shown that those who have hungry conditions (VAS1) correlated with blood glucose levels with $p = 0.01$. The lower the glucose level will be greater ($R = -0.59$).

Figure 1

- How hungry are you now?
- 0____10____20____30____40____50____60____70____80____90____100
- 2. How satisfied are you now?
- 0____10____20____30____40____50____60____70____80____90____100
- 3.How full are you now?
- 0____10____20____30____40____50____60____70____80____90____100
- 4.How many meal you can eat now?
- 0____10____20____30____40____50____60____70____80____90____100
- 5.how many of sweet meal you want to eat now ?
- 0____10____20____30____40____50____60____70____80____90____100
- 6.How many of acid meal you want to eat now?
- 0____10____20____30____40____50____60____70____80____90____100
- 7.How many of tasteful meal you want to eat now?
- 0____10____20____30____40____50____60____70____80____90____100
- 8.How many of d=fattening meal you want to eat now?
- 0____10____20____30____40____50____60____70____80____90____100

Figure 2

Graph 1. Mean glucose levels in both groups
DR = low energy density DT = high energy density



Discussion

This study shown that breakfast with low energy density increases low blood glucose levels than high energy density levels at 2 hours postpandrial, therefore this glucose levels tends to be maintained even slightly increased at 4 hours postpandrial. There were a significant differences in D2 and DT where the mean of the differences in the low energy density group have higher glucose levels than high energy density group [8]. This suggests that there was a stable increase in glucose levels of the low energy density group rather than high energy density. This result was similar to previous research that high-glycemic index diet will decline rapidly in glucose [9].

Decreased glucose levels in the high energy density group due to increased levels of hyperinsulinemia response by a rapid increase of glucose levels, thus, the decreased in glucose levels was faster than the low energy density group. This activity is known as glucostatic. The differences of corn fiber with fenugreek fiber were able to make a significant difference of glucose levels. The research by David stated that these fibers did not affect glucose levels postpandrial compared to the control group [10].

The results of this study implied that low-energy food density have more stable and favourable pattern of glucose levels in short and medium-term of energy homeostasis regulation. The energy density of the VAS affects the sensation of hunger and satiety at 4 hours postpandrial [11]. The energy density does not affect the desire for certain types of food, such as sweet, salty or savory. If this condition was connected to the blood glucose levels, then food density will affect hunger sensation. Low energy density can maintain glucose levels in the blood better to suppress hunger sensation [12].

This result was similar with some previous studies, Sholehah (2019) suggested that high index glycemic carbohydrates make satiety sensation in a short period (within one hour), however low glycemic index levels will keep it moderate at about two or three hours after eating. Meanwhile, it was different from a study by Mathern that stating the provision of fenugreek fiber on the diet will lower calorie intake, increase satiety, and reduce hunger. Eventhough in both these satiaty and hungry sensations have no correlation with pospandrial glucose [5].

Hunger and satiety were affected by the glucose levels that circulating in the peripheral and cerebral and the volume strain by the fibers in gastrointestinal tract, although glucose levels have a greater role than fiber strain. It said that the method of giving glucose either orally or intravenously did not affect the sensation of hunger satiety measured by VAS. It seems that satiety is not by the way inlet of glucose into the body, but by blood glucose levels [13].

When an individu has mild hypoglycemia, the limbic-striatal region of the brain will be activated and will create a strong appetite for high-calorie foods. Meanwhile euglikemia was more activate in medial prefrontal cortex that could lead to reduce food stimuli, in the other hands, high levels of glucose will brough out more powerful stimulation [14]. Thus, circulating glucose modulates stimulation regulation or barriers to food motivation. Increased of circulating glucose levels in the brain also increase functional connectivity between the hypothalamus, thalamus and striatum as well as decrease the cerebral blood flow thus full sensation will be achieved [15]. The result of this was the low energy density food produces a more stable blood glucose levels that lead to decreased of hunger sensation than in high energy density food [16].

Low energy density food have a higher fiber composition than high energy density food. Higher fiber in diet could increase the satiety within 1.5 to 2 hours after eating. Increased of satiety sensation is caused by the stimulation of satiety hormone production; peptide YY and glucoagon-like peptide-1. According to Oide et al. (2019), provision of high fermented fiber has a tendency to decrease the appetite. The provision of this fiber did not affect glucose levels, PYY, GLP-1 and ghrelin [17].

Based on the previous studies, the provision of a high glycemic index will increase hunger and reduce satiety in short-term interventions. However, this effect is varied when intervention performed in a long period. Increased blood glucose levels will trigger hyperinsulinemia and suppress ghrelin secretion. This study showed how the role of low and high energy density as an exposure to glucose levels, and hunger-satiety sensations. It has been found that low energy density food could maintain blood glucose levels and used as a way of decreasing caloric intake into the body. Further studies and explanations are needed if the low density food are exposed in the repeated frequency in a long term, thus its role in homeostasis energy will clearer.

Conclusions

The low energy density foods produce a pattern of increasing blood glucose levels were more stable, thus, more able to suppress the sensation of hunger than high energy density.

Ethical Clearance: This research involves participants in the process using a questionnaire that was accordant with the ethical research principle based on the regulation of research ethic regulation. The present study was carried out in accordance with the research principles. This study implemented the basic principle ethics of respect, beneficence, non-maleficence, and justice.

Conflict of Interest : No conflict or competing interest related with this article until now.

Source of Funding : We pay all of the sources of our own research without sponsorship from other.

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