

Short-term Satiety of High Protein Formula on Obese Subjects: A Pilot Study

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Abstract. Protein is considered to be the most satiating macronutrients. Therefore, three nutritional formulas differed in protein contribution to energy were developed to assess the satiating properties of higher protein content using subjective satiety ratings in obese subjects. Subjects received breakfast, either balanced protein formula (12.4%E), moderate protein formula (23.5%E), or high protein formula (40.6%E) in a randomized, single-blind design. To assess short-term satiety, subjective satiety ratings using VAS and energy intake at *ad libitum lunch* was measured. In this pilot study, high and moderate protein formula showed the tendency to be higher in inducing satiety than balanced protein formula. It was found that desire to eat at 15 min was significantly lower after high protein formula than balanced protein formula ($P < 0.05$). But, the higher satiety ratings produced by high protein formula were not large enough to induce a reduction in energy intake at *ad libitum lunch*.

Keywords: High protein, Satiety, Energy intake, Weight management, Obese

1. Introduction

Weight management requires a multi-factorial approach since body weight regulation involves several pathways [1]. One of conditions for successful weight management is sustained satiety despite a negative energy balance [6]. Satiety itself is defined as process that leads to inhibition of further eating, decline in hunger, increase in fullness after a meal has finished [13]. Macronutrients have different satiating effect, with protein being the most satiating, and fat the least. Dose dependent satiating effect of protein has been shown, with quite a range of concentrations of protein offered acutely, in a single meal, to subjects who are in energy balance and weight stable [2,3]. Although not conclusive, the body of evidence from studies of dietary protein and perceived hunger and satiety suggests that higher-protein meals have the potential to suppress hunger to a greater degree and result in enhanced sensations of satiety [4].

The present study aims to compare short-term satiety profile of three nutritional formulas developed which differ in protein contributions to energy in obese subjects. Specifically, this study will investigate whether higher protein formula produces higher subjective satiety compared to lower protein formula, resulting in lower energy intake in subsequent meal.

2. Subjects and Methods

2.1. Subjects

Four female volunteers (BMI 25-33 kg/m²; age 27-35 years) were recruited. They were selected on being in good health, having stable weight (no more than 4 kg change in weight) in the last 6 months, and not breastfeeding or being pregnant, not in a restricted diet or consuming supplements or drugs to lose weight, not allergic to milk products and other foods provided in this study and having the same level of activity (being sedentary, working in front of computer all day). They underwent a screening including measurement

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of body composition and medical history. Their mean age and body weight was 31.5 ± 3.42 years and 65.4 ± 5.24 kg, respectively. A written informed consent was obtained from these participants.

2.2. Design

A randomised, single-blind, crossover study was performed. All subjects came to the center on 3 occasions, separated by at least 3 days. On each test day, subjects received a subject-specific breakfast. Four hours after breakfast, subjects were offered lunch. Within this period, appetite ratings were obtained.

2.2.1. Breakfast

Test sample was offered as breakfast, which is chocolate-flavoured milk beverage differed in macronutrient composition (Table 1). The test sample was prepared by diluting the formula into 200 ml warm water. The protein content of the formula consisted of casein and whey. The breakfast contained 200 Kcal each serving. BMR was provided by InBody (InBody Co Ltd, Korea) body composition measurement.

Table 1: Macronutrient contributions on energy content of each test sample

	Balanced protein formula (BPF)	Moderate protein formula (MPF)	High Protein Formula (HPF)
Protein	12.4%	23.5%	40.6%
• Whey: Casein ratio	20:80	46:54	74:26
Carbohydrate	68.2%	56.9%	40.2%
Fat	22.6%	22.7%	22.4%
Energy density (kJ/gram)	3.54	3.59	3.56

2.2.2. Lunch

Lunch consisted of white rice (180 kcal/100 g), *cap cay* (sautéed mixed vegetables) (97 kcal/100 g), roasted chicken fillet (298 kcal/100 g), tofu (80 kcal/100 g), and boiled eggs (77 kcal/100 g).

2.2.3. Study Protocol

The day before the test, subjects were instructed to fast from 22.00 h, and on the test day, subjects came to the centre at 08.00 h. The test started at 08.00 h with scoring appetite ratings. Breakfast was offered ($t=0$ min) and completed within 10 minutes. Appetite ratings were completed at 0 (before breakfast), 15, 30, 60, 90, 120, 180, and 240 minutes. After completing the questionnaire at 240 minutes, subjects were offered an *ad libitum* lunch and were instructed to eat just as much until they were comfortably satiated. Subjects were allowed to drink maximally 500 ml of water spread over the entire test period. Subjects were instructed to maintain the same pattern for diet and exercise during the entire study period and confirmed by food diary.

2.2.4. Measurements

Appetite profile. To determine appetite profile, 100 mm visual analogue scales (VAS) anchored with describing the extremes (that is, 'I have never been more hungry'/'I am not hungry at all') were used during the test day. Subjective appetite ratings measured were hunger, fullness, desire to eat, satiety, appetite, and thoughts of food. Subjects were instructed to rate the appetite dimensions by marking the scale at the point that was most appropriate to their feeling at that time. VAS are valid and reproducible tools widely used to measure subjective appetite [5].

Energy intake at lunch. To explore the effect of different protein content to subsequent energy intake, subjects were provided with lunch. Lunch was a buffet-style meal, presented 4 hours after taking breakfast, that allowed subjects *ad libitum* self-selection of a variety of foods. The food presented in the lunch had varying amounts of fat, carbohydrate, and protein to allow subjects to vary not only energy intake but also proportions of macronutrients. All foods served were weighed before being eaten by the subjects and reweighed to obtain the net amount consumed (in grams) of each food. Energy intakes were calculated by using nutritional information for the foods obtained from Indonesian food composition table (*Tabel Komposisi Pangan Indonesia*).

2.2.5. Statistical Analysis

Data are presented as mean changes from baseline standard error to the mean (SEM), unless otherwise indicated. Differences between samples are tested for significance by using ANOVA with post hoc Tukey test. A p-value <0.05 was regarded as statistically significant. Statistical procedures were performed using SPSS version 13.0 (SPSS, Inc., Chicago IL).

3. Results

3.1. Satiety

Desire to eat after consumption of test sample (t 15min) rated by subjective VAS scores was statistically significant ($P<0.05$). At 120 min, ratings for hunger, prospective consumption, appetite and thoughts of food of balanced protein formula (BPF) were higher than moderate (MPF) and high protein formula (HPF), although, by ANOVA, this difference was not significant. It was also observed that fullness rating of BPF was lower than MPF and HPF, but also not significant ($P=0.38$). Overall, BPF showed lower subjective satiety ratings than MPF and HPF, while HPF has the highest subjective satiety ratings for all the parameters.

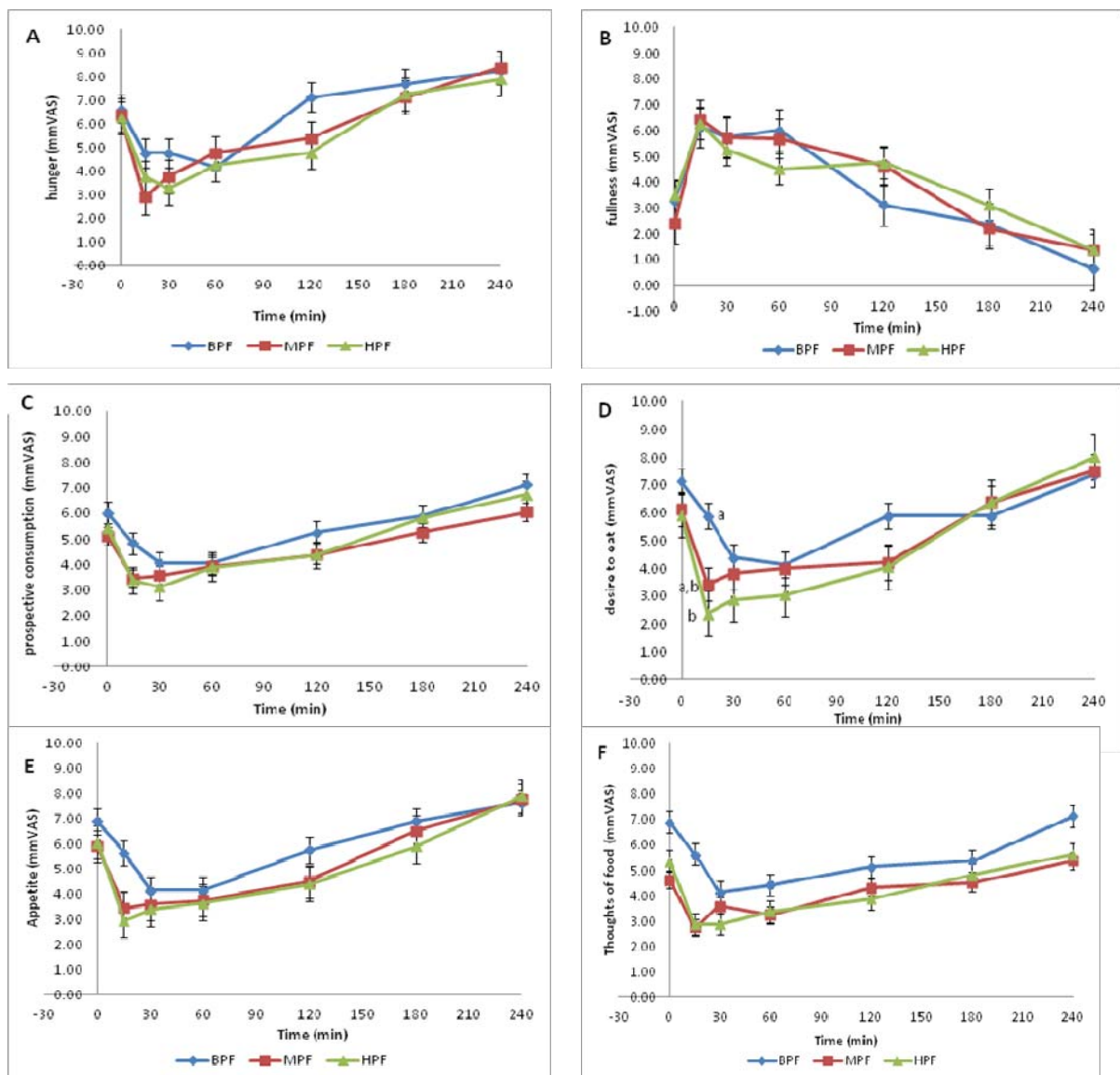


Fig. 1: Subjective appetite sensations after intake of test samples with different protein percentage to energy. A visual analogue scale corresponds to A hunger, B fullness, C prospective consumption, D desire to eat, E appetite, F thoughts of food. Data are mean values, with their standard errors represented by vertical bars. By ANOVA, there was a treatment effect just after the test sample (t 15 min) for desire to eat ($P<0.05$). Different letter marked significant difference.

3.2. Energy Intake at Lunch

Subjects' energy intake after moderate protein formula (MPF) was lower than after consuming balanced protein formula (BPF) and high protein formula (HPF). Energy intake at lunch did not differ significantly ($P=0.31$) when compared among the three formulas with different protein percentage to energy.

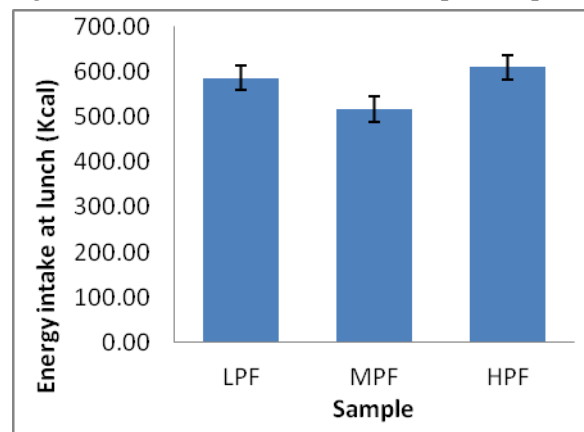


Fig. 2: Energy intake at an *ad libitum* lunch 240min after consumption of test sample. Mean energy intakes at lunch were 587 Kcal after the balanced protein formula, 517 Kcal after moderate protein formula and 610 Kcal after high protein formula. There was no significant difference in energy intake at lunch ($P=0.31$).

4. Discussions

The World Health Organization recommends that dietary protein should account for 10–15% of energy when in energy balance and weight stable. Given the range of the 'normal' protein intake, meals with on average 20% to 30% of energy from protein are representative for high protein meals, when consumed in energy balance [1].

Protein-induced satiety has been shown acutely, with single meals, with contents of 25% to 81% of energy from protein in general or from specific proteins, while subsequent energy intake reduction was significant [6]. While on a review by Halton et al, eight of 15 studies showed that consuming foods high in protein, at least 30% of total calories will cause the subjects to consume fewer calories at the next meal intake [7].

Three samples were developed to be high protein formula, moderate protein formula and balanced protein formula, having different contributions to energy as seen in Table 1. It was observed that the subjective satiety ratings for balanced protein formula (12.4% E) were consistently lower than moderate and high protein formula, although this difference was later proved to be not statistically significant for parameters of hunger, fullness, appetite, prospective consumption, and thoughts of food.

Subjects were shown to respond higher in subjective satiety ratings to moderate (23.5%E) and high protein formula (40.6%E) than to balanced protein formula, although this difference was not proven to be statistically significant in hunger, fullness, appetite, prospective consumption and thoughts of food. However, at $t=15$ min, desire to eat as response after high protein formula was significantly lower than balanced protein formula ($P<0.05$). This result might suggest that balanced protein might not be enough to give satiety to obese subjects, but high protein formula showed the potential to reduce desire to eat in obese people, who have been suggested to experienced altered regulation of satiety [8]. Meanwhile, there was no significant difference between balanced protein formula and moderate protein formula. Although this was only observed in one parameter, this result supported the notion that high protein food may produce higher satiety [7].

The weight of evidence suggests that higher protein intakes cause a decreased subsequent energy intake although the results are not entirely consistent [7]. In this study, however, the tendency to show a higher satiety for high protein intake was not shown in *ad libitum* lunch. It was observed that energy intake was highest after high protein formula, and the lowest after moderate protein formula, although this difference was not statistically significant. It was shown by Veldhorst et al [9] that differences in appetite ratings need to be at least larger than 15 mm VAS in order to have a significant effect on subsequent energy intake. In this study, although high protein formula was rated as more satiating than balanced protein formula, the difference was not large enough to be translated as a reduction in energy intake. Furthermore, differences in

timing may explain different results; timing is essential in studying ad libitum energy intake after a preload or a meal as shown by Anderson et al [10]. It is suggested that one may use the satiating power of a high protein meal optimally when timing of the meal interval synchronizes with timing of the amino acid profiles [11].

There is some suggestion that different protein will differentially affect satiety. Thus, difference in whey:casein ratio of the test sample may also play a role. Several studies have highlighted the potential of whey having higher satiating capacities than casein [12]. Although the high protein formula (with the highest whey:casein ratio) showed the tendency to have the highest satiating capacity, however, the result at *ad libitum* lunch did not support that notion. With regard to the result of this study, it is of interest to further explore the effect of different whey:casein ratio in nutritional high protein formula to satiety ratings and/or satiety hormones and energy intake and also the timing effect.

The limitations of this study are the small numbers of subjects, thus may not have sufficient power to detect small difference in satiety ratings. But, this study has promising result to be continued into a larger study, involving more subjects and more specific satiety parameters, such as satiety hormones.

In conclusion, high protein formula has been shown to be able to reduce desire to eat in obese subjects compared to moderate and balanced protein formula, but not significantly in other satiety parameters. Overall, high protein formula showed the highest satiety ratings, but in this pilot study the difference was not large enough to induce a reduction in energy intake.

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6. References

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