

The effect of high protein milk supplementation on satiety in normal weight subjects

Muliadi, R.D., *Kartawidjajaputra, F. and Antono, L.

Nutrifood Research Center, PT Nutrifood Indonesia, Jl Rawa Bali II no. 3, Pulogadung, Jakarta, Indonesia, 13920

Article history:

Received: 4 October 2021
Received in revised form: 10 November 2021
Accepted: 2 March 2022
Available Online: 19 November 2022

Keywords:

High protein milk,
Satiety,
Energy intake,
Normal BMI

DOI:

[https://doi.org/10.26656/fr.2017.6\(6\).805](https://doi.org/10.26656/fr.2017.6(6).805)

Abstract

Obesity has become a serious problem in the world. Protein is known for giving higher satiety rather than other macronutrients. However, most studies conducted their research on, either overweight or obese subjects, whereas the satiety response might be different. The objective of the study was to evaluate the effect of high protein milk (HPM) supplementation on self-reported satiety and energy intake in healthy adult men with normal BMI (18.5 – 22.9 kg/m²). In a controlled single-blind cross-over study, 17 healthy adult men (age 27±5 years; BMI 21.4±1.13 kg/m²) attended 2 sessions 1 week apart. In each session, all participants consumed a drink of 200 mL HPM (12 g protein, 2.5 g fat, 12 g carbohydrate, 120 kcal) or standard protein milk (SPM) (4g protein, 2.5 g fat, 20 g carbohydrate, 120 kcal) together with standardized breakfast±4 hours before ad libitum lunch. The result showed that fullness and hunger ratings were significantly greater on HPM supplementation than SPM (P = 0.031, P = 0.043, respectively). However, there was no significant effect on the rating of the desire to eat (P = 0.123) and energy intake during lunch (P = 0.926). The results support the hypothesis that supplementation of HPM could improve satiety in healthy adult men with normal BMI.

1. Introduction

Nowadays, people are living in the modern era, where the improvement of technology is getting massive and hastens humans to fulfil their needs. One of the facilities offered is the ease of obtaining food. People need only a small effort using mobile technology to order the food they want, then the food will be delivered to them. However, this phenomenon leads to a higher complexity of health problems, such as increased overweight and obesity (Purnamasari, 2018).

Obesity is a condition when adipose tissue or fat is accumulated excessively. Even though there is no specific cut-off for a fat percentage to be classified as obese, there are some parameters such as body mass index and waist circumference (central obesity) (Purnell 2018). This accumulation occurred because calorie intake is higher than expenditure which causes imbalance (Jih *et al.*, 2014). A sedentary lifestyle and poor consumption behaviour become the most affecting factor in causing obesity (González-Muniesa *et al.*, 2017). Especially with all convenience that the world offers nowadays, those two factors, without a doubt are quite possible to be reached in no time. While humans are carried away by the euphoria of being comfortable,

silent threats always lurk. This condition makes even healthy people become more prone to excessive calorie intake if they do not take full responsibility to improve their lifestyle.

Obesity emerges as a root cause of other non-communicable diseases and for suffering further chronic complication disease (Purnamasari, 2018). Based on the updated data related to obesity by Basic Health Research, the prevalence of obesity in adults in Indonesia is increasing from 10.5% (2007) to 14.8% (2013) and reaching up to 21.8% in 2018 (Kementerian Kesehatan Republik Indonesia, 2018).

To date, there are many efforts done to prevent calorie excess, such as increasing energy expenditure and limiting food intake. One important factor in limiting food intake is to increase satiety. Thus, consuming suitable food to increase satiety becomes crucial. Protein is a macronutrient whose satiating property has been widely studied. Several studies showed that high protein consumption; in the form of skim milk, high-protein milk, and a high-protein meal had contributed to the increase in satiety followed by decreasing in energy intake (Harper *et al.*, 2007; Dove *et al.*, 2009; Lorenzen

*Corresponding author.

Email: felicia@nutrifood.co.id

et al., 2012; Pertiwi *et al.*, 2012; Leidy *et al.*, 2013).

However, these researches employed overweight and obese subjects, and none has been found on healthy adults with normal body mass index (BMI 18.5 – 22.9 kg/m², Asia-Pacific region) (WHO, 2000). The satiety response between the normal and obese groups was different. Meyer-Gerspach *et al.* (2014) observed that obese people tend to have delayed gastric emptying which leads to decreased secretion of the satiation peptides, GLP-1 and PYY. They tend to reach maximal satiation in a shorter time than normal weight but consumed more calories to get full. Tsani *et al.* (2021) also mentioned that obese and normal-weight people have different satiety profile due to some reasons. Normal-weight people have a lower score in fullness right after eating yet a higher score in the next 3 hours compared with obese people. This could occur because of different levels of leptin between obese and normal people. Normal people have higher leptin so that they could preserve longer fullness than obese people.

Therefore, this study aimed to evaluate the satiating effect of high protein milk on healthy adults with normal BMI and whether it will give the same beneficial effect as overweight or obese subjects.

2. Materials and methods

2.1 Subjects

Male subjects were recruited for this study at PT. Nutrifood Indonesia (Jakarta, Indonesia). The inclusion criteria were: male age 19-40 years, normal weight (BMI 18.5-22.9 kg/m²), not being on a restricted diet and not having an allergy to dairy products, had been weight-stable (no more than 6% change in weight in the last 3 months), and regularly have breakfast.

Subjects completed the International Physical Activity Questionnaire (IPAQ) before the test. Weight, body composition, and basal metabolic rate (BMR) (InBody720, Biospace, Korea) were measured. IPAQ was used to measure the activity level of the subject. Daily energy requirements (DER) were assumed to be equal to total daily energy expenditure (as subjects reported to be weight stable) (Astbury *et al.*, 2010). DER was calculated by multiplying measured BMR by a physical activity level, which was estimated using the IPAQ (Craig *et al.*, 2003). The purpose was to calculate the calorie needed by each subject for breakfast.

All subjects gave their written consent after the experimental procedure had been explained to them. The study was approved by the Institute of Research and the Community Service Atma Jaya Catholic University of Indonesia with register number 0908/III/LPPM-

PM.10.05/07/2019.

2.2 Study design

A single-blind, controlled, cross-over trial was performed. All subjects were involved on two separate occasions with a washed-out period of 7 days between each study. Subjects were advised to refrain from doing vigorous exercise for 24 hours before the trial. They were instructed not to consume any other foods or drinks (except a maximum of 200 mL water) after 10.30 pm on the day before the trial until 8.00 am on the next morning.

Subjects were instructed to arrive at the place of the experiment at 8.00 am. On arrival, subjects were seated in a room for 15 mins in order to adapt to the room condition. At 08.15 am (t = 0 min), the subjects' appetite profile was assessed using a visual analogue scale (VAS) questionnaire. After the assessment, subjects were given a standardized breakfast with preloads (high protein milk (HPM) or standard protein milk (SPM)) at approximately 08.30 am, which they had 15 mins to consume. Appetite ratings were repeated 15 mins after breakfast (08.45 am) and then keep recorded every 30 mins. At 09.45 am (t = 90 mins) and 11.15 am (t = 180 mins), subjects were provided with 100 mL of water before they recorded the appetite rating. At approximately 12.15 pm (t = 240 mins), Subjects were then provided with an ad libitum meal to consume. They were instructed to eat as much as they wished of the meal, within 20 mins, until they felt comfortably full. Subjects completed the appetite VAS questionnaire immediately.

2.2.1 Breakfast

The standardized breakfast was a strawberry sandwich, which consisted of double soft white bread (Sari Roti, Indonesia) and strawberry spread (Morin Brand, Indonesia) as well as preloads (HPM or SPM). This meal was made equivalent to 20% of individual DER and the proportion of energy from protein, fat, and carbohydrate was 18, 18, and 64% (from the breakfast's total energy), respectively with HPM preloads and 11, 18, and 71%, respectively with SPM preload.

2.2.2 Preloads

Preloads were two-fixed energy, chocolate-flavoured milk beverages. Preloads were two iso-energetic 120 kcal milk beverages containing 12 g protein for HPM preloads and 4 g protein for SPM preloads (Table 1).

2.2.3 Lunch

The food which was provided in ad libitum lunch consisted of fried rice with a fried egg. Subjects were initially provided with 200 g of fried rice and 50 g of

fried egg. A new portion of food (100 g of fried rice and 25 g of fried egg) was offered after the dish became empty and subjects chose to eat another portion. This process was repeated until the subject indicated that they wished to terminate the meal. Each portion (200 g of fried rice and 50 g of fried egg) consisted of 16% energy from protein, 26% from fat, and 58% from carbohydrates.

Table 1. Nutrient composition of preloads

	HPM	SPM
Energy (kcal)	120	120
Protein (g)	12	4
Energy (%)	40.5	13.5
Fat (g)	2.5	2.5
Energy (%)	19	19
Carbohydrate (g)	12	20
Energy (%)	40.5	67.5
Energy density (kcal/mL)	0.6	0.6

2.2.4 Appetite and taste ratings

Visual analogue scale (VAS), 10 cm in length with words anchored at each end, expressing the most positive and the most negative rating, was used to assess hunger, satiety, and desire to eat (Figure 1). Subjects did not discuss or compare their ratings with each other (Flint *et al.*, 2000).

Nothing at all	How big is your desire to eat? 1 2 3 4 5 6 7 8 9 10	A lot
Not at all full	How full do you feel? 1 2 3 4 5 6 7 8 9 10	Totally full that I can't eat anymore
Not hungry at all	How hungry do you feel? 1 2 3 4 5 6 7 8 9 10	Have never been hungrier

Figure 1. Questions on subjective appetite ratings

2.3 Statistical analysis

Data were analyzed using IBM SPSS statistics software (version 21). All results are presented as means with their standard errors unless otherwise stated. Differences were considered significant at $P < 0.05$.

ANOVA for repeated measures was used to analyze the differences in VAS appetite ratings between treatment and control, the area under the curve (AUC) of VAS appetite ratings, and energy intake at the test meal. If a significant main effect of preload was obtained, post-hoc analysis was conducted using two-tailed paired t-tests to determine the location of the difference. In order to confirm the baseline of the appetite rating at $t = 0$ was not different within treatments (bias prevention), two-tailed paired t-tests were conducted.

3. Results and discussion

3.1 Subjects

Seventeen healthy adult men (age 27 ± 5 years; BMI 21.4 ± 1.13 kg/m²) completed this study and there was no dropout. To detect a 1.6 mm difference in VAS, with an 80% power and SD of 1.42 mm based on a similar previous study by Pertiwi *et al.* (2012), a minimum of 15 participants were required for the study. Table 2 displays subject characteristics.

Table 2. Subject characteristics

	Subject ($n: 17$)	
	Mean	SD
Age	26.71	4.96
BMI (kg/m ²)	21.40	1.13
BMR (kcal)	1485.30	101.96
DER (kcal)	2535.20	329.08

3.2 Appetite profile

The appetite ratings during the experiment were assessed to evaluate the effect of high-protein milk on subjective appetite ratings. Before the breakfast ($t = 0$), the parameters for fullness, hunger, and desire to eat between HPM and SPM treatments were not significantly different (Table 3).

Table 3. Baseline appetite ratings (two-tailed paired t-tests)

	Mean VAS rating (95% CI)		
	HPM (mm)	SPM (mm)	P
Fullness	2.53 \pm 1.97	2.53 \pm 1.74	1.000
Hunger	7.41 \pm 1.73	6.82 \pm 1.84	0.264
Desire to eat	7.41 \pm 1.84	7.59 \pm 1.91	0.753

After breakfast, for all treatments, the VAS score for fullness decreased while hunger and desire to eat increased (Figure 2). There were significant differences between time for fullness ($F(4,166,66.665) = 40.781$, $P < 0.001$), hunger ($F(4,321,69.143) = 37.273$, $P < 0.001$), and desire to eat ($F(3,854,61.657) = 32.177$, $P < 0.001$). Subsequently, there were significant differences between treatment for fullness ($F(1,16) = 5.578$, $P = 0.031$) and hunger ($F(1,16) = 4.811$, $P = 0.043$) while there was an increase in desire to eat in SPM compared with HPM (even though statistically it did not significant) as well as no significant differences in interaction between time and treatment for all parameters. Because significant differences between treatment in fullness and hunger parameters were achieved, a two-tailed paired t-test was conducted. For the fullness parameter, the time when the differences were significant were at $t = 60$ ($P = 0.044$), 120 ($P = 0.046$), 150 ($P = 0.028$), and 240 ($P = 0.011$) while for the hunger parameter at $t = 150$ ($P = 0.030$) and 240 ($P = 0.022$). For the AUC result, there were significant differences for fullness ($F(1,16) = 6.016$, $P = 0.026$) and hunger ($F(1,16) = 5.579$, $P = 0.031$). However, there were no significant differences in the

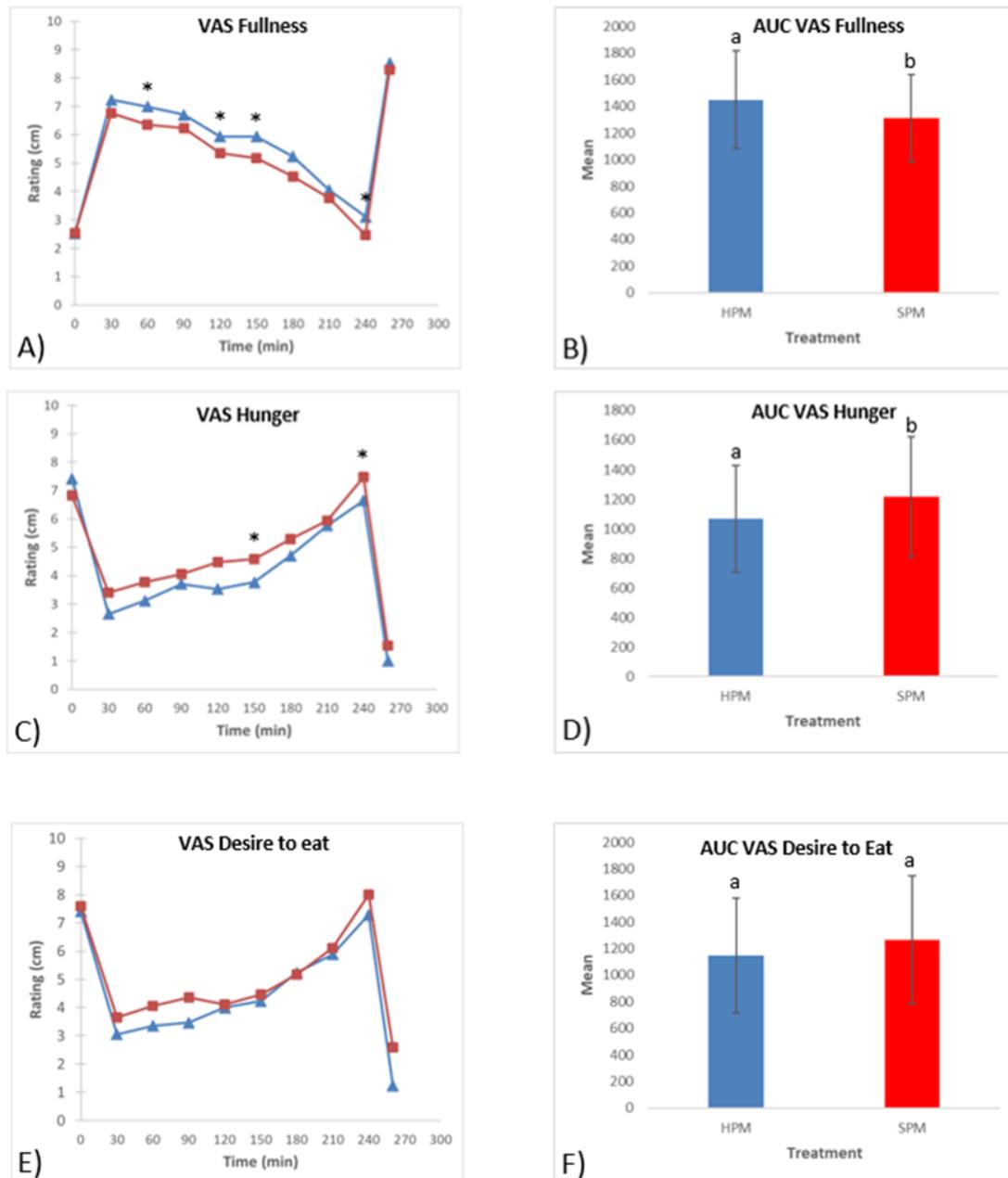


Figure 2. Changes in appetite ratings: VAS fullness (A), AUC VAS fullness (B), VAS hunger (C), AUC VAS hunger (D) VAS desire to eat (E), AUC VAS desire to eat (F) during the experiment. Data are expressed in mean values and the location of significant differences. Δ = high protein milk (HPM), \square = standard protein milk (SPM). ANOVA repeated measures with confidence intervals $p < 0.05$. *location of the significant differences using two-tailed paired t tests. Bars with different notations are significantly different using two-tailed paired t tests.

desire to eat although SPM gave a higher score than HPM.

3.3 Energy intake at test meal

Despite significant differences in fullness and hunger between high protein and standard preloads, no significant differences were observed in energy intake during *ad libitum* lunch for the two groups (Figure 3).

4. Discussion

When it came to evaluating the satiating effect of protein, previous researches mostly focus on overweight or obese subjects. As far as we know, this is the first

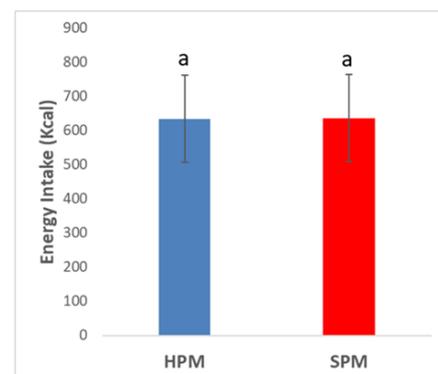


Figure 3. Energy intake. Values are means with their standard errors. ANOVA repeated measures with confidence intervals $p < 0.05$. Bars with different notations are significantly different using two-tailed paired t tests.

study that investigates the effect of high-protein milk on satiety in normal BMI subjects, especially for the Asia-Pacific Region. Besides, most studies used a high amount of protein (>20% protein) (Dhillon *et al.*, 2016). This study investigated whether a smaller amount of protein, near the bottom line in the high protein meal category (15%) (Foltz *et al.*, 2010), would be sufficient to give satiating effect to the subjects.

In this study, two controlled, fixed-energy milk beverages were given as preload. These two beverages contained the same energy content, with different ratios between protein and carbohydrate. HPM contained 12 g protein (40.5% energy from preloaded drink), around two times higher protein compared with cow milk (Pereira 2014). The other milk, SPM only contained 4 g of protein (13.5% energy from the preloaded drink). All iso-caloric preloads were consumed together with standardized breakfast resulting in 18.4% energy from the protein in the treatment final meal and 11.2% in the control final meal. This followed the criteria for treatment to be considered as high protein meal compared with control meal (meals and diets with an average >15% of energy from protein are representative of high protein meals and diets) (Foltz *et al.*, 2010).

In order to achieve valid data from the VAS score for measurement of appetite ratings and to show the detectable difference of appetite scores, there is a minimum subject needed to have participated. There were 17 subjects in this present study. This number was sufficient to cover a test of an effect size of 10% with a study power of 0.9 of the appetite ratings in a paired design (Flint *et al.*, 2000).

Satiety is the feeling of fullness that persists after eating, potentially suppressing further energy intake until hunger returns, which could not be recorded by one kind of rating alone. Usually, several parameters are used to see this feeling, such as fullness, hunger, and desire to eat (Benelam, 2009). This study showed high protein milk gave a better satiating effect significantly, especially for fullness and hunger ratings. The appetite rating on the desire to eat for SPM was higher than HPM which indicated that on this parameter, HPM also gave a better satiating effect even though statistically insignificant. These results confirmed our hypothesis about the satiating effect of protein. Protein has been known for its ability to prolong satiety compared with other macronutrients. Some studies also showed that a higher intake of protein (above 15%) gave a stronger effect on satiety than equivalent quantities of energy from carbohydrates or fat on overweight and obese subjects (Benelam, 2009). In our study, this satiating effect was also observed in normal-weight subjects. This

finding was in line with a study involving normal BMI subjects (even though the BMI cut-off was different from our study; the cut-off for overweight was 25) conducted by Fernández-Raudales *et al.* (2018). This study conclude that higher protein intake (50% energy of preload from plant-based protein) also showed a higher satiating effect.

There are several possible mechanisms. First, protein might influence the satiety hormone. A number of hormones are produced from the gut to indicate that food has been consumed, which gives signals directly or indirectly to the brain, and promotes satiety. High protein consumption increases glucagon-like peptide-1 (GLP-1), cholecystokinin, and PYY which cause an increase in satiety as well as a decrease in ghrelin hormone, which is responsible for decreasing hunger (Veldhorst, Smeets, Soenen *et al.*, 2008; Morell and Fisman, 2017). A study carried out by Ghazzawi and Mustafa in 2019 confirmed this mechanism, even though it was conducted on overweight subjects. The finding showed that PYY levels were significantly higher when subjects were given high protein breakfast (51% protein, 13% CHO, 36% fat) compared to a high carbohydrate breakfast (0% protein, 60%CHO, 30% fat) as well as the satiety VAS score. Second, higher protein intake can increase body temperature and oxygen consumption. This increase may lead to feeling deprived of oxygen and thus promote satiety. Not only increase energy expenditure, but protein also decreases energy intake through mechanisms that influence appetite control (Benelam, 2009; Morell and Fisman, 2017).

Third, there is a hypothesis saying that the brain has a satiety centre. This centre is sensitive to serum amino acid levels, and once reaching a certain point, hunger would decrease. Fourth, is gluconeogenesis. The satiating effect could be related to the improvement of glucose homeostasis through the modulation of hepatic gluconeogenesis and subsequent glucose metabolism (Veldhorst, Smeets, Soenen *et al.*, 2008). Fifth, is the brain reward system. The central mesolimbic reward system generates a sensation of pleasure and promotes the motivation for food consumption through its activation. In a study, a high-protein diet could reduce reward-driven eating behaviour through the activation of specific brain regions in the corticolimbic system, which decreases the hunger sensation (Cuenca-Sánchez *et al.*, 2015)

Whilst appetite rating showed significant improvement, the tendency to show higher satiety for high protein intake was not shown in ad libitum lunch. Veldhorst, Nieuwenhuizen, Hochstenbach-Waelen *et al.* (2008) in their research concluded 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, even though the differences between treatments for appetite ratings were statistically significant, the average score was lower than 15 mm for all locations, which means the difference was not large enough to be translated as a reduction in energy intake. The other possibility was the ad libitum lunch implementation. In this study, the subjects were asked to eat more subjectively by raising their hand and it occurred when their dishes were empty. This condition can make them terminate their meal even though they are still not comfortable full because people tend to finish the meal and would not leave leftovers. The researcher should add a new portion of food before the dish became empty and the subject continued to eat. This ensured the cue of an empty dish did not prompt meal termination (Marriott, 1995; Astbury *et al.*, 2010).

A limitation of this study is we did not do further confirmation from the VAS score by measuring hormones level. VAS score is a subjective parameter that is affected by many factors, such as psychological issues in individuals to choose on which scale, they will measure their appetite ratings (tendency to avoid extreme score, etc.) (Benelam, 2009). The other limitation was that we did not control H-1 dinner to homogenize the baseline level of satiety in the subjects. It could affect the variation of baseline level in the morning before subjects started the experiment, such as the second meal effect (Ibrügger *et al.*, 2014).

In conclusion, our study found that high protein milk supplementation has been shown to be able to increase fullness and reduce hunger ratings in healthy adults with normal body mass index (BMI 18.5 – 22.9 kg/m², Asia-Pacific region). However, this difference in satiety level was not sufficient to reduce energy intake during the subsequent meal. This finding could trigger deeper research possibilities in the satiating effect of protein on healthy normal BMI subjects (Asia-Pacific cut-off).

Conflict of interest

The authors are employees of PT Nutrifood Indonesia.

Acknowledgements

This study was fully funded by PT Nutrifood Indonesia.

References

Astbury, N.M., Stevenson, E.J., Morris, P., Taylor, M.A. and Macdonald, I.A. (2010). Dose-response effect of

a whey protein preload on within-day energy intake in lean subjects. *The British Journal of Nutrition*, 104(12), 1858-1867. <https://doi.org/10.1017/S000711451000293X>

Benelam, B. (2009). Satiating, satiety and their effects on eating behaviour. *Nutrition Bulletin*, 34(2), 126–173. <https://doi.org/10.1111/j.1467-3010.2009.01753.x>

Craig, C.L., Marshall, A.L., Sjöström, M., Bauman, A.E., Booth, M.L., Ainsworth, B.E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J.F. and Oja, P. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine and Science in Sports and Exercise*, 35(8), 1381-1395. <https://doi.org/10.1249/01.MSS.0000078924.61453.FB>

Cuenca-Sánchez, M., Navas-Carrillo, D. and Orenes-Piñero, E. (2015). Controversies Surrounding High-Protein Diet Intake: Satiating Effect and Kidney and Bone Health. *Advances in Nutrition*, 6(3), 260–266. <https://doi.org/10.3945/an.114.007716>

Dhillon, J., Craig, B.A., Leidy, H.J., Amankwaah, A.F., Osei-Boadi Anguah, K., Jacobs, A., Jones, B.J., Keeler, C.L., Keller, C.E.M., McCrory, M.A., Rivera, R.L., Slebodnik, M., Mattes, R.D. and Tucker, R.M. (2016). The Effects of Increased Protein Intake on Fullness: A Meta-Analysis and Its Limitations. *Journal of the Academy of Nutrition and Dietetics*, 116(6), 968–983. <https://doi.org/10.1016/j.jand.2016.01.003>

Dove, E.R., Hodgson, J.M., Puddey, I.B., Beilin, L.J., Lee, Y.P. and Mori, T.A. (2009). Skim milk compared with a fruit drink acutely reduces appetite and energy intake in overweight men and women. *The American Journal of Clinical Nutrition*, 90(1), 70–75. <https://doi.org/10.3945/ajcn.2008.27411>

Fernández-Raudales, D., Yor-Aguilar, M. andino-Segura, J., Hernández, A., Egbert, R. and López-Cintrón, J. (2018) Effects of High Plant Protein and High Soluble Fiber Beverages on Satiety, Appetite Control and Subsequent Food Intake in Healthy Men. *Food and Nutrition Sciences*, 9, 751-762. <https://doi.org/10.4236/fns.2018.96057>

Flint, A., Raben, A., Blundell, J.E. and Astrup, A. (2000). Reproducibility, power and validity of visual analogue scales in assessment of appetite sensations in single test meal studies. *International Journal of Obesity*, 24, 38-48. <https://doi.org/10.1038/sj.ijo.0801083>

Foltz, M., Portier, M. and Tome, D. (2010). Food Proteins or Their Hydrolysates as Regulators of Satiety. In Mine, Y., Li-Chan, E. and Jiang, B. (Eds). *Bioactive Proteins and Peptides as Functional Foods and Nutraceuticals*, p. 135-148. United Kingdom:

- Blackwell Publishing. <https://doi.org/10.1002/9780813811048.ch10>
- Ghazzawi, H.A. and Mustafa, S. (2019). Effect of high-protein breakfast meal on within-day appetite hormones: Peptide YY, glucagon like peptide-1 in adults. *Clinical Nutrition Experimental*, 28, 111–122. <https://doi.org/10.1016/j.yclnex.2019.09.002>
- González-Muniesa, P., Martínez-González, M.A., Hu, F.B., Després, J.P., Matsuzawa, Y., Loos, R.J.F., Moreno, L.A., Bray, G.A. and Martínez, J.A. (2017). Obesity. *Nature Reviews Disease Primers*, 3, 17034. <https://doi.org/10.1038/nrdp.2017.34>
- Harper, A., James, A., Flint, A. and Astrup, A. (2007). Increased satiety after intake of a chocolate milk drink compared with a carbonated beverage, but no difference in subsequent ad libitum lunch intake. *The British Journal of Nutrition*, 97(3), 579. <https://doi.org/10.1017/S0007114507339846>
- Ibrügger, S., Vignsnaes, L.K., Blennow, A., Škuflić, D., Raben, A., Lauritzen, L. and Kristensen, M. (2014). Second meal effect on appetite and fermentation of wholegrain rye foods. *Appetite*, 80, 248–256. <https://doi.org/10.1016/j.appet.2014.05.026>
- Jih, J., Mukherjea, A., Vittinghoff, E., Nguyen, T.T., Tsoh, J.Y., Fukuoka, Y., Bender, M.S., Tseng, W. and Kanaya, A.M. (2014). Using appropriate body mass index cut points for overweight and obesity among Asian Americans. *Preventive Medicine*, 65, 1–6. <https://doi.org/10.1016/j.ypmed.2014.04.010>
- Kementerian Kesehatan Republik Indonesia. (2018). Potret Sehat Indonesia dari Riskesdas 2018. Retrieved on April 20, 2020 from Kementerian Kesehatan Indonesia Website: <https://www.kemkes.go.id/article/view/18110200003/potret-sehat-indonesia-dari-riskesdas-2018.html> [In Bahasa Indonesia].
- Leidy, H.J., Ortinau, L.C., Douglas, S.M. and Hoertel, H.A. (2013). Beneficial effects of a higher-protein breakfast on the appetitive, hormonal, and neural signals controlling energy intake regulation in overweight/obese, “breakfast-skipping,” late-adolescent girls. *The American Journal of Clinical Nutrition*, 97(4), 677–688. <https://doi.org/10.3945/ajcn.112.053116>
- Lorenzen, J., Frederiksen, R., Hoppe, C., Hvid, R. and Astrup, A. (2012). The effect of milk proteins on appetite regulation and diet-induced thermogenesis. *European Journal of Clinical Nutrition*, 66(5), 622–627. <https://doi.org/10.1038/ejcn.2011.221>
- Marriott, B.M. (1995). Not Eating Enough: Overcoming Underconsumption of Military Operational Rations. Washington, USA: National Academies Press. <https://doi.org/10.21236/ADA300575>
- Meyer-Gerspach, A.C., Wölnerhanssen, B., Beglinger, B., Nessenius, F., Napitupulu, M., Schulte, F. H., Steinert, R.E. and Beglinger, C. (2014). Gastric and intestinal satiation in obese and normal weight healthy people. *Physiology and Behavior*, 129, 265–271. <https://doi.org/10.1016/j.physbeh.2014.02.043>
- Morell, P. and Fiszman, S. (2017). Revisiting the role of protein-induced satiation and satiety. *Food Hydrocolloids*, 68, 199–210. <https://doi.org/10.1016/j.foodhyd.2016.08.003>
- Pereira, P.C. (2014). Milk nutritional composition and its role in human health. *Nutrition*, 30(6), 619–627. <https://doi.org/10.1016/j.nut.2013.10.011>
- Pertiwi, K., Kurniati, A. and Susana. (2012). High Protein Milk Significantly Lowered Desire to Eat in Obese Subjects: A Pilot Study. *International Journal of Chemical Engineering*, 3(4), 282–287. <https://doi.org/10.7763/IJCEA.2012.V3.200>
- Purnamasari, D. (2018). The Emergence of Non-communicable Disease in Indonesia. *Acta Medica Indonesiana*, 50(4), 273–274.
- Purnell, J.Q. (2000). Definitions, Classification, and Epidemiology of Obesity. In Feingold, K.R., Anawalt, B. and Boyce, A. (Eds). *Endotext*. Retrieved on November 12, 2021 from NCBI website: <https://www.ncbi.nlm.nih.gov/books/NBK279167/>.
- Tsani, A.F.A., Widowati, S.A., Dieny, F.F., Widyastuti, N. and Septiyani, A. (2021). Satiety Profiles in Obese and Normal Adults After High-Carbohydrate Diet Ingestion. *Pakistan Journal of Medical and Health Sciences*, 15(7), 2051–2055. <https://doi.org/10.53350/pjmhs211572051>
- Veldhorst, M.A.B., Nieuwenhuizen, A.G., Hochstenbach-Waelen, A., Westerterp, K.R., Engelen, M.P.K.J., Brummer, R.J.M., Deutz, N.E.P. and Westerterp-Plantenga, M.S. (2008). Comparison of the effects of a high- and normal-casein breakfast on satiety, ‘satiety’ hormones, plasma amino acids and subsequent energy intake. *The British Journal of Nutrition*, 101(02), 295–303. <https://doi.org/10.1017/S0007114508003061>
- Veldhorst, M., Smeets, A., Soenen, S., Hochstenbach-Waelen, A., Hursel, R., Diepvens, K., Lejeune, M. and Westerterp-Plantenga, M. (2008). Protein-induced satiety: Effects and mechanisms of different proteins. *Physiology and Behavior*, 94(2), 300–307. <https://doi.org/10.1016/j.physbeh.2008.01.003>
- WHO (World Health Organization). (2000). The Asia-Pacific perspective: redefining obesity and its treatment. Sydney, Australia: Health Communications Australia, Regional Office for the Western Pacific.