

# The effect of whole pulses and their fractions on satiety, food intake, glucose control, and components of the metabolic syndrome

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# Health Effects of Pulses

- **Regular consumption for 2-8 weeks of beans (3.5-14 cups per week) have shown improved glycemic control, improved blood lipid profiles and/or weight loss**

*Shutler et al. Br J Nutr. 1989; Anderson et al. Am J Clin Nutr 1990; Winham et al. J Am Coll Nutr, 2007; Winham and Hutchins Nutr Res, 2007*

- **Adults and teens who regularly consume beans weigh less and have a lower risk of becoming overweight**

*Papanikolaou et al. JACN 2008*

- **A traditional diet relying on rice and beans was associated with lower risk of becoming overweight and obese in a Brazilian population**

*Sichieri Obesity Research, 2002*

# Pulses: The Ideal Food for Satiety, Reducing Food Intake and Control of Blood Glucose?

- Pulses are the edible seeds of legumes  
e.g. lentils, beans, peas and chickpeas
- Solid food
- Low energy density
- Low GI
- High Fiber
- High Protein



# Pulse Studies

- Four short-term in male subjects of healthy bodyweights
  - Two to five hours duration
  - Feed pulse treatments
  - Measure :Blood glucose, **satiety** (appetite), food intake
- One long-term study in overweight/obese men and women
  - Eight weeks consuming pulses 5X/wk
  - Measure characteristics of the metabolic syndrome

# Short-term Study Design

Control

Defined time e.g. 120 min

Water, Bread, Noodles?



Measure  
Food Intake  
900kcal



Subjective satiety , Glycemic Response  
Area Under the Curve (AUC)



Measure  
Food Intake  
600kcal ?

Test Food (300 kcal)

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2006 - 2007

Effect of pulses consumption (300 kcal) on satiety, glycemic response and food intake at an ad libitum pizza meal two hours later.

Are pulses the ideal food to curb hunger?

***Supported by:***

***SASKATCHEWAN DEPARTMENT OF AGRICULTURE AND FOOD***

 Saskatchewan Pulse Growers

PROJECT #20050762

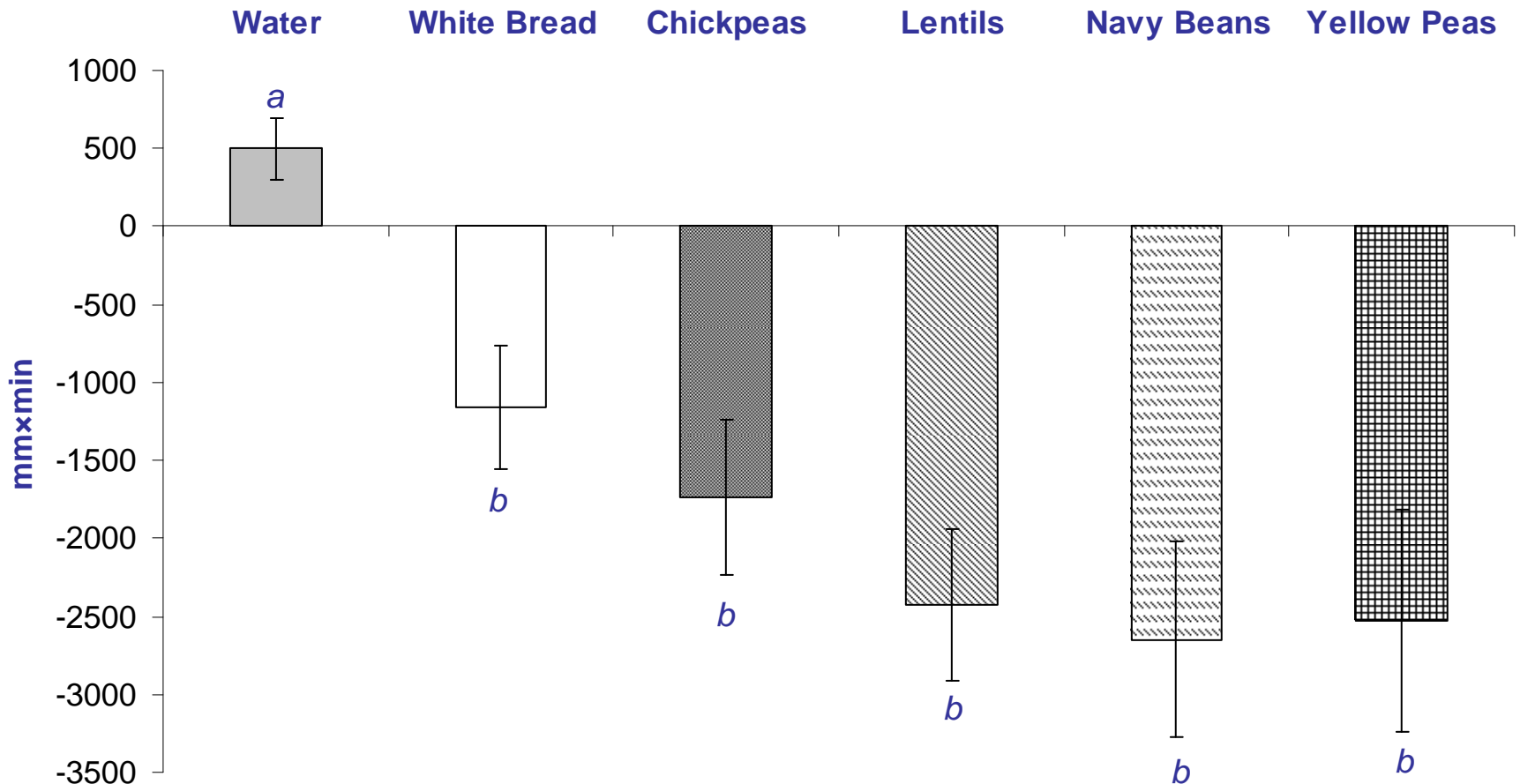
# Pulse Treatments: Composition

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<b>PER SERVING</b>	<b>Lentils</b>	<b>Chickpeas</b>	<b>Yellow peas</b>	<b>Navy Beans</b>	<b>White Bread</b>
<b>Weight (g)</b>	451	341	491	359	235
<b>Total Energy (kcal)</b>	<b>300</b>	<b>300</b>	<b>300</b>	<b>300</b>	<b>300</b>
<b>Available CHO (g)</b>	52.2	47.8	50.6	53.3	64.0
<b>Protein (g)</b>	18.3	16.1	17.2	18.7	9.9
<b>Fiber (g)</b>	13.5	11.3	9.1	16.6	2.8
<b>Fat (g)</b>	1.9	4.9	3.1	1.4	0.5
<b>Sodium (mg)</b>	2425	1955	2294	1402	2150
<b>Energy Density</b>	0.6	0.8	0.6	0.8	1.1
<b>Volume (mL)</b>	494	384	516	381	282

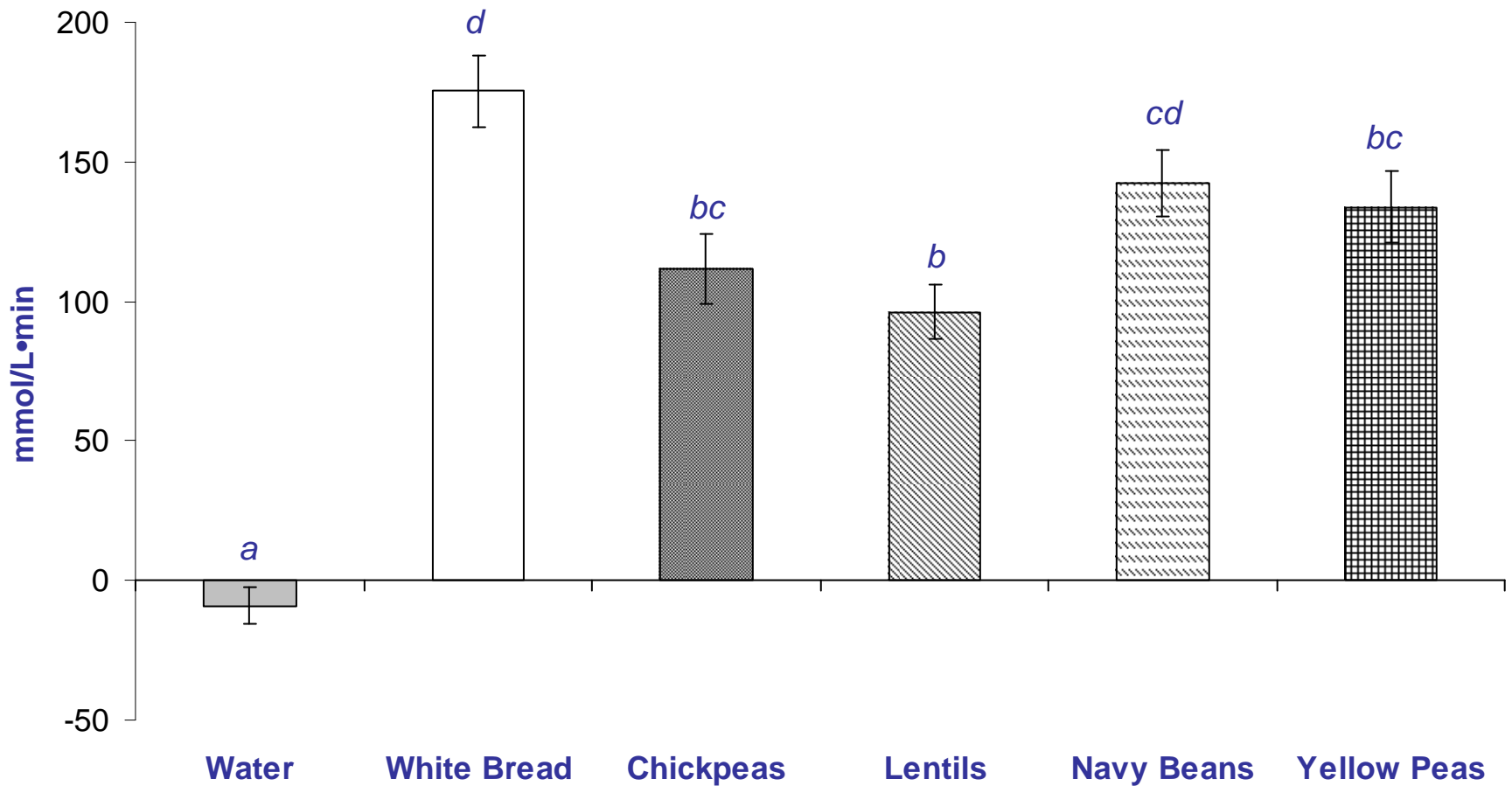
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# Pulses and Subjective Appetite AUC



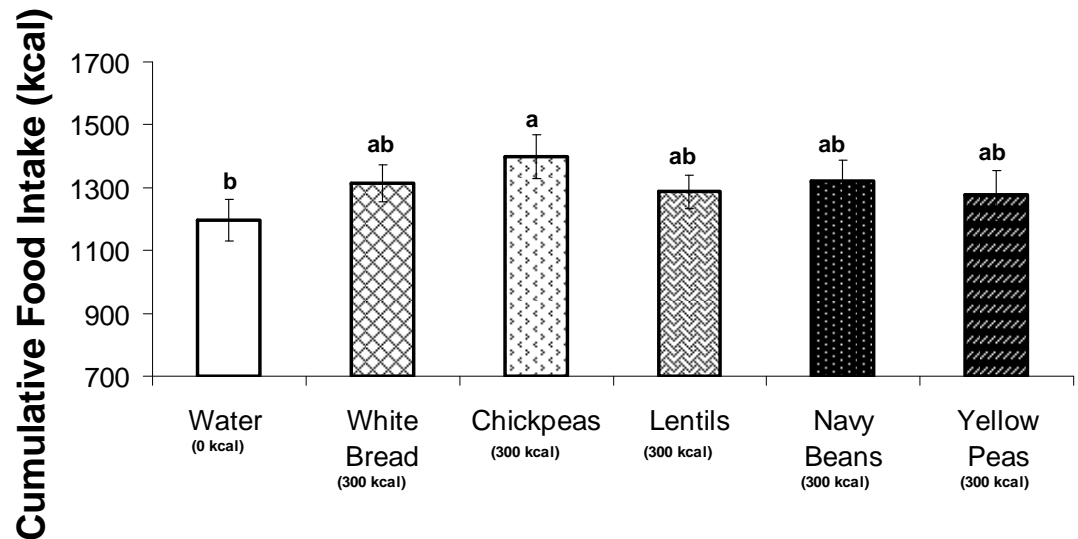
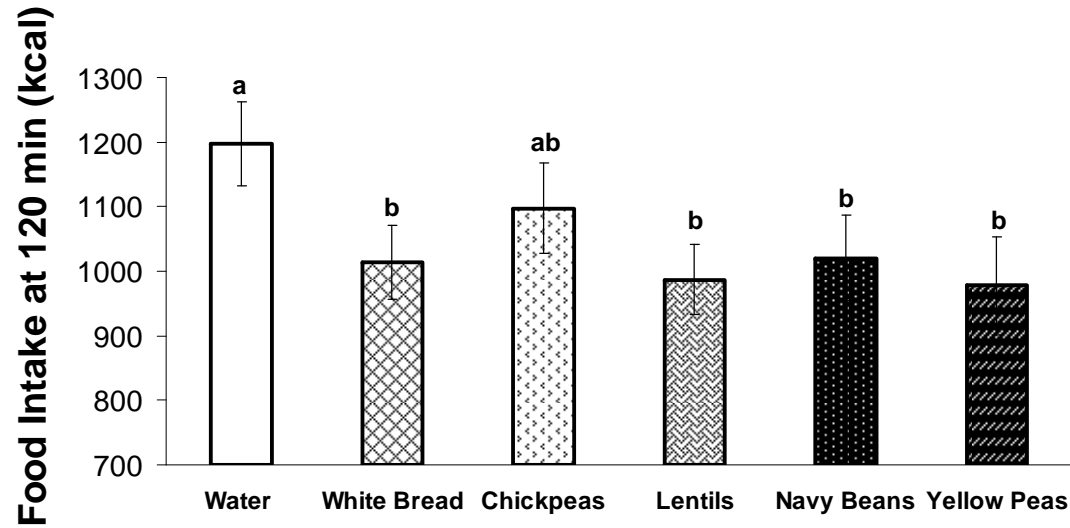
**Average appetite AUC to 120 min after treatment consumption.  
Mean  $\pm$  SEM. n = 15. One-way ANOVA with Tukey's post-hoc test; p < 0.05.**

# Pulses and Blood Glucose AUC



**AUC for blood glucose over two hours after treatments. Mean  $\pm$  SEM, n=15. One-way ANOVA with Tukey's post-hoc test; p < 0.05.**

# Pulses and Short-term Food Intake (kcal)



\*Cumulative intake = treatment + food intake at 120 min from pizza meal

# Effect of a larger fixed meal of pulses on satiety, glycemic response and food intake four hours later

Is there a delayed response element to benefiting from pulse consumption?

# Pulse Meal Followed by Pizza Meal 4 hours Later: Study Design

## Subjects:

18 healthy males, nonsmokers

Age:  $22.3 \pm 0.6$  y

Body weight:  $71.3 \pm 1.5$  kg

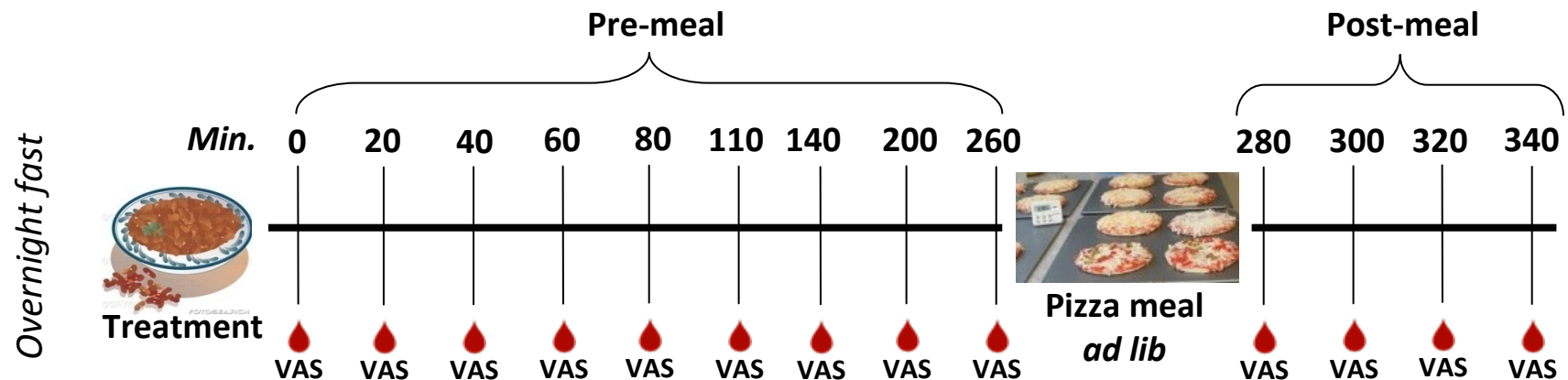
Body Mass Index:  $22.6 \pm 0.3$  kg/m<sup>2</sup>

Randomized Crossover Design

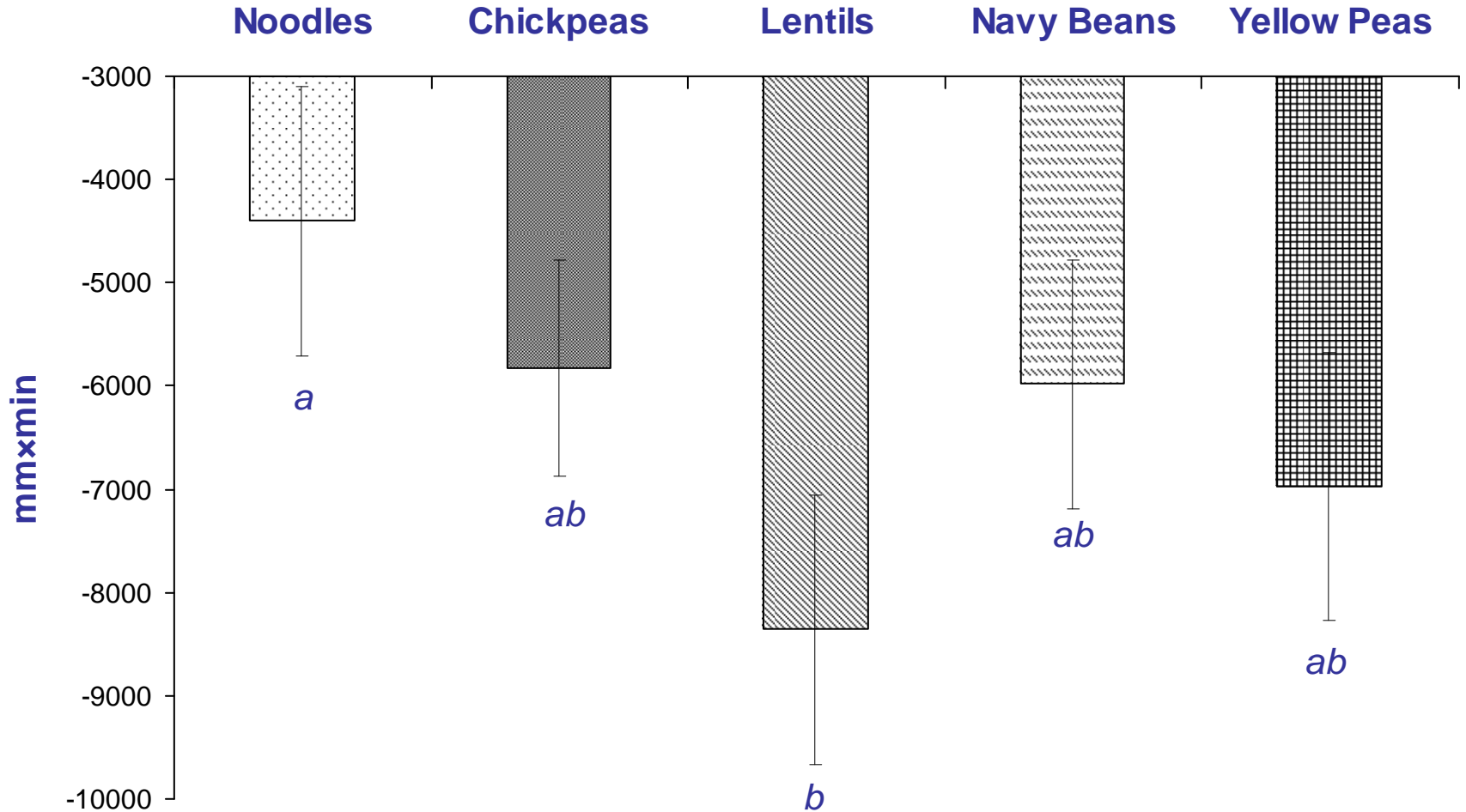
Treatments were: Isocaloric (600 kcal),  
composed with diced tomatoes and spices

## Treatments:

1. Control (noodles with cheese) 600kcal
2. Chickpeas replaced 250 kcal
3. Lentils replaced 250kcal
4. Navy beans replaced 250 kcal
5. Yellow peas added replaced 250 kcal

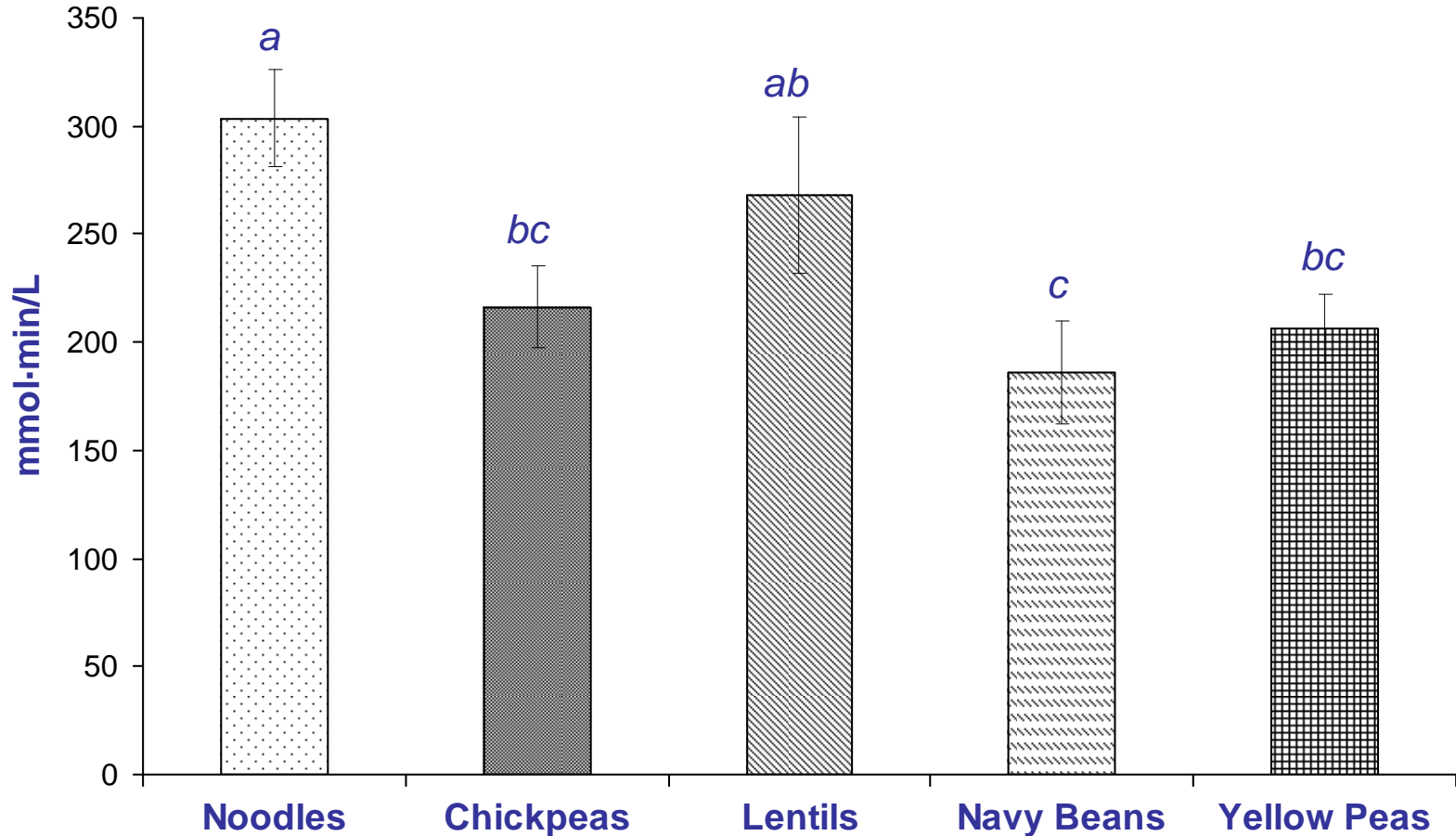


# Post Pulse Meal Subjective Appetite AUC



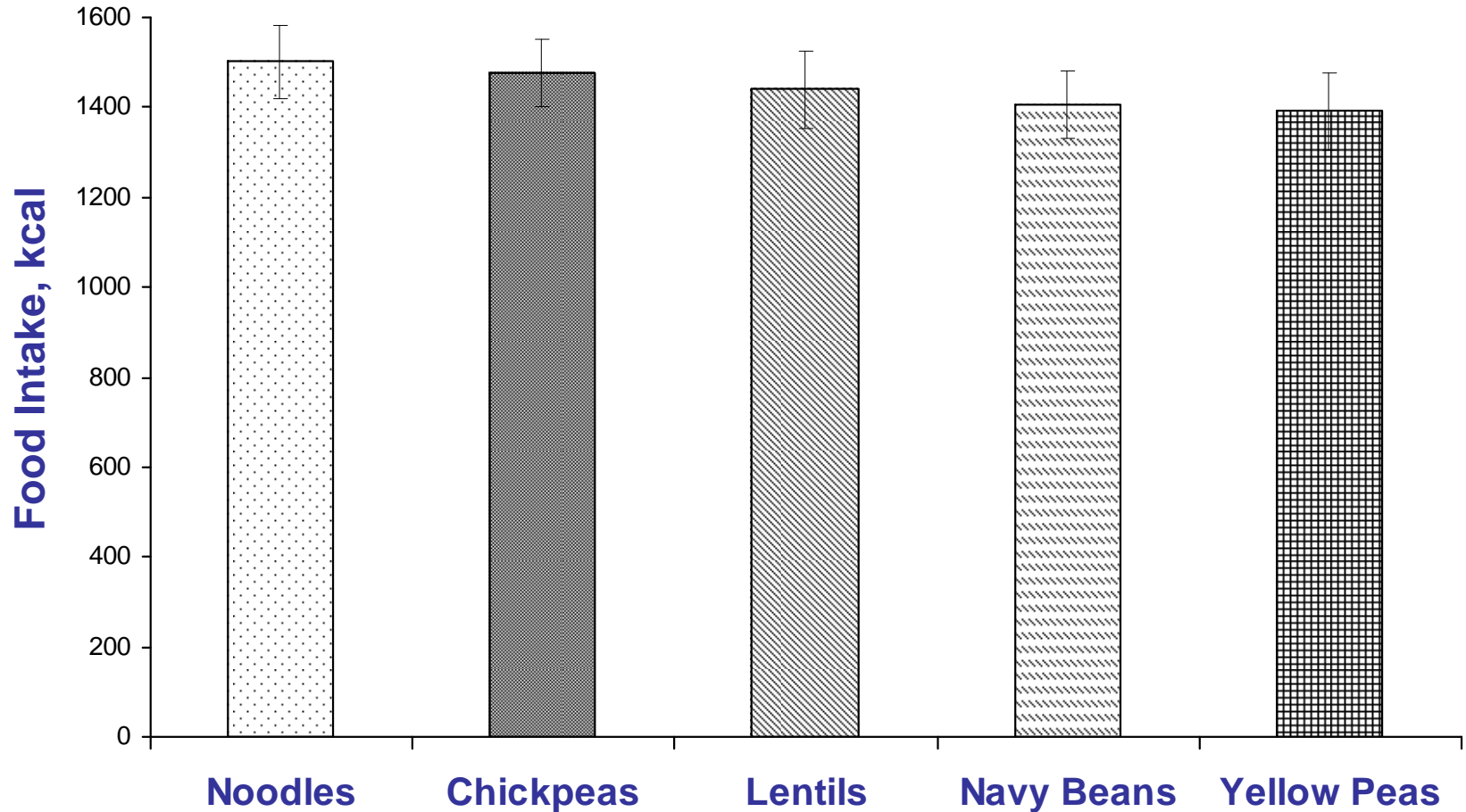
**AUC (0-260 min) for average appetite after pulse meal. Mean  $\pm$  SEM, n=18.  
One-way ANOVA,  $p < 0.05$ .**

# Post Pulse Meal Blood Glucose net AUC



AUC for blood glucose over four hours after the treatments. n=18. Mean  $\pm$  SEM.  
One-way ANOVA with Tukey's post-hoc test;  $p < 0.05$

# Pulse Meal Effects on Food Intake Four Hours Later



Mean  $\pm$  SEM, n = 18. One-way ANOVA,  $p > 0.05$

Effect of pulse consumption on glycemic response before and after a pizza meal of fixed size two hours later.

Does the consumption of pulses have a “second meal” effect on satiety and blood glucose?

# Pulse Preloads Followed by Fixed Amount of Pizza Meal: Study Design

## Subjects:

15 healthy males, nonsmokers

Age:  $22.5 \pm 0.8$  y

Body weight:  $71.8 \pm 1.5$  kg

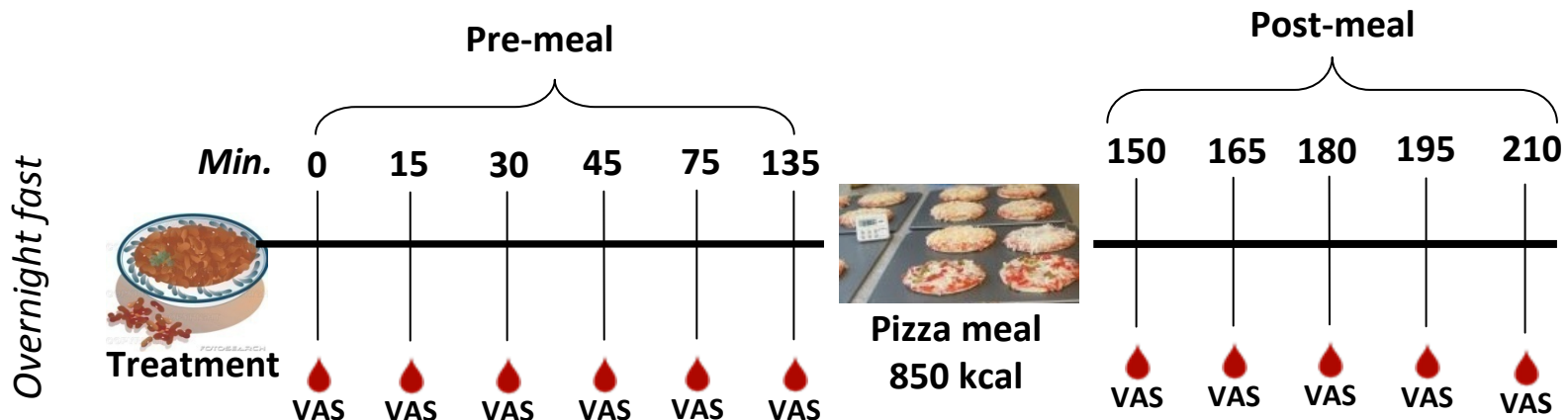
Body Mass Index:  $22.9 \pm 0.4$  kg/m<sup>2</sup>

Randomized Crossover Design

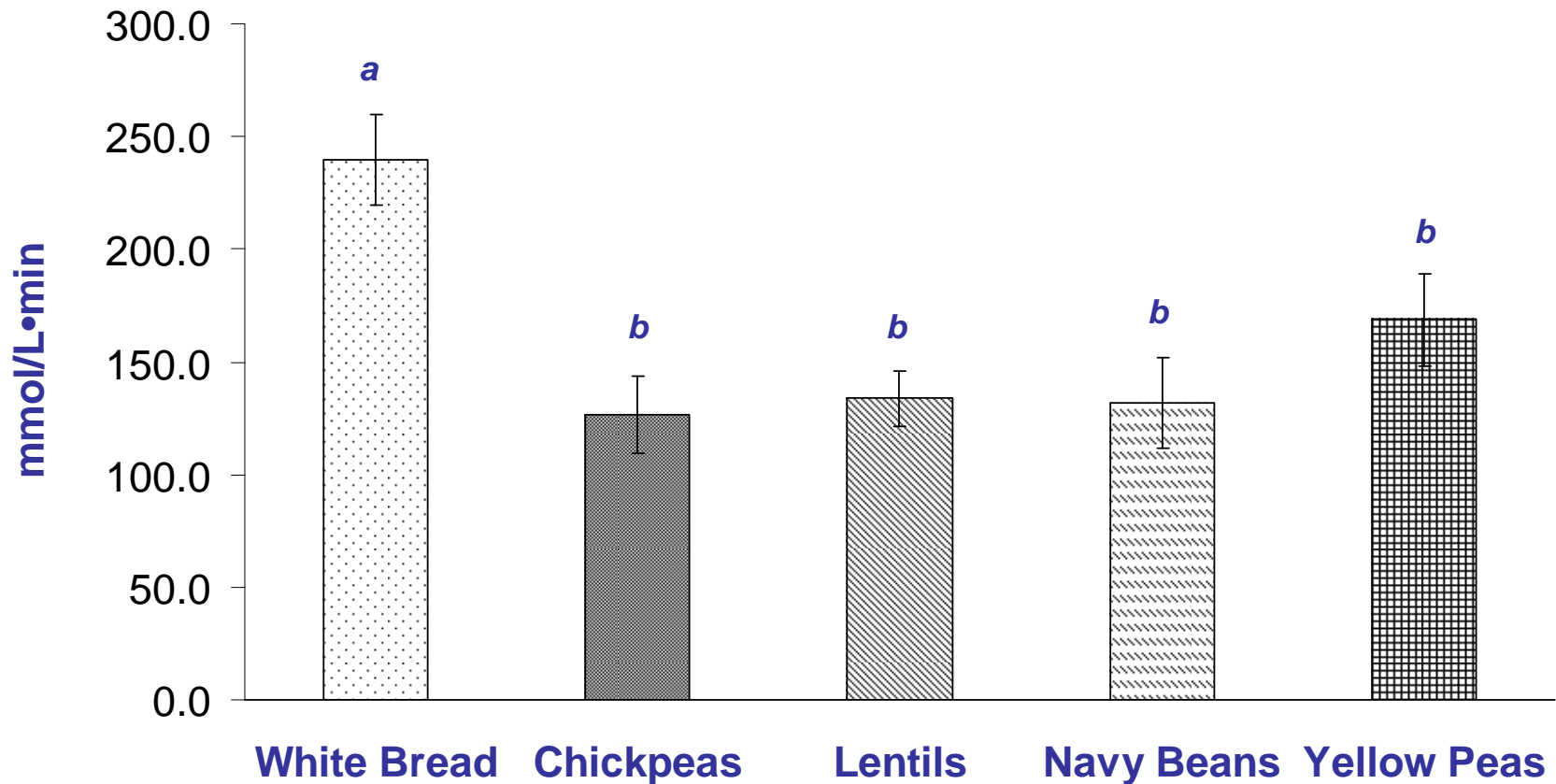
Treatments were: Isocaloric (300 kcal),  
composed with Heinz tomato sauce

## Treatments:

1. Control (white bread)
2. Chickpeas
3. Lentils
4. Navy beans
5. Yellow peas

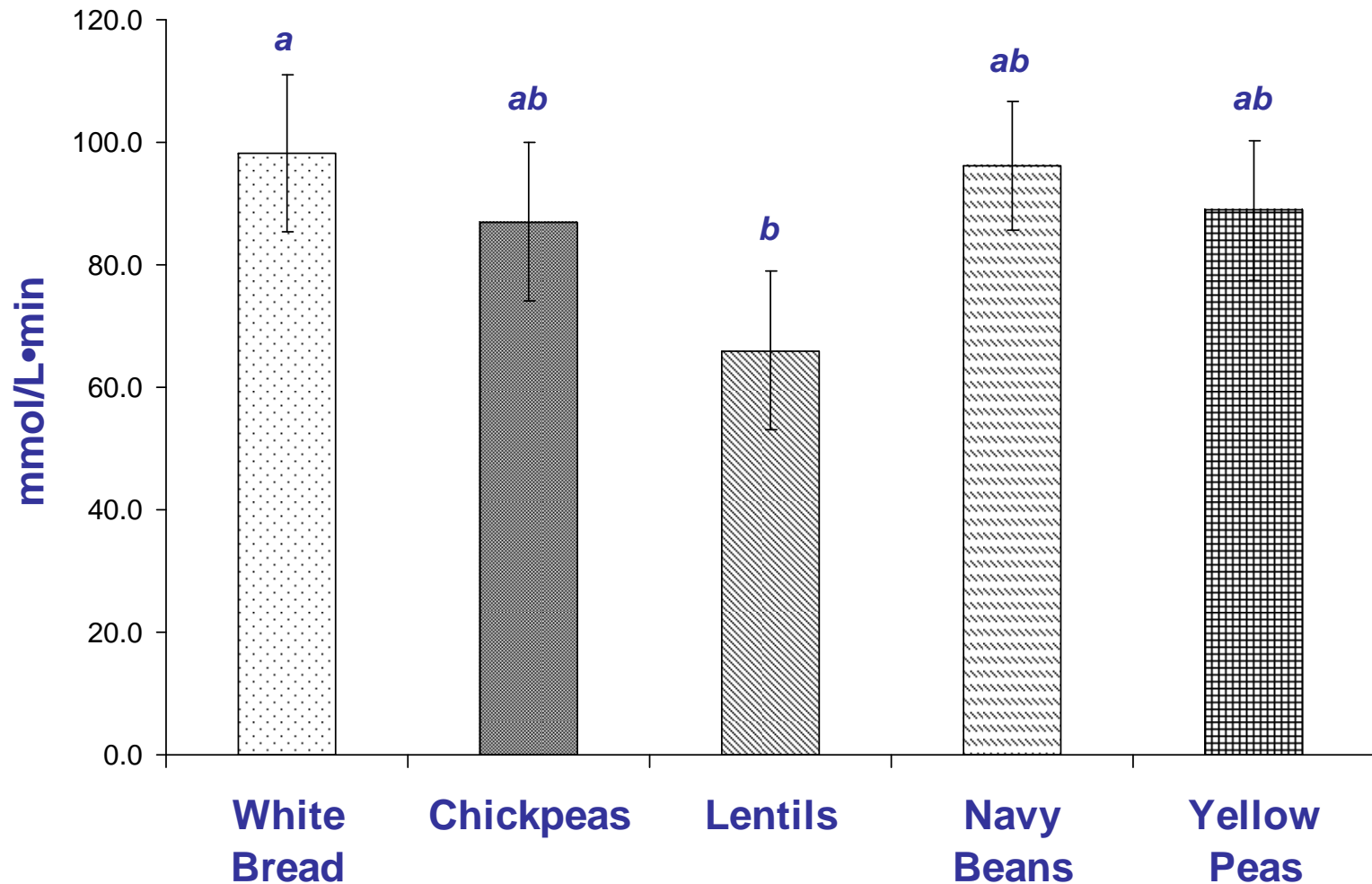


# Pre-meal (*before pizza*) Blood Glucose



**Pre-meal net incremental AUC for blood glucose over two hours after treatments. Mean  $\pm$  SEM, n=15. Treatments with various letters are significantly different. One-way ANOVA,  $p < 0.05$ .**

# Post-meal (*after pizza*) Blood Glucose

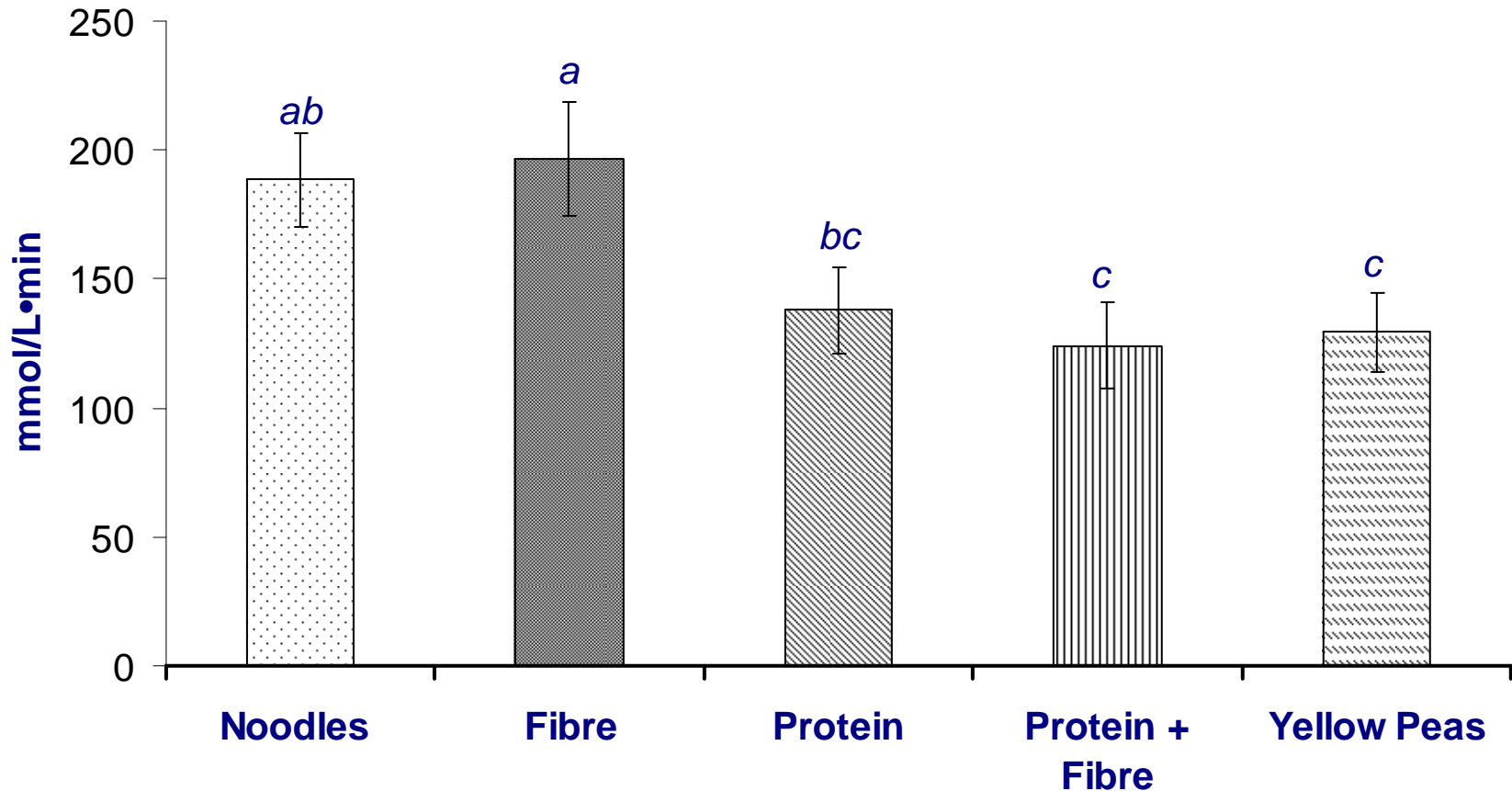


**Post-meal net incremental AUC for blood glucose over one hour after pizza meal. Mean  $\pm$  SEM, n=15. Treatments with various letters are significantly different. One-way ANOVA,  $p < 0.05$ .**

# Effect of pea protein and fibre on satiety, and glycemic response

Is the effect of pulses on glycemic control due to the carbohydrate or to its protein and fibre content?

# Blood Glucose AUC to Two Hours



AUC for Blood Glucose over two hours after treatments. Mean  $\pm$  SEM, n=15. One-way ANOVA with Tukey's post-hoc test;  $p < 0.05$ .

# Short-term Effects of Pulses

1. Satiety? **Weak**
2. Food Intake? **Calories not Composition**
3. Glucose Control? **Yes Composition?**

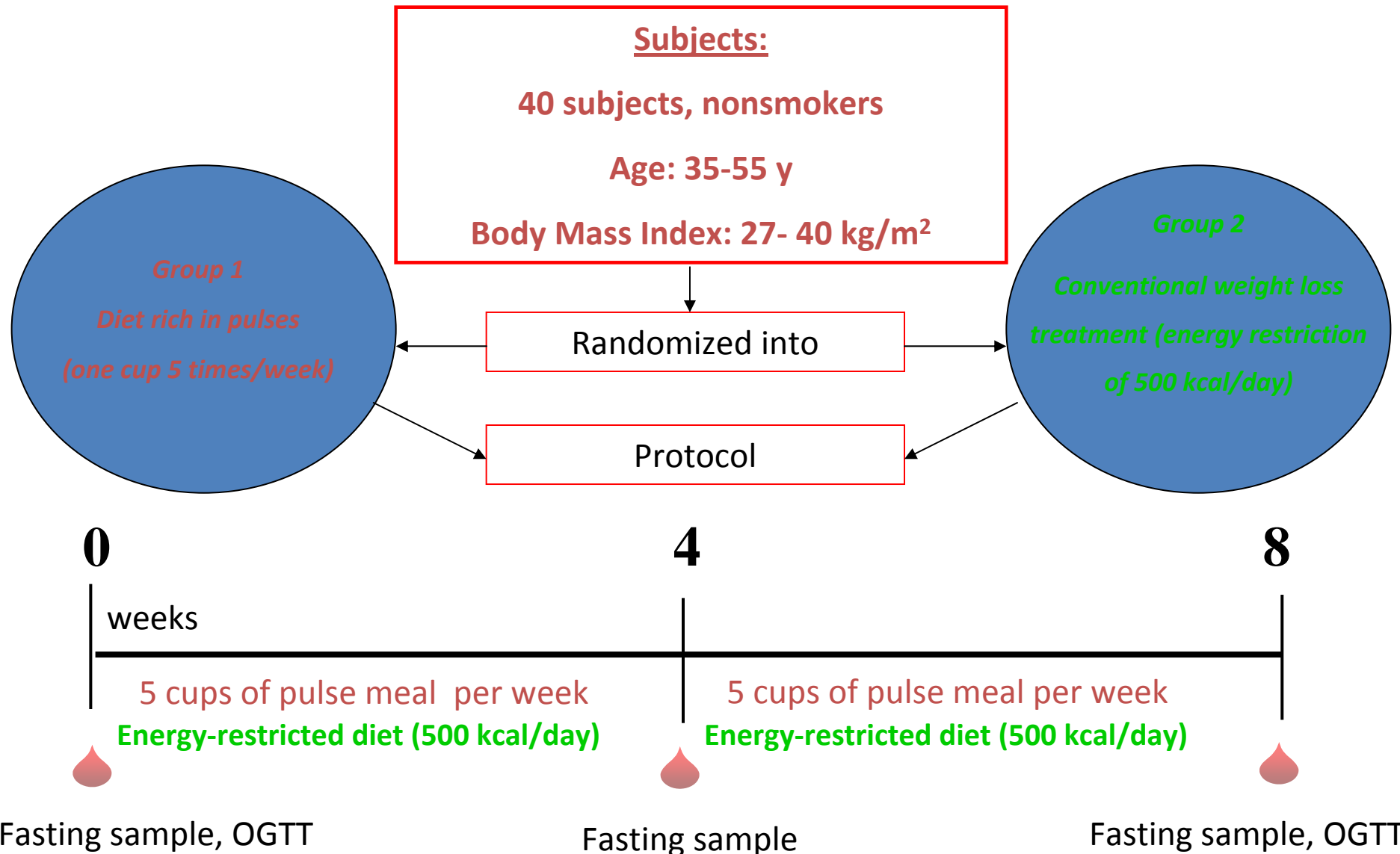
- Solid food
- Low energy density
- Low GI
- Fibre
- Protein



# The Effect of Frequent Consumption of Pulses for Eight Weeks by Overweight and Obese Subjects

Does the incorporation of pulses in the daily diet without dietary advice achieve the same benefits as following an energy restricted diet with dietary counselling?

# Pulse diet vs. an energy-restricted diet: study design



# Meals of pulses prepared based on 20 recipes



To Subjects



# Recipe Examples: SAVORY YELLOW SPLIT PEAS



## Nutrition Facts

Serving Size (134g)  
Servings Per Container

Amount Per Serving

**Calories** 330      **Calories from Fat** 25

% Daily Value\*

**Total Fat** 3g      **5%**

Saturated Fat 0.5g      **3%**

Trans Fat 0g

**Cholesterol** 0mg      **0%**

**Sodium** 510mg      **21%**

**Total Carbohydrate** 61g      **20%**

Dietary Fiber 18g      **72%**

Sugars 22g

**Protein** 16g

Vitamin A 15%      •      Vitamin C 45%

Calcium 4%      •      Iron 15%

\*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300 mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:

Fat 9 • Carbohydrate 4 • Protein 4

# Recipe Examples: TUSCAN BEANS



## Nutrition Facts

Serving Size (256g)  
Servings Per Container

Amount Per Serving

**Calories** 260      **Calories from Fat** 35

% Daily Value\*

**Total Fat** 3.5g      **5%**

Saturated Fat 0.5g      **3%**

Trans Fat 0g

**Cholesterol** 0mg      **0%**

**Sodium** 680mg      **28%**

**Total Carbohydrate** 43g      **14%**

Dietary Fiber 15g      **60%**

Sugars 2g

**Protein** 15g

Vitamin A 4%      • Vitamin C 25%

Calcium 10%      • Iron 30%

\*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300 mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:

Fat 9 • Carbohydrate 4 • Protein 4

# Recipe Examples: LENTIL SALAD



## Nutrition Facts

Serving Size (264g)  
Servings Per Container

Amount Per Serving

**Calories** 180      **Calories from Fat** 30

% Daily Value\*

**Total Fat** 3.5g      **5%**

Saturated Fat 0g      **0%**

Trans Fat 0g

**Cholesterol** 0mg      **0%**

**Sodium** 510mg      **21%**

**Total Carbohydrate** 28g      **9%**

Dietary Fiber 14g      **56%**

Sugars 3g

**Protein** 12g

Vitamin A 25%      • Vitamin C 100%

Calcium 6%      • Iron 30%

\*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

		Calories: 2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300 mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:  
Fat 9 • Carbohydrate 4 • Protein 4

# Recipe Examples:

## CREAMY CHICKPEA & ROSEMARY SOUP



### Nutrition Facts

Serving Size (362g)  
Servings Per Container

Amount Per Serving

**Calories 270**      **Calories from Fat 80**

% Daily Value\*

**Total Fat 9g**      **14%**

Saturated Fat 1g      **5%**

Trans Fat 0g

**Cholesterol 0mg**      **0%**

**Sodium 1310mg**      **55%**

**Total Carbohydrate 39g**      **13%**

Dietary Fiber 11g      **44%**

Sugars 2g

**Protein 11g**

Vitamin A 10%      • Vitamin C 8%

Calcium 8%      • Iron 25%

\*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

		Calories: 2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300 mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:

Fat 9 • Carbohydrate 4 • Protein 4

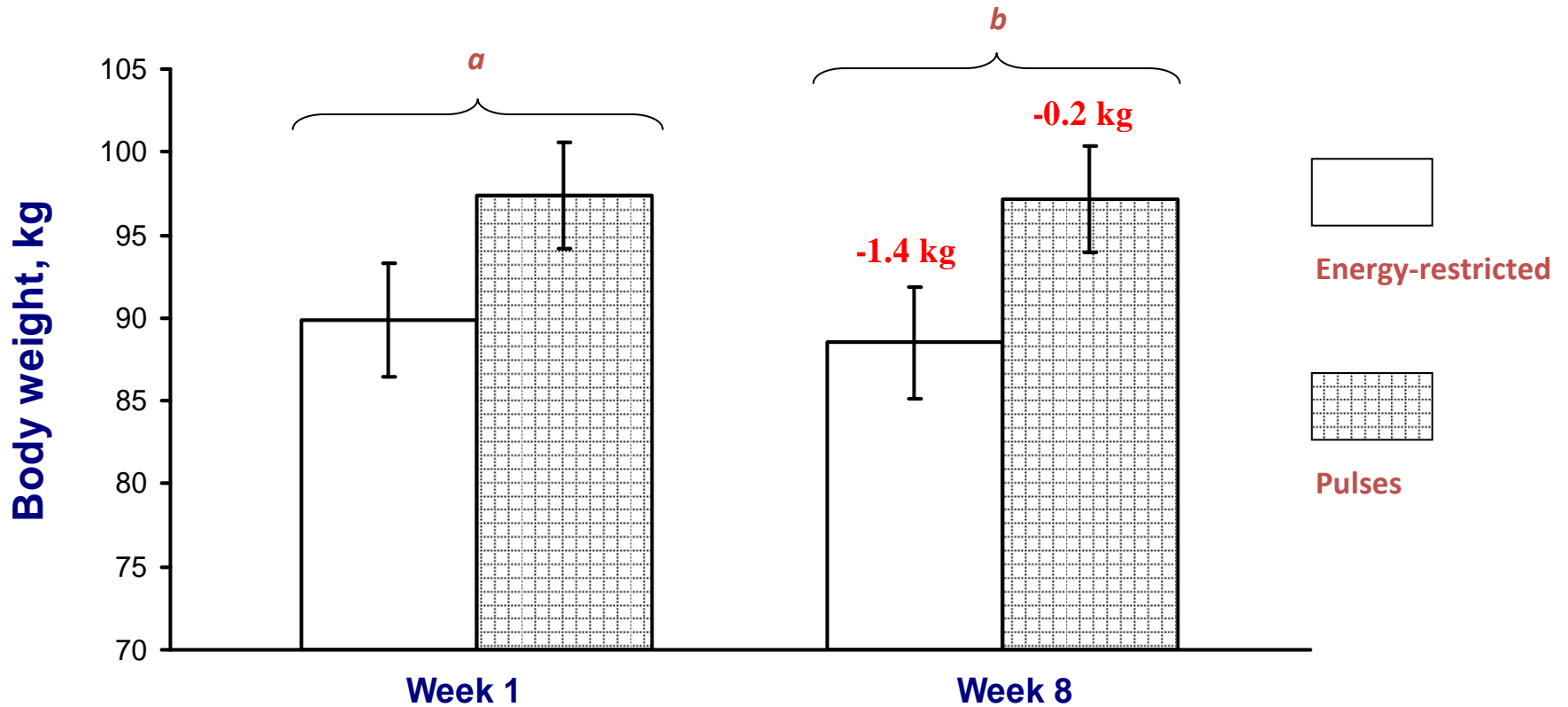
# Pulse diet vs. an energy-restricted diet: Food Intake

	Energy Restricted		Pulse	
	Week 1	Week 8	Week 1	Week 8
*Energy (kcal)	1947 215	1524 193	2128 191	1871 172
*Carbohydrate (g)	274 36	188 22	275 32	251 20
Protein (g)	75 11	78 12	90 9	90 10
Fat (g)	62 9	56 12	77 8	61 11

*\*Decreased from week 1 to week 8 regardless of treatment,  $P < 0.05$*

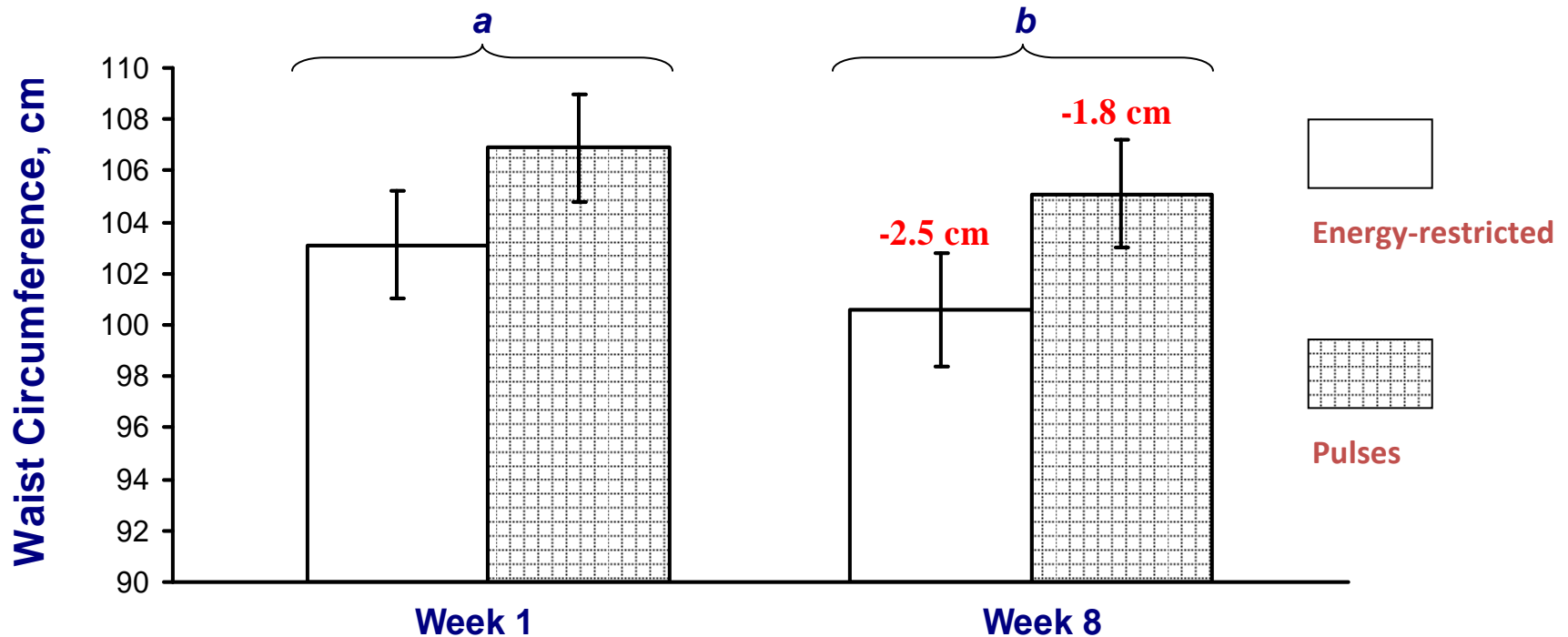
*2-way (treatment, sex) repeated measures ANOVA, estimated marginal means  $\pm$  SEM*

# Pulse diet vs. an energy-restricted diet: Body Weight



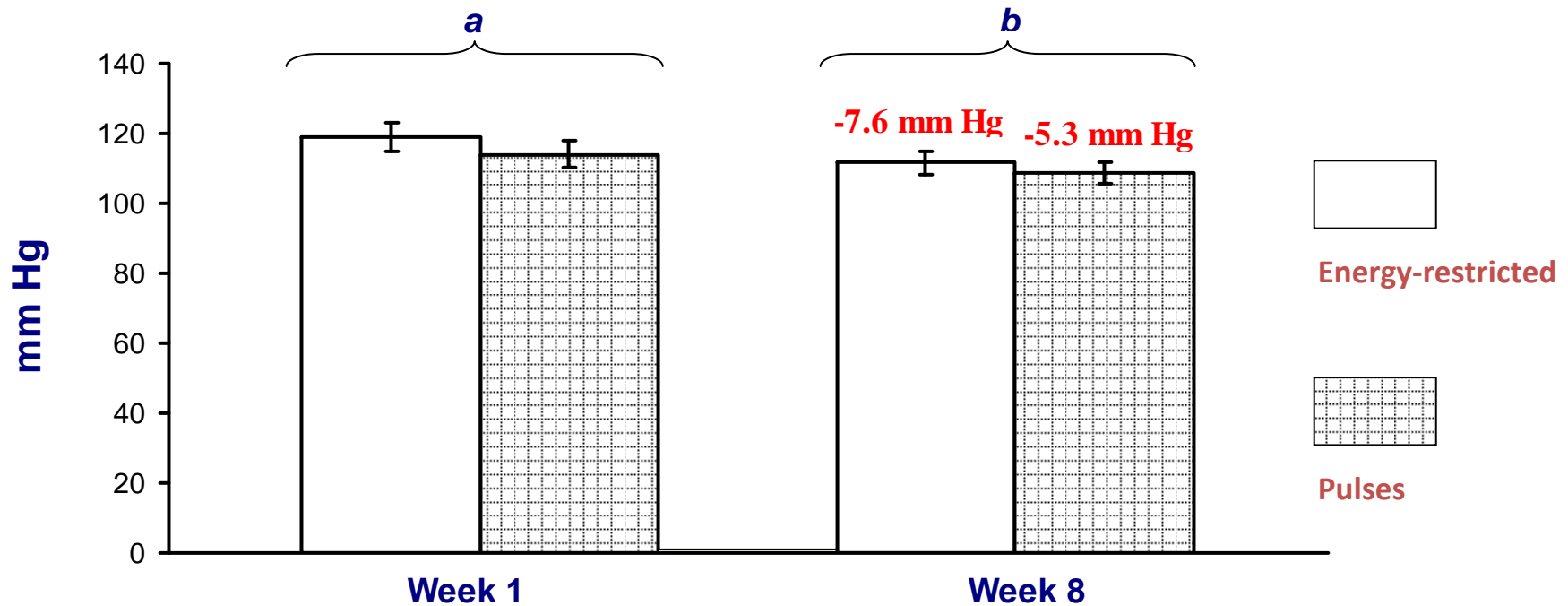
*Mean  $\pm$  SEM, n = 40. Different letters indicate significant differences among weeks; Two-way repeated measures ANOVA,  $p < 0.05$ .*

# Pulse diet vs. an energy-restricted diet: Waist Circumference



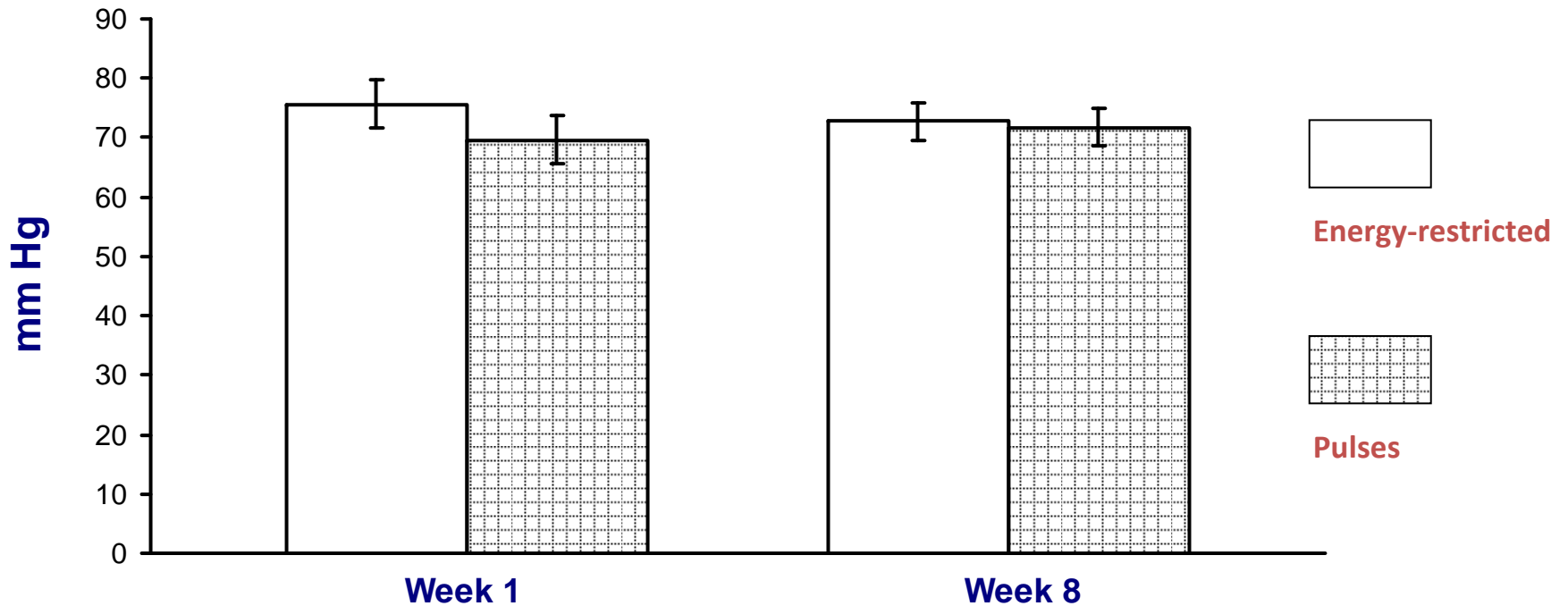
*Mean  $\pm$  SEM, n = 40. Different letters indicate significant differences among weeks; Two-way repeated measures ANOVA,  $p < 0.05$ .*

# Pulse diet vs. an energy-restricted diet: Systolic Blood Pressure



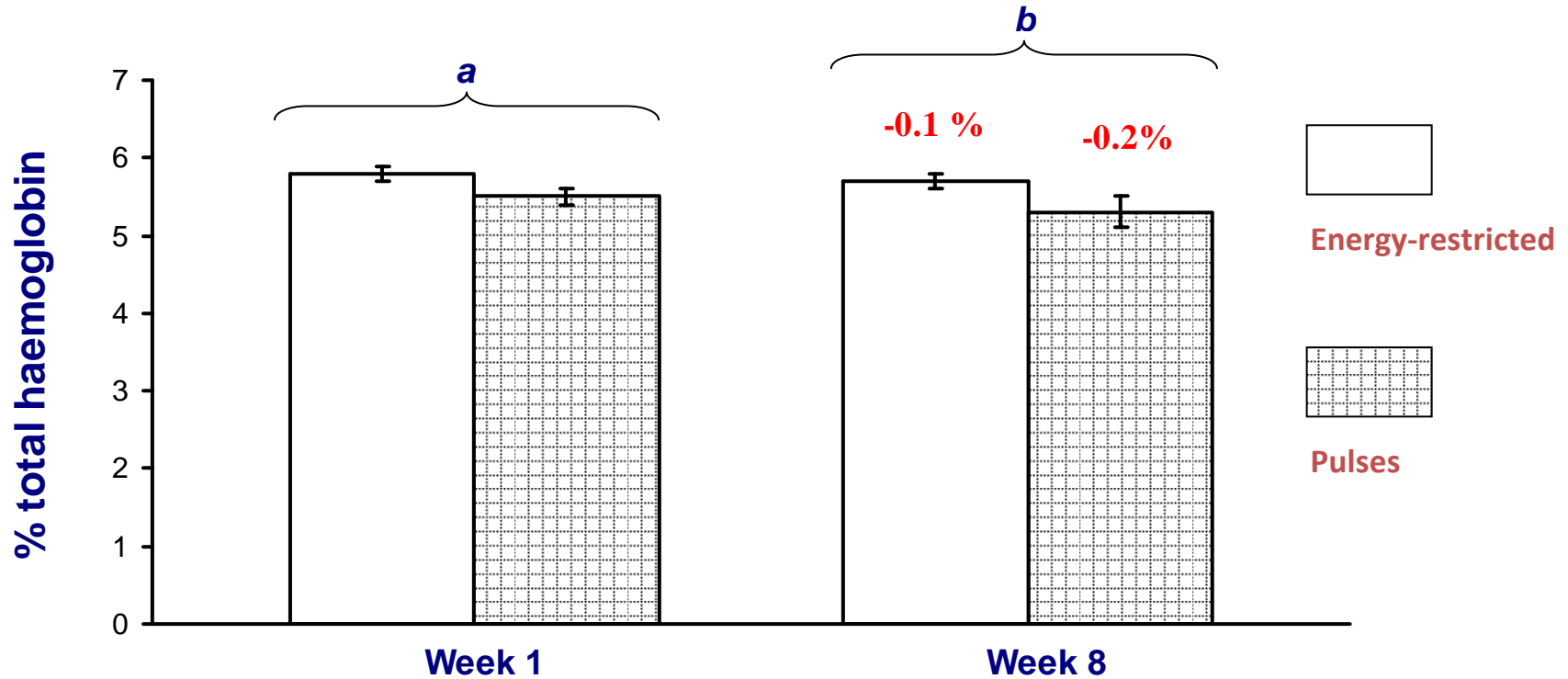
*Mean  $\pm$  SEM, n = 40. Different letters indicate significant differences among weeks; Two-way repeated measures ANOVA,  $p < 0.05$ .*

# Pulse diet vs. an energy-restricted diet: Diastolic Blood Pressure



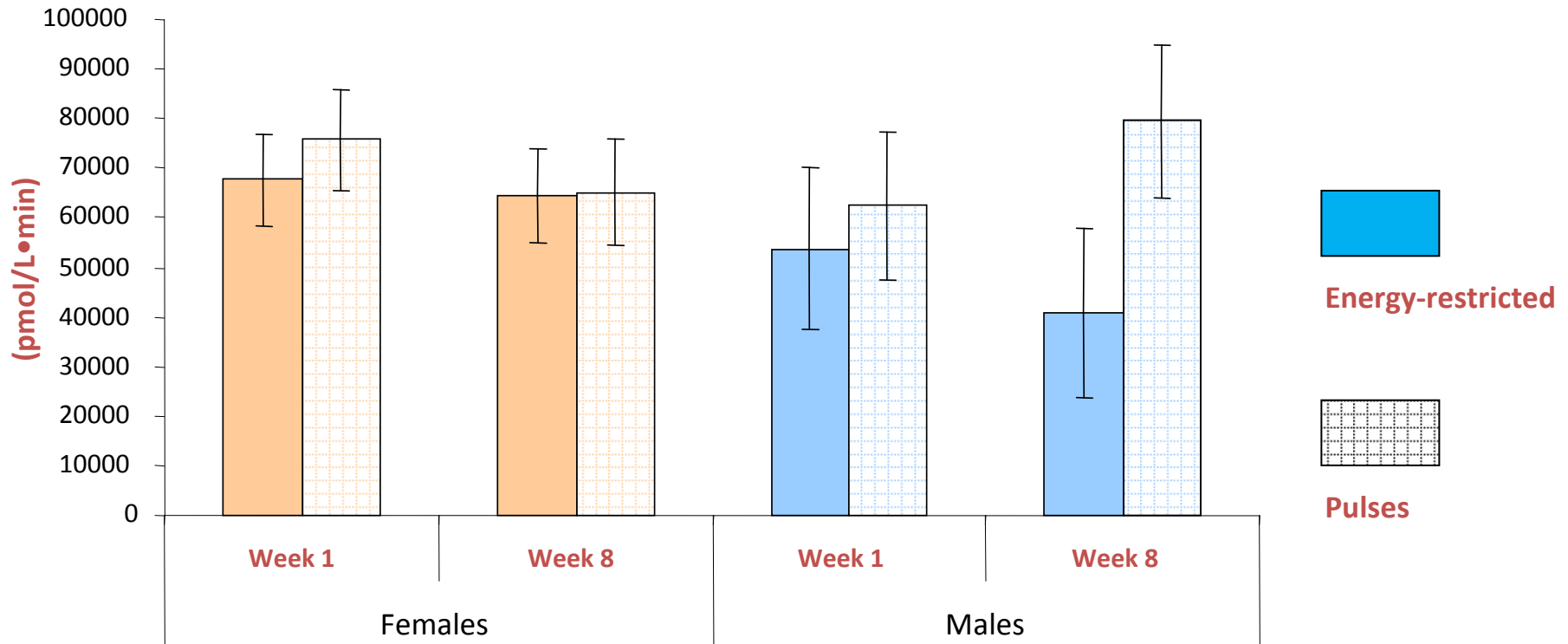
*Mean  $\pm$  SEM, n = 40. Two-way repeated measures ANOVA.*

# Pulse diet vs. an energy-restricted diet: HbA1c



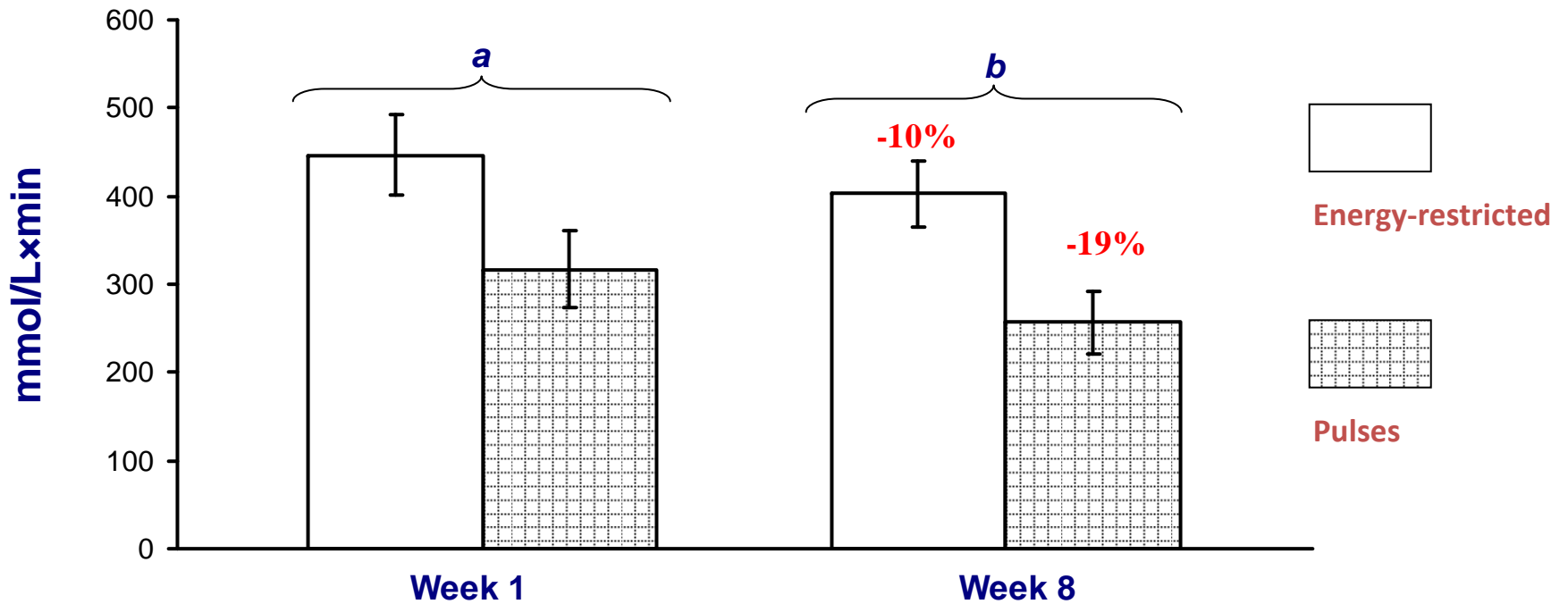
*Mean  $\pm$  SEM, n = 40. Different letters indicate significant differences among weeks; Two-way repeated measures ANOVA,  $p=0.05$ .*

# Pulse diet vs. an energy-restricted diet: Insulin AUC after OGTT



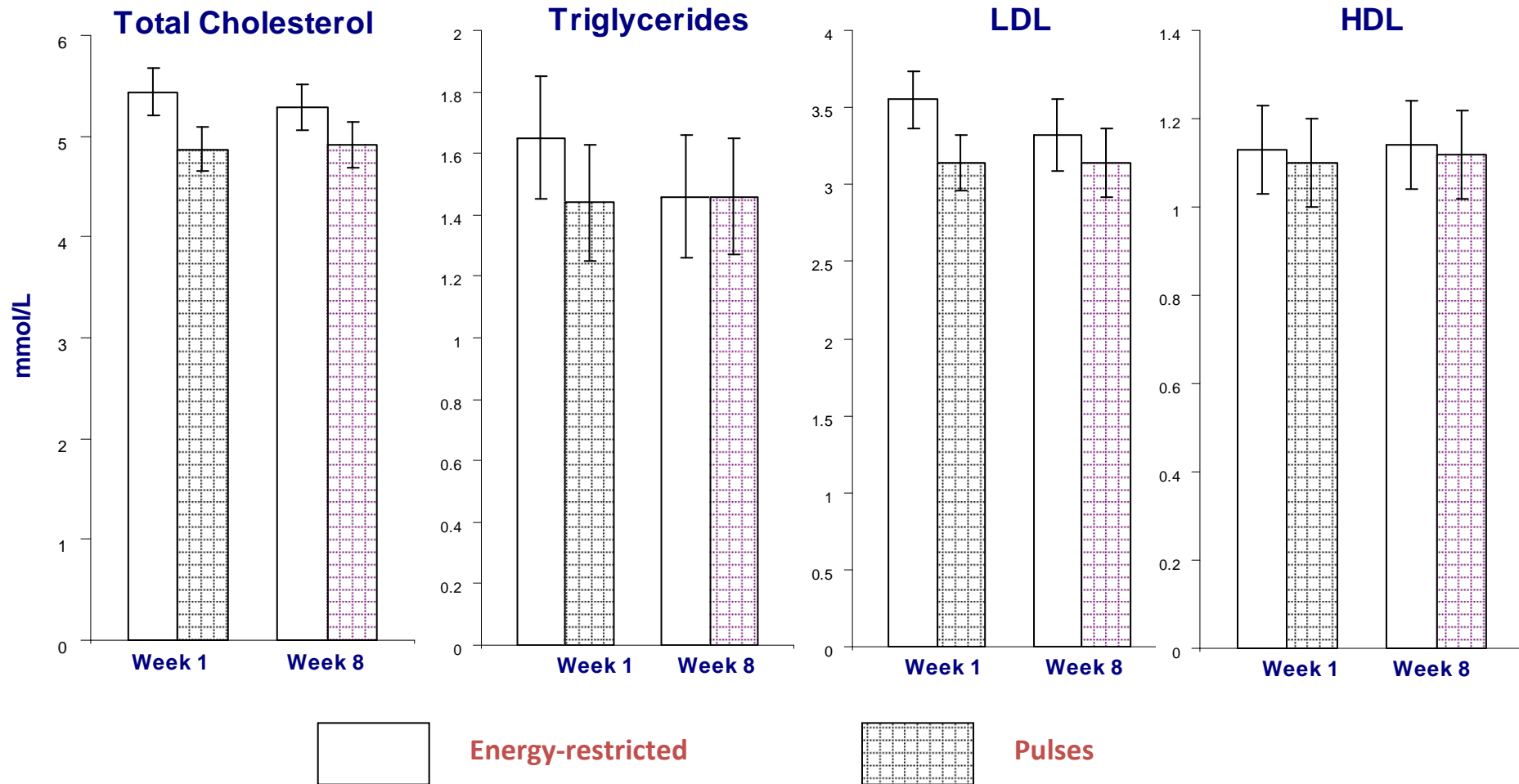
**Mean  $\pm$  SEM, n = 40. Two-way repeated measures ANOVA.  
Week by sex by diet interaction (p = 0.008)**

# Pulse diet vs. an energy-restricted diet: Glucose AUC after OGTT



*Mean  $\pm$  SEM, n = 40. Different letters indicate significant differences among weeks; Two-way repeated measures ANOVA, p=0.05.*

# Pulse diet vs. an energy-restricted diet: Blood Lipids



*Mean  $\pm$  SEM, n = 40. Two-way repeated measures ANOVA.*

# Long-term Study: Conclusion

Incorporation of 5 cups/week of pulses into the diet, with no other dietary guidance, had the same beneficial effects as dietary counseling to reduce energy intake.

## Acknowledgments:

*Pulse Canada* 

 *Saskatchewan* Pulse Growers

**Special Thanks to the TEAM**





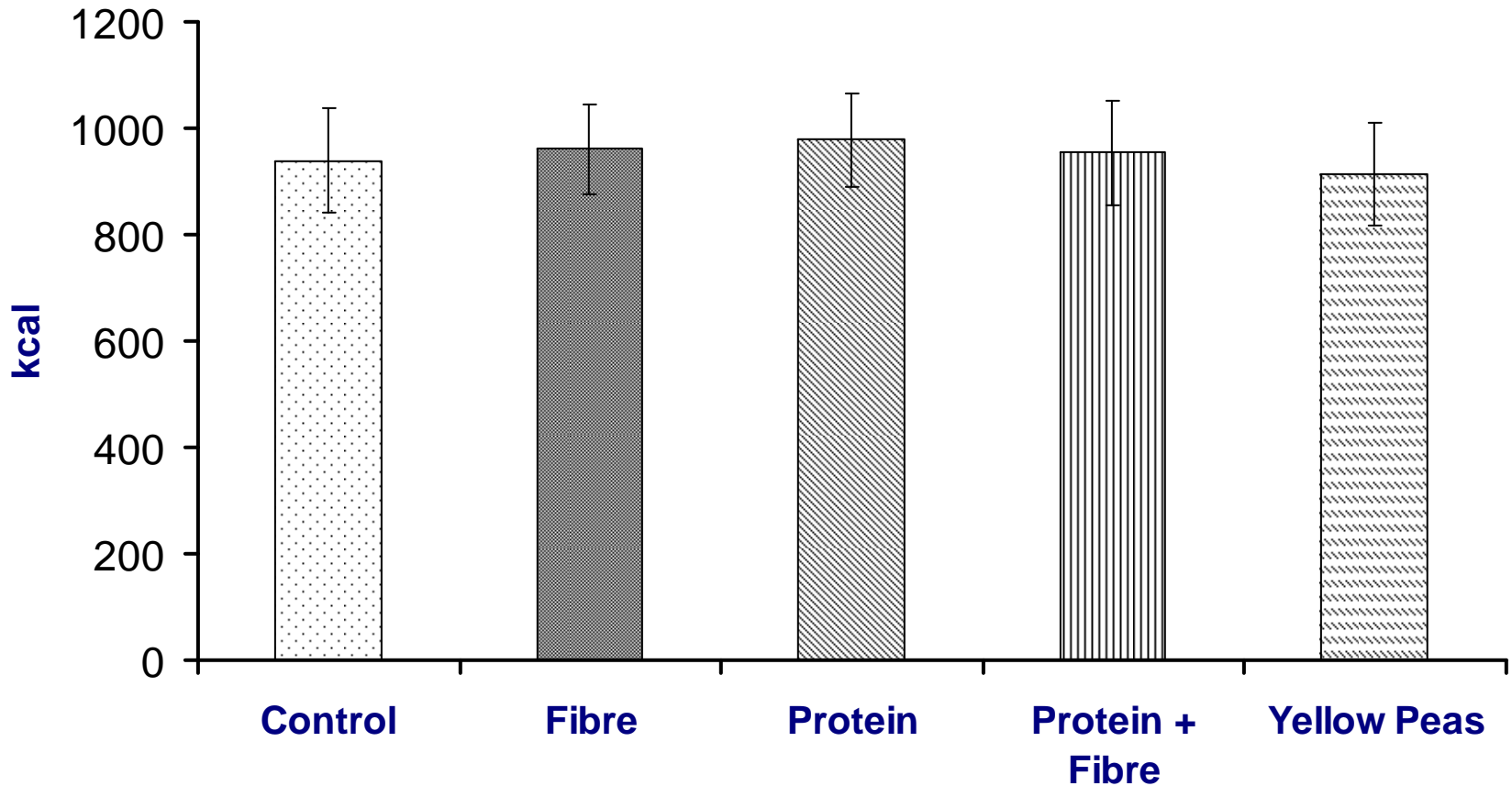
# Priorities

- Current: Long-term study: To complete analysis of
  - Dietary records
  - Gut satiety hormones
- Future: To investigate
  - Effect of pulses on satiation
  - Effect of pea protein on satiety, food intake and post-meal glycemic control
  - Whole beans vs dried vs powdered
  - Flours

# Pulse Studies: Conclusion

- The short-term effect of pulse consumption on satiety is positive but later food intake is dependent on energy content and not composition.
- Pulses contribute to glycemic control, an effect of composition. Have second meal effect.
- Frequent consumption is associated with correction of characteristics of the metabolic syndrome.

# Effect of Pea Fractions on Food Intake



Food intake two hours after treatments expressed by one-way ANOVA. Mean  $\pm$  SEM, n = 15.

# Objective:

To compare the effect of consuming 5 cups/week of commercially available pulses over 8 weeks with a conventional energy restriction diet on:

1. Body weight and waist circumference
2. Risk factors associated with the metabolic syndrome
3. Satiety hormones

# Fractions of pulses available on the market for human consumption

*Fractions are not available*



**Chickpeas**



**Lentils**



**Navy beans**

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*Fractions are available*



**Yellow Peas**

**Pea protein**

**Pea fiber**

# Study Design

## Subjects:

15 healthy males, nonsmokers

Age:  $21.5 \pm 1.0$  y

Body weight:  $73.6 \pm 1.8$  kg

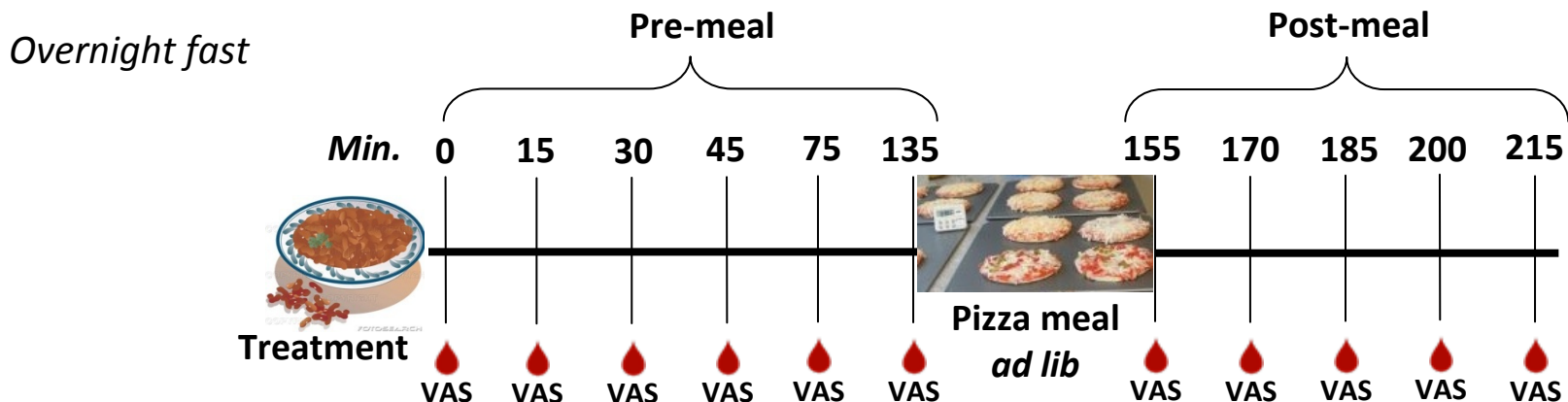
Body Mass Index:  $22.5 \pm 0.4$  kg/m<sup>2</sup>

Randomized Crossover Design

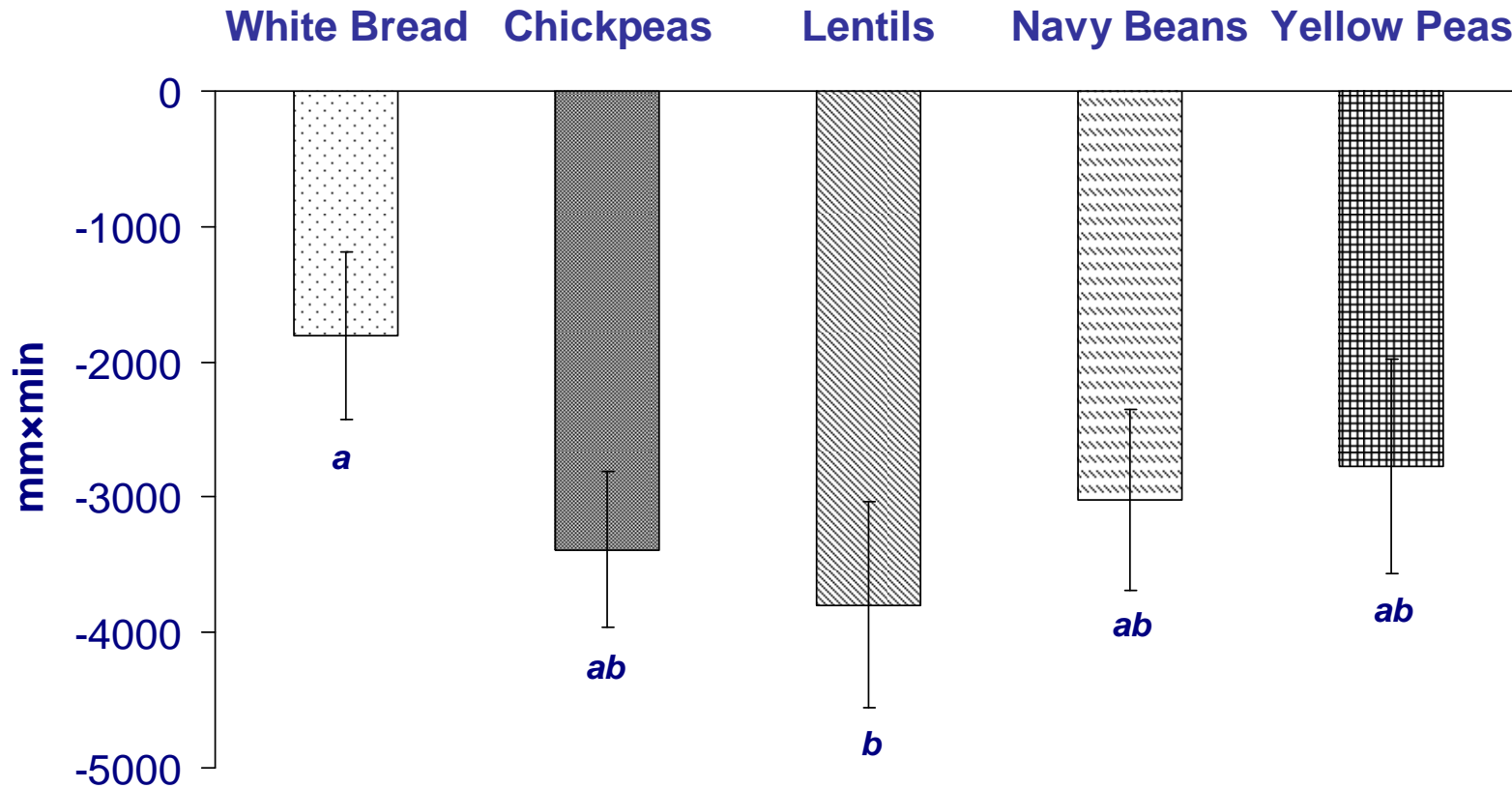
All Treatments were: Isocaloric (310 kcal), Isovolumetric (575 ml), and contained tomato sauce and noodles\*(\*except YP trt).

## Treatments:

1. Control (noodles with tomato sauce)
2. Pea protein
3. Pea fibre
4. Pea protein with pea fibre
5. Yellow peas

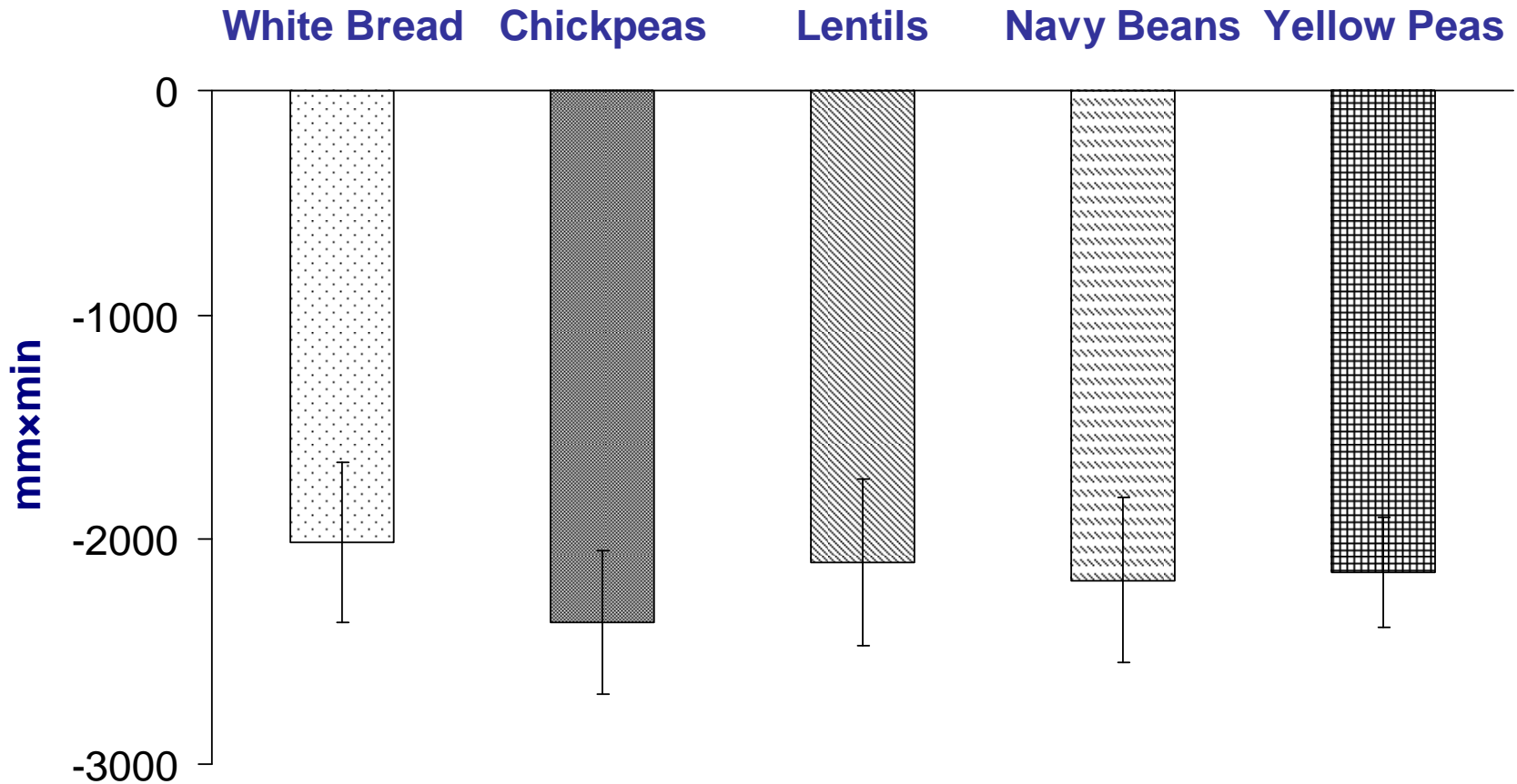


# Pre-meal (*before pizza*) Subjective Appetite



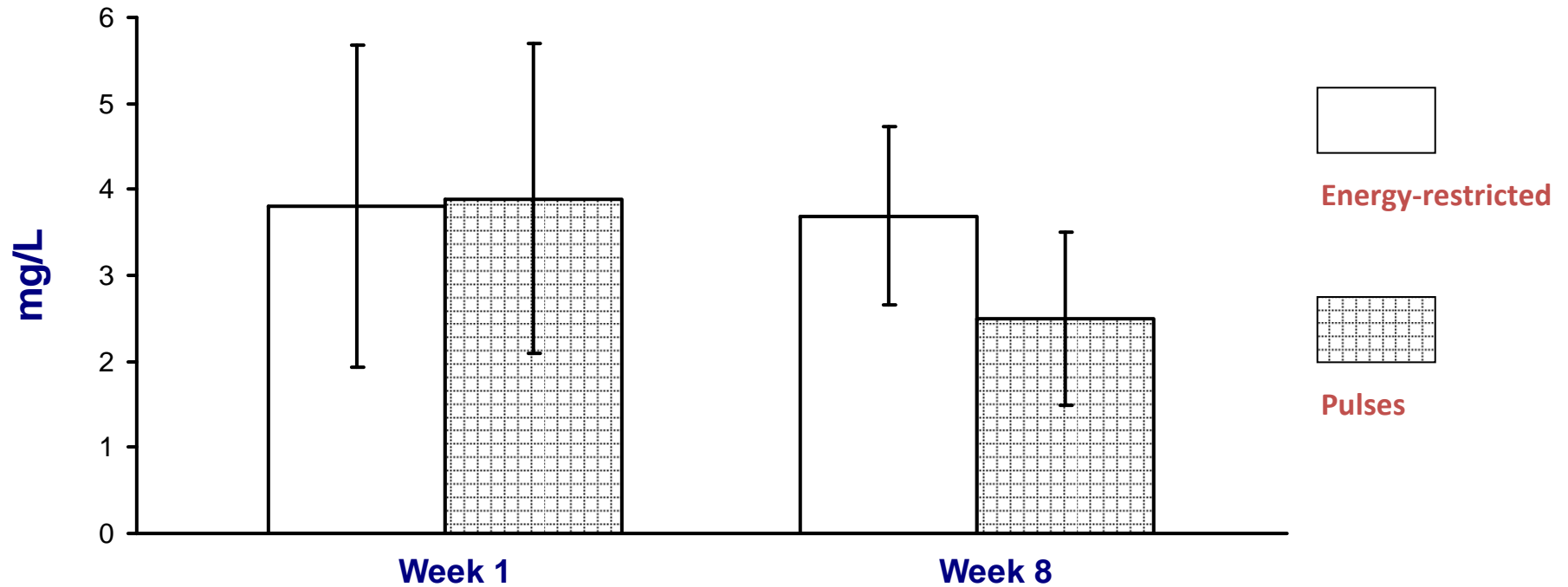
**Pre-meal net incremental AUC for subjective appetite over two hours after treatments. Mean  $\pm$  SEM, n=15. Treatments with various letters are significantly different. One-way ANOVA,  $p < 0.05$ .**

# Post-meal (*after pizza*) Subjective Appetite



**Post-meal net incremental AUC for blood glucose over one hour after pizza meal. Mean  $\pm$  SEM, n=15.**

# Pulse diet vs. an energy-restricted diet: C-reactive protein in serum



*Mean  $\pm$  SEM, n = 40. Two-way repeated measures ANOVA.*

# Pulse Studies: Short-term

1. Effect of pulse consumption on satiety, glycemic response and food intake at an ad libitum pizza meal two hours later. (SPG)
2. Effect of a fixed meal size of pulses on satiety, glycemic response and food intake four hours later. (Pulse Canada).
3. Effect of pulse consumption on satiety and glycemic response before and after consuming a pizza meal of fixed size two hours later. (Pulse Canada)
4. Effect of pea protein and fibre on satiety, glycemic response and food intake. (Pulse Canada)