

Soup and satiety[☆]

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Abstract

Energy-yielding fluids generally have lower satiety value than solid foods. However, despite high water content, soups reportedly are satiating. The mechanisms contributing to this property have not been identified and were the focus of this study. A within-subject design, preload study was administered to 13 male and 18 female adults (23.7 ± 0.9 years old) with a mean body mass index (BMI) of 23.0 ± 0.7 kg/m². At approximately weekly intervals, participants reported to the lab after an overnight fast and completed questionnaires on mood, appetite, psychological state, strength, and fine motor skills. After administration of motor tasks, participants consumed a 300-kcal preload in its entirety within 10 min. The test foods included isocaloric, solid, and liquefied versions of identical foods high in protein, fat, or carbohydrate. Single beverage and no-load responses were also tested. The same questionnaires and motor skills tests were completed at 15-min intervals for 1 h and at 30-min intervals for an additional 3 h after loading. Diet records were kept for the balance of the day. The soups led to reductions of hunger and increases of fullness that were comparable to the solid foods. The beverage had the weakest satiety effect. Daily energy intake tended to be lower on days of soup ingestion compared to the solid foods or no-load days and was highest with beverage consumption. Thus, these data support the high satiety value of soups. It is proposed that cognitive factors are likely responsible.

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1. Introduction

It is now widely recognized that behavioral factors underlie the increasing prevalence of overweight and obesity. Low energy expenditure has been implicated [1–6], but this is only problematic for energy balance because it has not been accompanied by a commensurate change of intake. Indeed, several changes of dietary habits have exacerbated the problem, including increased consumption of energy-yielding beverages. Based on data from the U.S. Department of Agriculture's Economic Research Service, in 1997, per capita consumption of energy from carbonated soft drinks, milk, beer, fruit juices, fruit drinks, wine, and

distilled spirits was about 535 kcal/day or roughly 25% of daily energy intake [7]. This is an underestimate of total energy derived from beverages because it fails to include contributions from coffee, tea, and many new products, such as sports drinks. Moreover, intake of all these products has continued to grow [7,8]. Liquid nutritional products are now over a US\$1 billion category [9]. These trends are due, in part, to increased frequency of use, but also to increased portion sizes [10].

Concern about beverage consumption stems from evidence that energy-yielding fluids elicit weak appetitive [11–17] and compensatory dietary [13,18–23] responses. Recently, an independent inverse influence of viscosity on hunger was demonstrated [12]. Supplemental noncaloric fluid ingestion is not associated with increased intake or body weight, but addition of an energy source to a fluid leads to increases in both [19,24]. There have been studies that did not observe solid versus fluid differences in intake [25–28], but their interpretation is hampered by the use of

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foods that differed along many dimensions and testing under nonnormal eating conditions (e.g., delivery of load by pump or eating in a laboratory).

Attributes of energy-yielding fluid sources that allow them to elude satiety mechanisms have not been characterized. Insights may be gained through the study of soups because they appear to be an anomaly in the literature on fluid versus solid food effects on appetite and intake. Although soups generally are fluid, they have been reported to hold strong satiety value by several [28–31] investigators, although more equivocal results have been observed by others. In one instance, the ingestion of 300 g of tomato soup failed to elicit a change of hunger ratings compared to a nonsoup control condition [32]. However, before embarking on studies of the exception to better understand the rule, simple methodological factors that may account for the discrepant findings must be excluded.

One issue hampering interpretation of the literature is the use of dissimilar foods for the soup and solid meal [28]. Thus, differential responses cannot be unambiguously ascribed to the food form. In one study where identical foods were served in solid and soup versions, the soup was a liquid–solid mixture rather than in a liquified blend [31]. Studies in rats indicate that the mechanical act of chewing promotes satiety [33,34] and reduced food intake, especially among lean, as compared to obese animals. It has been proposed that high-fiber diets that require greater mastication hold higher satiety value in humans and may account for lower body weights among populations ingesting them [33]. Consistent with this hypothesis, several groups [14,35] have reported higher satiety ratings from individuals consuming whole fruits that require mastication when compared to ratings after drinking juice from the same foods. The present study controlled these two potential confounds by monitoring responses to solid and liquified versions of the identical foods.

Soup is a very heterogeneous food category but, generally, soups differ in nutrient content from beverages, the other principal source of energy-yielding dietary fluids. The principle source of energy in the most widely consumed beverages (e.g., soda, fruit juices, sports drinks, sweetened tea, and coffee) is carbohydrate whereas this is more variable in soups. Studies, primarily with solid foods, indicate that, when presented as isoenergetic loads (preserving differences in energy density), there is a hierarchy of satiety values for the macronutrients: protein > carbohydrate > fat [36–38]. Although there is some evidence that the hierarchy holds in fluids (e.g., Ref. [38]), surveys generally indicate beverages with different macronutrient compositions (e.g., soda, alcohol, milk) are all ineffective in prompting dietary compensation [19,20]. Indeed, protein holds high satiety in solid foods [39–47], but the data are equivocal for protein's effects in fluids [45–54]. Whether the macronutrient satiety hierarchy holds in soups and whether the protein and fat commonly present in soups contribute to their stronger satiety property compared to

high-carbohydrate beverages is not known. A second aim of this study was to contrast the satiety effects of soups and solid foods high in carbohydrate, protein, or fat.

Another feature of soups that distinguishes them from beverages is the cognitive impression they impart. Rather than providing a means to reduce thirst or aid deglutition, they may be perceived more as a food source to reduce hunger. The present study also examined this mechanism by contrasting appetitive and dietary responses to the same liquid (apple juice) served both as a beverage and soup.

Additional features of beverages, soups, and solid foods that may account for differential appetitive and dietary responses include temperature, mode of consumption, timing of ingestion, energy density, and volume. The independent effects of each of these factors have either been addressed previously or must await future studies.

2. Methods

2.1. General protocol

This was a within-subject design preload study with seven conditions. Participant eligibility was based on age of 18–60 years, body mass index (BMI) between 18 and 35 kg/m², stable weight (no deviation >3 kg over the past 3 months) and activity (no deviation >1×/week at 30 min/session), good health, no anticipated change of medication use, low dietary restraint (≤8 on the Three Factor Eating Questionnaire), and regular consumption of ≥3 meals per day, including breakfast. To minimize the potential for biased responding, participants were informed that the intent of the study was to assess the effects of food on motor skills and coordination.

Individuals responding to public advertisements reported to the laboratory for baseline measurement of height, weight, and body composition (by bioelectric impedance analysis). They also completed demographic, health, and dietary questionnaires and received training on food intake recording using food models. Qualified individuals completed an informed consent form approved by the Purdue University Institutional Review Board.

Upon arrival to the study site, a finger stick blood test was taken (to confirm participants were fasted) and a questionnaire eliciting information about their mood, appetite, strength, and fine motor skills was completed. A variety of motor tasks and questionnaires of psychological state were then completed. Next, participants were provided a 300-cal portion of food and asked to consume it in its entirety within 10 min. The same questionnaires and motor skills tests were completed at 15-min intervals for 1 h. Finally, participants were provided timers to remind them to complete questionnaires at 30-min intervals for an additional 3 h. They kept a diet record for the balance of the day. After completion of the final test, participants were

informed about the study's true purpose and offered the opportunity to withdraw their data (none declined).

2.2. Test foods

The composition and rheological properties of the study foods are presented in Table 1. The apple was a fresh Fuji apple with the core removed. The apple juice was 100% apple juice from concentrate (unsweetened, pasteurized; Mott's Natural 100% Apple Juice, Mott's, Stamford, CT). Both the apple and juice were served chilled (approximately 10 °C). To prepare the apple soup, 217.5 g of apple juice were mixed with 480 g of applesauce (Mott's natural 100% applesauce, Mott's). The mixture was liquefied in a blender and microwaved for 1 min, stirred, and microwaved for an additional minute and served at about 60 °C. For the solid chicken load, a chicken breast (Tyson Skinless/Boneless Chicken Breast, Tyson Foods, Springdale, AR) was thawed and added to boiling chicken stock (474 g water containing two chicken boullion cubes; Wyler's Reduced Sodium Chicken Flavored Boullion Cubes, Borden Foods, Columbus, OH) for 15 min. To prepare the chicken soup, the chicken was prepared as above and then placed in a blender with 118 g of the broth and liquefied. The remainder of the broth was then added and further blended. It was served at 60 °C. The solid peanuts were lightly salted, dry roasted (Planters' Dry Roasted Peanuts, Nabisco, East Hanover, NJ) and were heated at 17 °C for 3 min, cooled for 1.5 min and served warm. Peanut soup was prepared by bringing 50.6 g peanut butter (Jiff Creamy Peanut Butter, Procter & Gamble, Cincinnati, OH) and 118.5 g water to a slow boil while mixing. The mixture was then liquefied in a blender. It was served at 60 °C. The hardness of the apple and chicken was measured with a cone probe, 5 mm penetration, test speed of 5 mm/s and trigger force of 4 g at the serving temperature. The peanuts were tested with a knife probe with a penetration distance of 3 mm. The viscosity of the fluids was measured with a number 1 spindle at 60 rpm at the serving temperature.

2.3. Dietary analyses

Diet records were analyzed by a single individual using version 7.6 of the Food Processor nutrition database (ESHA, Research, Salem, Oregon).

2.4. Appetite/sensory assessments

Participants rated their hunger and fullness at stipulated times on nine-point category scales. The verbal labels on the scales ranged from "None at all" to "Extremely ...". Test food palatability was rated on 13-point bipolar category scales with end anchor descriptors of "Extremely Pleasant" and "Extremely Unpleasant".

2.5. Diversionary tasks

Hand steadiness was monitored using a handheld stylus (1.5 mm diameter) and vertical metal plate with circular holes cut through it. Participants extended their arm and attempted to hold the stylus in a hole of 8 mm diameter without touching the sides for 30 s. The stylus was connected to an impulse counter and the average number of contacts was determined. Rotary tracking ability involved tracking a metal disk located 5 cm from the edge of a 24.4-cm turntable rotating at 45 rpm with a metal stylus connected to an impulse counter. The contact time was determined during 1-min trials. Grip strength was measured by squeezing a dynamometer for 10 s. Reaction time was measured by having participants push a button in response to a tone as rapidly as possible.

2.6. Statistical analysis

Treatment effects on appetite were assessed by repeated-measures analysis of variance. Paired *t*-tests were conducted for post hoc comparisons when appropriate. Because of skewing in the distributions of the intake and hedonic data, nonparametric tests (i.e., Friedman's, Sign, Wilcoxon, Mann-Whitney tests) were applied in these analyses. The Bonferroni correction was applied for multiple testing where applicable. In all cases, the criterion for statistical significance was $p \leq 0.05$, two-tailed. Data are reported as means \pm standard errors.

3. Results

Participants included 13 males and 18 females, 23.7 ± 0.9 years of age with a BMI of 23.0 ± 0.7 kg/m². There were 23

Table 1
Weight, energy density, macronutrient, and rheological properties of test stimuli

Food	Weight (g)	Volume (ml)	Energy density (kcal/g)	Carbohydrate (g)	Fat (g)	Protein (g)	Kcals	Viscosity (cps)/hardness (g)
Apple juice	652	620	0.46	74	1	1	300	11 cps
Apple soup	652	620	0.46	74	1	1	300	8 cps
Apple	508	600	0.59	78	2	1	300	770 g
Chicken soup	670	560	0.45	1	6	57	300	45 cps
Chicken breast	199	130	1.51	0	6	58	300	257 g
Peanut soup	169	170	1.78	10	26	13	300	69 cps
Peanuts	51	55	5.88	11	26	12	300	2142 g

lean participants (BMI=17.9–24.9 kg/m²) and 8 overweight/obese participants (BMI=25.0–35.3 kg/m²).

3.1. Appetite ratings

Mean (S.E.) hunger ratings and fullness ratings are presented in Fig. 1. Hunger ratings were comparable prior to and following ingestion of the chicken soup and chicken (high protein), peanut soup and peanuts (high fat) and, with the exception of the 15-min time point, apple soup and apples (high carbohydrate). In contrast, significant differences were observed when the high carbohydrate beverage was included in the test [$F(2,58)=5.70, p=0.005$]. Post hoc tests revealed the apple juice elicited a significantly smaller reduction of hunger than the apple soup or solid apple over the entire postload interval. Similar, but inverse, responses were made for fullness. No fullness differences were observed for the chicken versus chicken soup or peanut versus peanut soup responses. A significant treatment effect was observed for the carbohydrate foods [$F(2,60)=9.80, p<0.001$]. Post hoc tests revealed the apple soup and apples prompted similar fullness responses at all time points, except 15, 45 and 60 min postloading when fullness was rated slightly, but significantly lower after the soup. Both the apple soup and apples elicited significantly higher fullness ratings than the apple juice over the postload period except at the 60-min time point when there was no difference between the juice and soup.

Significant treatment effects were also observed in comparisons of the three soups and three solid foods (Fig. 2). For hunger ratings after soup ingestion, there was a significant main effect of food type [$F(2,64)=12.72,$

$p<0.001$] and food type×time interaction [$F(14,448)=4.0, p<0.001$]. This also held for hunger responses to the solid foods [$F(2,60)=5.47, p<0.001$ —main effect] and [$F(14,420)=4.24, p<0.001$ food type×time interaction]. The apple (high carbohydrate) and chicken (high protein) soups led to significantly greater reductions of hunger than the peanut soup (high fat). The difference between apple and peanut also held for the solid foods, but the ratings after chicken consumption were generally intermediate. The reverse pattern was observed for the fullness ratings. There was a main effect of food type [$F(2,58)=14.40, p<0.001$] and a food type×time interaction [$F(14,406)=2.23, p=0.006$]. There was also a main effect of food type with the solid foods [$F(2,56)=11.57, p<0.001$] and a food type×time interaction [$F(14,392)=4.62, p<0.001$].

The loads represented a smaller proportion of the daily energy requirement for males and the overweight than females and the lean, respectively. Thus, smaller reductions of hunger and increments of fullness were expected and observed in these subgroups. No significant interactions were noted with the different loads.

3.2. Intake

Median energy intake data are presented in Fig. 3. Twenty-four-hour energy intake on days soups were consumed tended to be lower than intake on days the solid foods were ingested ($p=0.075$). A significantly greater number of individuals had lower daily energy intakes when soups were provided compared to when the solid foods were ingested ($p<0.05$). This was primarily attributable to intake differences between apple and apple soup ($p<0.05$) and

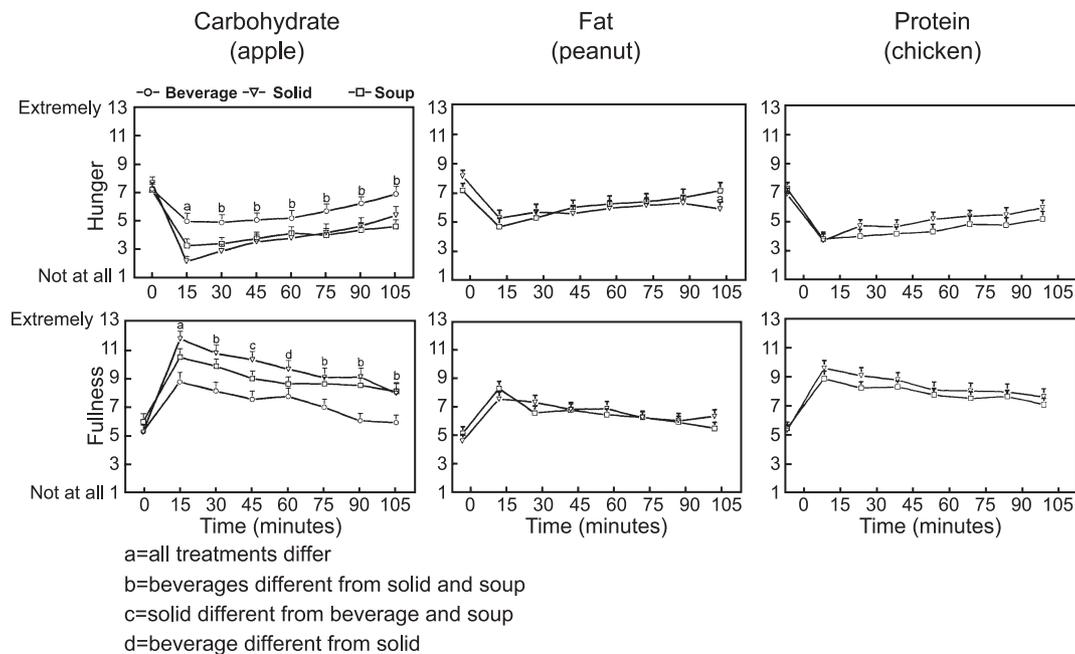


Fig. 1. Mean (S.E.) hunger and fullness ratings of the test beverage, soups and solid foods grouped according to the predominant source of energy (carbohydrate, fat, or protein).

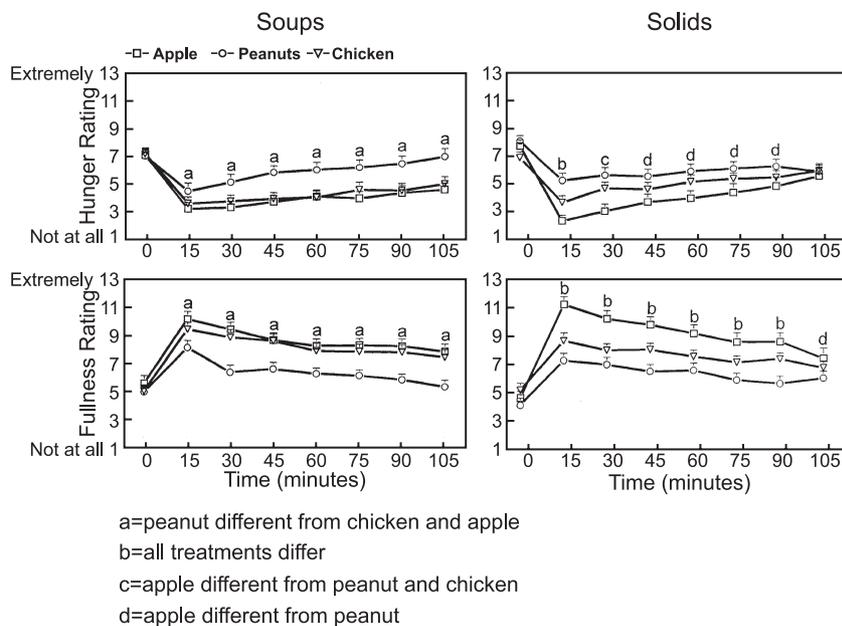


Fig. 2. Mean (S.E.) hunger and fullness ratings of the test soups (left panels) and solid foods (right panels) grouped according to food form (soup or solid).

chicken and chicken soup ($p < 0.05$). Energy intake on the day peanut soup was ingested was comparable to the days other soups were ingested, but the difference compared to peanut ingestion was not significant due to lower intake on the day this solid food was eaten. The soups tended (significant for chicken only) to reduce energy intake relative to the day no load was ingested. Energy intake was highest on the day apple juice was ingested compared to apple and apple soup, although not significantly. The failure to observe differences of intake may be due, in part, to high variance and, as a consequence, lower than expected power (0.65) for the study.

Median daily energy intake was greater for males compared to females (2390 versus 1812 kcal; Mann–Whitney $U = 33.0$, $p = 0.001$). The overweight tended to ingest more energy than the lean (2236 versus 2007 kcal), but this difference was not statistically significant ($p = 0.16$). There were no gender or weight interactions over time with energy intake.

There was no evidence of a macronutrient-related hierarchy effect on 24-h energy intake associated with the addition of 300 kcal of predominantly high-protein, carbohydrate or fat loads in soup or solid form. However, there were significant effects on daily macronutrient intake. The high-fat solid food (peanuts) led to a significantly [$F(7,203) = 3.45$, $p = 0.002$] higher intake of fat relative to days the high-protein or high-carbohydrate soups were ingested. High-fat soup consumption led to higher fat intake compared to days the other soups and the high-carbohydrate solid food and beverage were consumed as well as the control day. The high-carbohydrate soup led to significantly [$F(7,203) = 5.86$, $p < 0.001$] higher daily carbohydrate intake compared to days the other soups were ingested or when the high-fat solid food was consumed. The high-carbohydrate solid food and beverage led to the same effects as well as higher carbohydrate intake relative to the high-protein solid food. The high-protein soup and solid foods led to significantly [$F(7,203) = 14.93$, $p < 0.001$] higher daily protein intake compared to all other days. Thus, there was little evidence of macronutrient compensation.

The median gram weights of food consumed over the 24-h treatment days were: apple juice—3090 g; apple—2365 g; apple soup—2737 g; peanut—2496 g; peanut soup—2408 g; chicken—2813 g; chicken soup—3074 g. The nonparametric Friedman’s test indicated there was a significant treatment effect. Post hoc testing indicated the gram weight of food and beverages consumed was lower when the peanut preload was ingested compared to the apple juice or chicken soup.

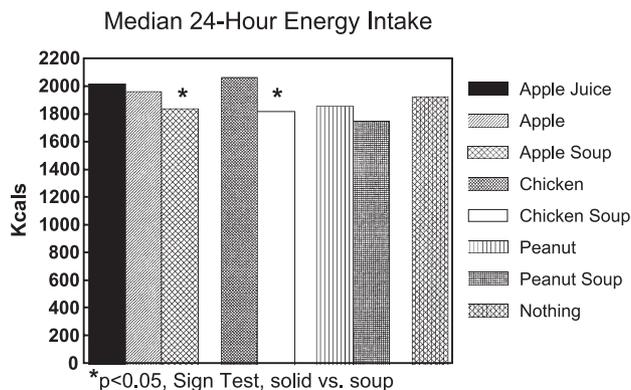


Fig. 3. Median 24-h energy intake on a no-load day and days the beverage, soups, or solids were consumed.

3.3. Thirst ratings

Mean thirst ratings differed significantly during the postprandial period [$F(6,180) = 19.82$, $p < 0.001$]. Ratings

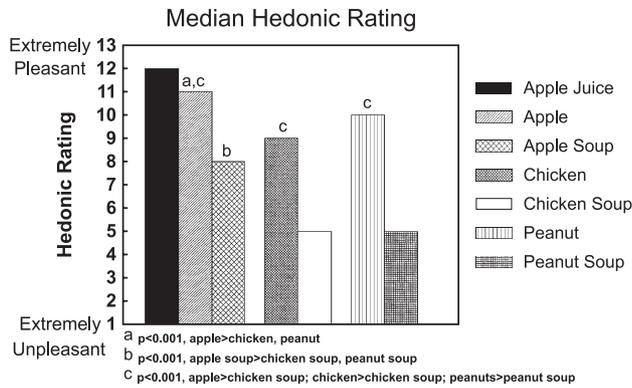


Fig. 4. Median hedonic ratings of the preload beverage, soups, and solids.

were lower after ingestion of the beverage, soup, and solid carbohydrate (apple) loads compared to all other treatments. The three forms of apple loads did not differ from each other. Peanut consumption led to higher thirst ratings compared to all other loads except solid chicken. Chicken led to higher thirst ratings compared to all treatments except peanut ingestion.

3.4. Hedonic ratings

Data on the hedonic ratings of the preloads are presented in Fig. 4. Following correction for multiple testing, all solid foods were rated as significantly more pleasant than their corresponding soup versions (all $p < 0.005$). No significant differences were observed between the soups. The apples were rated significantly more pleasant than the chicken, but the peanuts did not differ from either of the other solid foods. The apple juice was significantly more palatable than the apple soup, but similar to the apples. Mean ratings for all foods/beverages were within the upper two thirds of the response scale.

There were no significant correlations between daily energy intake, hedonic ratings for the test foods, or mean daily appetite ratings.

4. Discussion

While there are compelling data that energy-yielding fluids have weak satiety properties [11–17], the opposite has been noted in several [28–31] studies of soups. Because the hypothesis under study in the previously published trials was not that soups hold special satiety properties, their design was not ideal for examining this issue. In one early study that hypothesized food volume was a key determinant of satiety, loads of soup or crackers, cheese, and apple juice were provided in equal weights and intake of a second course of macaroni and cheese was monitored [30]. Less of the second course was ingested after the soup, but because the two loads differed in nutrient composition, chemosensory properties, total energy, energy density, temperature,

and other properties, the authors noted that it was not possible to identify the attribute accounting for the effect. A follow-up study controlled the energy value of the soup and mixed meal loads [30]. Again, the soup was noted to have stronger satiety value, but many of the same confounds remained. A later study exploring the influence of caloric content, energy density, and sensory-specific satiety on intake of a second meal also contrasted soup to a variety of dissimilar solid items (melon, cheese, crackers) [28]. A strong satiety effect of the soup was supported. While several possible mechanisms were excluded, (e.g., sensory specific satiety, palatability), the numerous differences between the solid and liquid foods tested did not permit a test of the independent effect of food form. In a more tightly controlled trial, satiety ratings were obtained subsequent to ingestion of a solid–liquid or homogenized form of the same vegetable-rich meal [55]. The homogenized form led to greater satiety, but it was likely not viewed as soup as it was served on a plate. More recently, appetitive responses were obtained to the same foods served as a casserole, casserole with water, or casserole mixed with water to resemble soup [31]. The aim was to explore the role of food volume (determined by water content) on appetite and intake. The soup version had a stronger effect on satiety than the casserole as assessed by hunger ratings immediately after load ingestion and lower energy intake of a meal presented 17 min later. However, total energy intake over the test day did not vary between treatments. The independent effects of the soup and solid food were not assessed. Interestingly, participants thought they could consume less soup than casserole prior to loading, suggesting a cognitive component to the satiety properties of soup.

The present study controlled many potential interpretative confounds. First, solid and liquefied versions of the identical foods were compared. Thus, they were matched on energy and macronutrient content. Second, appetitive ratings were obtained over time after ingestion of the test foods alone. This permitted assessment of the satiety properties of the food forms rather than the still informative, but interactive, effects with other foods. Third, for one food system (apples), responses were monitored for beverage and soup versions that had similar viscosity properties. The latter provided additional insights on a cognitive effect on appetite ratings.

We observed that the soup loads led to reductions of hunger that matched the changes observed with the solid food counterparts. This is consistent with an earlier report [13] and confirms that soups have a high satiety value despite their fluid form. Numerous researchers have proposed that cognitive factors likely contribute to the high satiety value of soups [13,15,20,31]. Soup may be viewed as a meal component ingested to address sensations of hunger as compared to a beverage used to satisfy thirst. This is consistent with the present observation that hunger ratings to the apple soup were significantly lower than and fullness ratings were significantly higher than, those to the apple

juice over the assessment period. The only differences between the beverage and soup forms were the mode of presentation and temperature. With respect to the former, beliefs about the energy content of food/beverage are known to exert a strong influence on appetite, one that may supersede metabolic cues. Exemplary literature includes evidence that (A) the perceived energy value of food consumed better predicts hunger ratings than its actual energy value [56]; (B) amnesiacs willingly eat second meals immediately after completing a meal [57]; (C) merely asking individuals to think about food for 5 min before a meal reduces intake at the meal in normal individuals [58]; (D) oral ingestion of soup suppresses appetite better than intragastric delivery of the same load [59]; and (E) ingestion of a homogenized food leads to higher satiety ratings than the fluid and solid components served separately [30,55].

While several studies report discrepant responses to hot soups as compared to solid foods served at room temperature or chilled [28,30], an influence of temperature seems unlikely. Earlier work revealed the temperature of soup does not alter its effect on appetite or intake of a subsequent meal [60]. Temperature was also discounted in a study where discrepant responses were noted when the same heated food was consumed in a soup or solid form [31]. The common practice of consuming a hot beverage (e.g., coffee) after a meal is also inconsistent with it contributing to satiety.

Several additional plausible explanations exist, but are not consistent with the present findings. In neither the present study nor earlier studies [31] could differences in thirst or palatability account for the observed satiety effects. In the present study, the solid forms of the high-protein and high-fat foods were judged as more palatable and led to greater thirst than the soup versions but did not lead to differences in appetite ratings. The apples and apple juice were equipalatable but consumption of the former led to greater suppression of hunger and increased fullness. In addition, hedonic ratings were not significantly correlated with appetite ratings. Load volume also fails to fully explain the findings. The chicken and peanut soups were larger in volume than the respective solid forms, but did not result in different appetitive ratings. The apple juice and soup were equal in volume but did produce different hunger and fullness ratings. This is consistent with evidence that adding water as a beverage to a solid food meal to increase load volume did not alter appetitive ratings or intake [31]. Other work reported augmented fullness with the addition of water to a meal, but this was not maintained after the meal nor did it result in altered subsequent intake [61]. The pattern of responses is also inconsistent with an effect of energy density. The apple soup and juice had identical energy density and volume, but elicited markedly different appetitive responses.

Although not relevant in this study where soups were not presented in the context of a multicourse meal, the customary timing of their ingestion may augment their satiety effects. Inclusion of soup may prolong the eating event and

permit a greater influence of postingestive feedback which could suppress intake during the latter part of the meal [30]. Varying the timing of soup ingestion relative to a solid food second course alters gastric emptying of the latter as well [32].

Only tenuous evidence was obtained for an effect of food form on daily energy intake. No significant differences were noted between the soup and solid versions of each food or between intake on days the loads were consumed compared to the no-load control day. However, a significantly greater number of people ingested less energy on the days they consumed the apple soup and chicken soup relative to the days the solid versions of these foods were provided. The observation of only a marginal effect is not surprising given the plethora of factors that influence intake. While some work has revealed soups reduce energy intake in a subsequent meal [11,28,30,31], effects were not large enough to exert a significant effect over a 24-h period [31]. This observation neither supports nor refutes claims about the value of soups in a weight management regimen. Such an evaluation will be aided by evidence demonstrating the ability of soup's satiety property to enhance compliance with an energy-controlled diet. The potential for soup ingestion to moderate daily energy intake among free-feeding individuals will require a strongly powered chronic feeding trial. The short-term effects and present suggestive findings support such an effort because of the potential benefit that may accrue from a small but sustained moderating effect.

Considerable data support a macronutrient hierarchy with respect to satiety properties wherein protein > carbohydrate > fat, assuming no attempt is made to manipulate energy density [36–38]. However, failures to note differences have also been reported (e.g., Ref. [62]). These discrepancies may be attributable to other food properties, such as rheology. Given the weak satiety properties of energy-yielding beverages, it was hypothesized that these differences would be lost or ameliorated in the fluids but apparent in the solid foods. This was only partially observed. No differences in hunger or fullness ratings were observed for the high-carbohydrate and high-protein soups whereas ratings differed significantly after consumption of the high-fat soup and the solid foods. The peanut soup and peanuts were associated with weaker appetitive responses than the other stimuli. This latter observation is consistent with predictions that a high-fat stimulus is the least satiating. However, because the loads were matched on energy, the high-fat foods were lower in volume than the high-carbohydrate or high-protein foods and this could have contributed to the effect. This may also account for the failure of the high-protein foods to elicit stronger effects on hunger and fullness than the high-carbohydrate foods.

In summary, these data support the weak satiety value or an energy-yielding beverage and high satiety value of soups. While discounting several plausible mechanisms and highlighting others, especially cognitive effects, further explorations

tion of the influence of soup on appetite and food choice is worth pursuing as it may reveal useful insights for weight management.

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