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Effects of blenderized watermelon consumption on satiety and postprandial glucose in overweight and obese adolescents

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ABSTRACT

Background: Watermelon and its rind are rich in fiber, vitamins, minerals, and L-citrulline. Despite these nutritional benefits, research on the effects of blenderized watermelon (WM), especially in adolescents, remains limited. This study aimed to address this gap by examining the impact of blenderized WM (*Citrullus lanatus*, including both flesh and rind) on satiety, postprandial glucose responses, and overall acceptability among overweight and obese adolescents.

Methods: In a randomized crossover design, 20 participants consumed 240 mL of either blenderized watermelon (WM) or an isocaloric sugar-sweetened beverage (SSB) on separate days. A triangle sensory test assessed participants' ability to distinguish between WM with and without rind, while acceptability assessments rated flavor, sweetness, and overall satisfaction using a seven-point hedonic scale.

Results: Blenderized WM consumption resulted in significantly lower postprandial glucose levels at 20 and 40 min ($P < 0.01$) compared to SSB. Satiety responses showed delayed increases in hunger and desire to eat with WM. Feelings of fullness increased at 20 min for WM ($P = 0.033$), while SSB resulted in lower fullness than baseline at 120 min ($P = 0.006$). Participants reported increased appetite after 120 min with WM, compared to 60 min with SSB ($P < 0.05$). In the triangle sensory test, 70 % of participants correctly identified WM with and without rind, with acceptability assessments favoring WM without rind.

Conclusion: Blenderized WM shows potential for stabilizing postprandial glucose levels and enhancing satiety in overweight and obese adolescents. However, improving the sensory qualities of WM with rind is crucial to increase its appeal as a healthier alternative to sugary snacks. While these findings highlight its promise for managing glucose and promoting satiety, further efforts to enhance its palatability are needed.

1. Introduction

The prevalence of obesity in children and adolescents is on the rise, impacting more than 19.7 % of youth in the United States [1]. Prediabetes is more common among adolescents with obesity than in their normal-weight counterparts. Between 2005 and 2016, 18 % of U.S. adolescents were found to have prediabetes [2]. Childhood obesity significantly impacts health, increasing the likelihood of developing nutrition-related diseases such as type 2 diabetes, cardiovascular diseases (CVDs), and certain forms of cancer in later stages of the life cycle [3].

Obesity in children has been linked to unhealthful snacking, characterized by the consumption of over-processed foods and sugar-sweetened beverages [4]. These snacks are low in nutrient density and are less satiating, potentially resulting in an increased total energy intake [4–6]. However, snacking is an integral part of childhood food intake and can contribute to meeting recommended nutrient intakes [7]. Adolescents report consuming an average of 4.3 snacks a day [8]. One study reported that 28.4 %, or 450 kcal, of children's energy intake comes from snacks [9]. Replacing conventional snacks with fruit increases satiety and is recommended for many health benefits [6,10].

Watermelon is a fruit abundant in essential nutrients, including lycopene [11], ascorbic acid, potassium, beta carotene, and flavonoids [12]. Additionally, it serves as an excellent source of fluids, containing 92 % water, and provides dietary fiber [13,14]. In a recent study involving 33 overweight and obese adults, the consumption of two cups of watermelon led to greater satiety in an acute setting compared to an isocaloric snack for 90 min post-consumption [15]. This increased

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satiety can be attributed to high fiber content, which promotes satiety and reduces energy intake [15]. Furthermore, watermelon and its rind contain phenolic compounds such as 4-hydroxybenzoic acid, vanillin, and coumaric acid [16], and is particularly rich in L-citrulline [17]. In overweight and obese patients with type 2 diabetes, L-citrulline supplementation was found to improve glucose homeostasis and inflammatory markers [18]. Similarly, when fed to diabetic mice, watermelon was linked to decreased blood glucose and increased serum insulin [19]. Though the whole watermelon fruit—including the rind—is edible and abundant in nutrients, the rind is often discarded, contributing to food and environmental waste. Yet, the rind contains a rich array of nutrients, including dietary fiber, L-citrulline, phosphorus, calcium, sodium, vitamin A, and vitamin C [20]. This nutritional profile underscores its potential for enhancing nutritional intake while also addressing environmental concerns through innovate utilization strategies.

The purpose of this study was to compare the effects of blenderized watermelon (WM) and an isocaloric sugar-sweetened beverage (SSB) on perceived appetite and postprandial glucose levels in overweight and obese adolescents. Additional objectives of this study were to assess consumer acceptability and compare the sensory, physical, and chemical attributes of blenderized WM both with and without rind. It was hypothesized that the consumption of blenderized WM would lead to higher perceived satiety scores and improved glucose responses compared to an isocaloric SSB.

2. Methods and materials

2.1. Subjects

Twenty-six subjects were recruited for the present study through flyers posted at various locations in San Diego County. Based on a watermelon study of adult subjects [21], it was anticipated that significant differences in postprandial glucose can be obtained in a sample of 20–26 subjects between watermelon vs isocaloric control groups at 70–80 % power and an alpha-level of $P < 0.05$. The inclusion criteria were 10–17 years old and BMI ≥85th percentile for age and sex. Exclusion criteria included irregular menstruation; allergy to watermelon; taking medications that affect blood pressure, blood lipids, and blood glucose; and exposure to radiation over the past 12 months. Three participants were excluded due to not meeting the study's inclusion criteria: one participant declined to drink the samples, and two did not meet the required BMI criteria. The remaining 23 participants were randomized into two groups, with 11 participants allocated to the blenderized watermelon (WM) treatment and 12 to the sugar-sweetened beverage (SSB) treatment. A cross-over design was implemented, during which one participant from the blenderized WM group and two from the SSB group were lost to follow-up due to relocation or personal reasons unrelated to this study. A total of 20 participants between the ages of 10–17 years (9 males, 11 females; 9 overweight, 11 obese) completed the study. No participants were excluded from the final analysis (Fig. 1). Adolescent BMI percentile was calculated using CDC growth charts based on age, sex, height, and weight [22]. The study protocol was approved by San Diego State University's Institutional Review Board. All subjects and their parents or legal guardians provided assent and informed written consent before participation in the study. The trial was registered at clinicaltrials.gov (NCT04096586).

2.2. Study design

This study was a snack intervention that used a crossover design. On two separate occasions, participants were instructed to come to the laboratory in the morning following a 10-h overnight fast. Anthropometric measurements were taken during each visit. Height was measured barefoot using a stadiometer attached to a beam balance scale. Weight was measured using a digital scale. Body fat percentile was assessed via a BOD POD (Cosmed, Concord, CA) and bioelectrical impedance analysis (BIA) device (Omron, Lake Forest, IL). Waist-to-hip ratio was taken one inch above the navel and at the most expansive area on the hips. After a 10-min rest, blood pressure was measured using an automatic blood pressure cuff (Omron HEM-712C, Omron Healthcare,

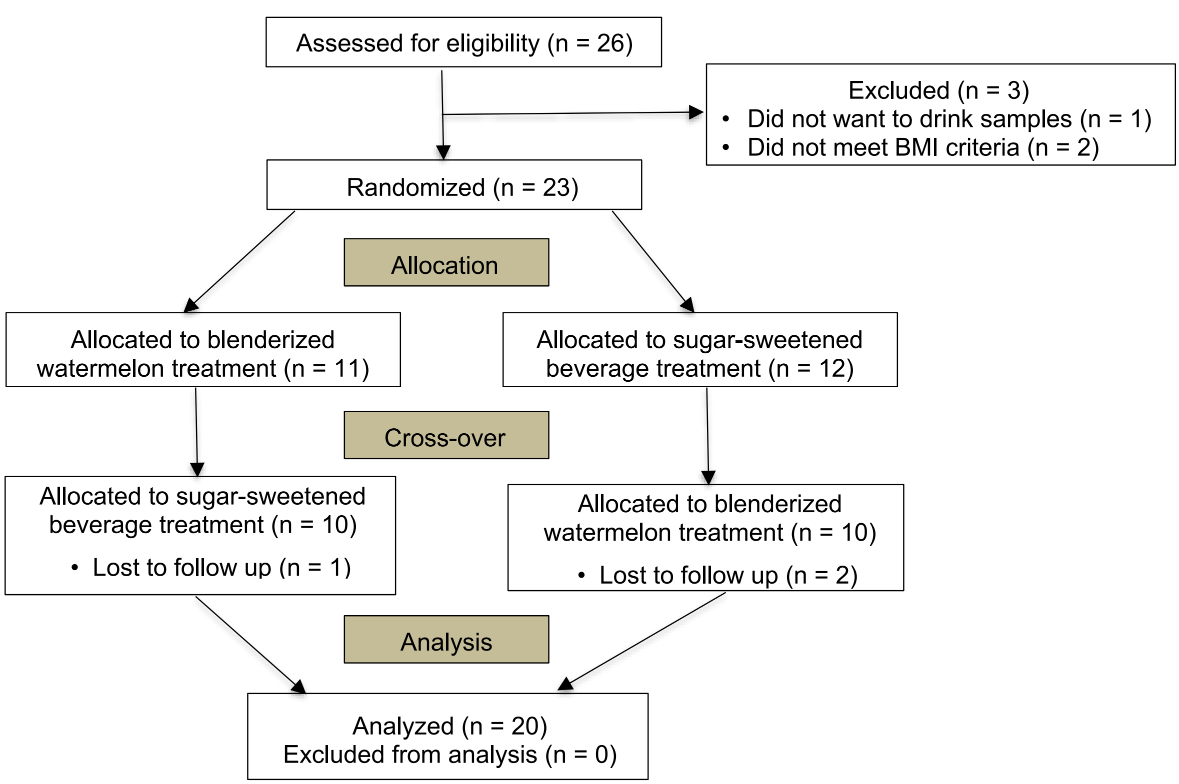

Fig. 1. CONSORT flow diagram of participant selection.

Inc. Bannockburn, IL).

Subjects completed a baseline visual analog scale (VAS) satiety questionnaire and finger prick for blood glucose analysis. Participants were then instructed to consume 8 oz of blenderized seedless red WM (*Citrullus lanatus*), including both the flesh and rind, or a SSB containing red dye (FD&C RED #40, Flavors and Color, Diamond Bar, CA). Both beverages provided 72 kcal and were consumed within 5 min. To prepare the blenderized WM with rind, the skin was removed, and the flesh and rind were blended together at an approximate ratio of 68.5 % flesh to 31.5 % rind (SD 7.1 %). The mixture was then portioned into 8 oz (240 mL) containers. The blenderized WM contains approximately 0.91 g of dietary fiber, and 18 g of carbohydrates including 14.8 g of sugar [23]. To prepare an isocaloric SSB with the same carbohydrate content, 18 g of sugar and a small drop of red dye were mixed with 7.85 oz of water, resulting in a final volume of 8 oz. The VAS satiety questionnaire and finger prick were further administered 20, 40, 60, 90, and 120 min following consumption of either beverage.

2.3. Satiety questionnaire

The visual analog scale (VAS) questionnaire measured satiety responses and included a series of five questions which included: (*i*) how hungry are you? ("not at all hungry" to "totally hungry"), (*ii*) how full are you? ("not at all full" to "totally full"), (*iii*) how strong is your desire to eat? ("not at all" to "extremely"), (*iv)* how much do you think you could eat right now? ("nothing" to "a large amount"), and (*v*) how thirsty are you? ("not at all thirsty" to "totally thirsty"). Each VAS question consisted of a 10-cm line anchored at the beginning and end by opposing statements [24]. Subjects were instructed to plot a point on the line for their perceived response to each question, with 0 cm being the lowest and 10 cm being the highest.

2.4. Postprandial glucose

Capillary glucose levels were measured using a glucometer (Nova Biomedical, Waltham, MA). A small drop of blood via a finger prick was placed on a disposable test strip that was inserted into a digital meter. Glucose was expressed in mg/dL.

2.5. Sensory evaluation

The sensory evaluation was comprised of two separate components: a triangle test and an evaluation of samples using a seven-point hedonic scale. In the triangle test, equal amounts of either blenderized WM with flesh only or blenderized WM with both flesh and rind were poured into three 2-oz (60 mL) clear plastic portion cups for every participant. Each set of samples consisted of two identical samples and one odd sample out, and every cup was assigned a random three-digit code. Participants were asked to identify the odd sample out of the three samples presented. Subjects were provided verbal and written instructions to follow, which included rinsing mouths with water before and between consuming samples. Subjects conducted the triangle tests in isolated test booths.

For the second component of the sensory evaluation, participants were given a separate set of blenderized WM with and without rind and were asked to rate the color, smell, flavor, sweetness, mouthfeel, aftertaste, and general acceptance of the samples using a seven-point hedonic scale. Participants were provided verbal and written instructions, as well as a printed questionnaire, and performed this evaluation in isolated test booths.

2.6. Analyses of physical and chemical properties

Blenderized WM samples with and without rind were analyzed to determine and compare their physical (i.e., color, texture, and total soluble solids) and chemical (i.e., pH) properties. Color, as defined by the redness of each sample, was determined using a CM-700d spectrophotometer (Konica Minolta, Sakai, Osaka, Japan). Texture was examined using a TA.XTPlus texture analyzer (Texture Technologies Corp., Hamilton, MA). Texture analysis was carried out in a back extrusion container (65 mm inner diameter x 55 mm height) approximately 75 % full using a TA-25 2″ diameter disc and 5-kg load cell. The extrusion disc was centrally positioned over the sample container. The pre-test speed, test speed, and post-test speed were 1.0 mm/s, 1.0 mm/s, and 10.0 mm/s, respectively. A 30-mm distance and trigger force of 10 g was used. The maximum force was defined as sample firmness, the area of the positive curve was taken as consistency, and the maximum negative force was defined as cohesiveness of the sample. The area of the negative curve was defined as work of cohesion, which is an indication of the consistency/viscosity of the sample. Additionally, total soluble solids were analyzed using a Sper Scientific 3,500,035 digital refractometer (Scottsdale, AZ). Lastly, pH was determined with a SevenExcellence pH meter (Mettler Toledo, Columbus, OH).

2.7. Statistical analysis

Data were analyzed using SPSS (version 25, IBM, Armonk, NY, USA). A repeated-measures analysis of variance (ANOVA) was used to analyze the effects of each treatment on time and any significant interactions. Since this study utilized a crossover design, measurements (WM vs. SSB) for each participant were matched prior to analysis. If significant interactions were found, Bonferroni post-hoc comparisons were performed. Findings were expressed in means ± SDs and a P value ≤ 0.05 was considered statistically significant.

The triangle test and seven-hedonic scale results were analyzed using a binomial test and student's *t*-test, respectively. The results from the color, texture, total soluble solids, and pH tests of blenderized watermelon with or without rind were analyzed using paired samples *t*-tests.

3. Results

3.1. Demographics and baseline characteristics

Participants were between the ages of 10–17 years, with a mean age of 12.80 ± 1.96 years (Table 1). To be considered overweight or obese, CDC guidelines require the BMI percentile to be between 85 and 94.9 for overweight and greater than or equal to 95 for obese [22]. Of the participants, nine were considered overweight, while 11 fell into the obese category. The mean BMI percentile was 93.28 ± 5.38, mean body fat % was 34.40 ± 4.25 %, and mean waist-to-hip ratio was 0.86 ± 0.07 (Table 1). The mean systolic blood pressure was 107.23 ± 10.01 mmHg and mean diastolic blood pressure was 69.48 ± 7.66 mmHg.

Table 1
Participant demographics.

Demographic Information	Mean ± SD
Age, years	12.80 ± 1.96
Height, cm	156.58 ± 9.48
Weight, kg	65.29 ± 17.11
BMI, kg/m^2	26.26 ± 4.51
BMI percentile	93.28 ± 5.38
Systolic blood pressure, mmHg	107.23 ± 10.01
Diastolic blood pressure, mmHg	69.48 ± 7.66
Waist, cm	85.95 ± 11.07
Hip, cm	100.23 ± 9.32
Waist-to-hip ratio	0.86 ± 0.07
Body fat, % - BIA	34.40 ± 4.25
Body fat, % - BOD POD	30.65 ± 6.75
Hemoglobin A1c, %	5.09 ± 0.27

Values are means ± SDs. N = 20 (9 males/11 females). BIA, Bioelectrical impedance analysis; BMI: Body mass index.

3.2. Postprandial glucose

There were no statistically significant differences in baseline blood glucose levels between trials (Fig. 2). Both trials resulted in increased postprandial glucose levels, peaking at 20 min and returning to baseline at 120 min ($P < 0.001$). Overall postprandial glucose levels were lower with blenderized WM consumption compared to SSB consumption ($P = 0.002$), particularly at 20 min and 40 min post-consumption ($P < 0.001$ and $P = 0.003$, respectively).

3.3. Satiety questionnaire

There were no main effects of trials in hunger, desire to eat, how much one could eat, and thirst between trials (Fig. 3). However, compared to baseline, blenderized WM consumption delayed increases in hunger and desire to eat until 60 min post-consumption versus 40 min for SSB consumption ($P < 0.05$, Fig. 3A and Fig. 3C). Blenderized WM consumption resulted in a greater feeling of fullness, which increased at 20 min from baseline ($P = 0.033$), while the SSB was lower than baseline at 120 min ($P = 0.006$, Fig. 3B). How much one could eat was greater than baseline at 120 min in the WM trial compared to 60 min in the SSB trial ($P < 0.05$, Fig. 3D). Both blenderized WM and SSB decreased thirst at 20 min compared to baseline ($P < 0.05$), but there were no significant differences between trials (Fig. 3E).

3.4. Triangle sensory evaluation

A proportion of 68.5 % ± 7.1 % flesh and 31.5 % ± 7.1 % rind (w/w) was used for preparing each sample of blenderized WM with rind. Fourteen out of 20 participants (70 %) identified the odd sample out from the three samples in the triangle test ($P = 0.010$) (Fig. 4).

3.5. Seven-point hedonic scale sensory evaluation

Participants preferred the flavor ($P = 0.031$) and sweetness ($P = 0.009$) of blenderized WM without rind compared to blenderized WM with rind (Table 2). No significant differences were observed for color, smell, mouthfeel, and aftertaste between the two blenderized WM samples. Blenderized WM without rind had a greater acceptance score (5.05 ± 1.32) than that of blenderized WM with rind (4.00 ± 1.30) ($P < 0.001$).

3.6. Properties of blenderized watermelon with and without rind

Blenderized WM without rind had greater redness, pH level, and total soluble solids content compared to blenderized WM with rind ($P < 0.001$) (Table 3). The higher amount of total soluble solids, an indicator of sugar content, of blenderized WM without rind was consistent with its perceived greater sweetness. Additionally, blenderized WM with rind displayed greater firmness, consistency, cohesiveness, and viscosity ($P < 0.05$).

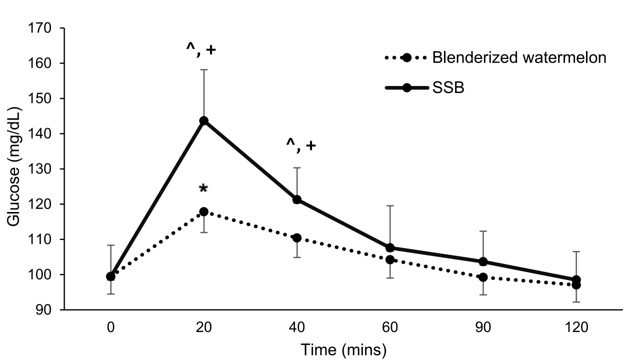

Fig. 2. Postprandial glucose response after blenderized watermelon and sugar-sweetened beverage (SSB) consumption over 120 min. Data are presented as means ± SDs. (*, $P < 0.05$ compared to baseline in watermelon trial; ^, $P < 0.05$ compared to baseline in SSB trial; +, $P < 0.05$ difference between trials).

4. Discussion

The current study investigated the effects of blenderized seedless red watermelon (WM) (*Citrullus lanatus)* versus an isocaloric sugar-sweetened beverage (SSB) on perceived satiety and postprandial glucose responses in overweight and obese adolescents, as well as physical properties and sensory attributes of blenderized WM with and without rind.

In the blenderized WM trial, participants consistently had lower postprandial glucose levels compared to those in the SSB trial. This difference is likely due to the higher fiber content in both the flesh and rind [15,25] of WM compared to the SSB, as the blenderized WM and SSB samples were isocaloric and matched in carbohydrate content. Fiber, an indigestible carbohydrate in plants, delays gastric emptying and slows intestinal glucose absorption, contributing to lower blood glucose levels [26,27]. Another investigation that observed postprandial serum glucose response following the consumption of fiber-enriched orange juice versus a fiber-free orange juice placebo reported a decrease in serum glucose levels 15 min post-consumption with the fiber-enriched orange juice compared to the placebo [26].

Subjects in the present study who consumed blenderized WM reported greater feelings of fullness by 20 min compared to those who consumed an isocaloric SSB. This increased satiety may also be attributed to the fiber content in blenderized WM, as fiber is known to enhance satiety [28–30]. A study by Borkoles et al. [30] found that participants who received fiber supplementation felt fuller and experienced a reduction in appetite compared to those who received a placebo. However, Flood-Obbagy et al. [28] discovered that adding fiber to apple juice did not heighten satiety compared to plain apple juice. Participants reported greater feelings of fullness and reduced levels of hunger when consuming apple pieces as opposed to fruit juice with added fiber. The divergent results from these studies suggest that the form in which fruit is consumed may influence energy intake independently from fiber content, as consuming whole fruit requires mastication. Mastication has been shown to significantly reduce self-reported hunger by influencing gut hormone responses associated with satiety [31]. Therefore, while the fiber content in blenderized WM may have contributed to increased satiety in the current study's participants, it is also likely that mastication further contributed to increased feelings of fullness. However, the potential effects of mastication on the fullness feeling in relation to WM consumption should be further investigated.

L-citrulline, a free amino acid, is converted to nitric oxide (NO) in the body [32]. NO plays a critical role in glucose metabolism by enhancing insulin delivery to peripheral tissues and improving glucose homeostasis [33]. NO enhances the expression and translocation of GLUT4 in skeletal muscles, facilitating glucose uptake into insulin-sensitive cells and decreasing gluconeogenesis while increasing hepatic insulin-sensitizing substance secretion [33,34]. Additionally, L-citrulline supplementation has been linked to improved blood glucose levels in both mice and human [35,36]. In one study, WM rind extract significantly reduced blood glucose levels compared to WM flesh after four weeks [18]. Similarly, WM juice has been shown to lower fasting blood glucose levels in alloxan-induced diabetic rats compared to untreated diabetic control rats, which was attributed to L-citrulline's inhibition of α-amylase and α-glucosidase activity [37]. These mechanisms suggest that the L-citrulline content in blenderized WM likely played a role in the improved postprandial glucose levels observed in this study. However, further research is needed to directly evaluate the specific effects of L-citrulline on postprandial glucose response.

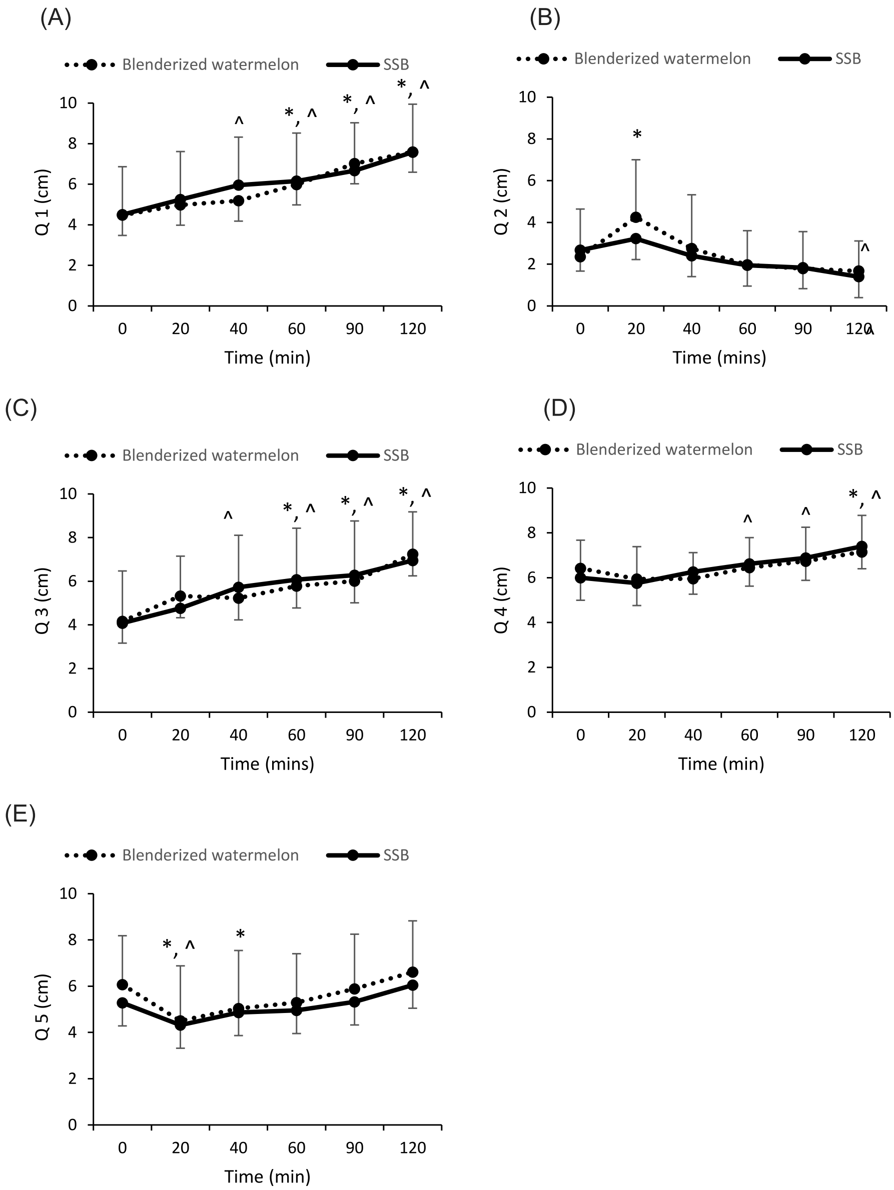

Fig. 3. Effects of blenderized watermelon and sugar sweetened beverage (SSB) on perceived appetite following consumption determined by VAS satiety questionnaire. (A) How hungry are you? (B) How full are you? (C) How strong is your desire to eat? (D) How much do you think you could eat? (E) How thirsty are you? Data are presented as means ± SDs. (*, $P < 0.05$ compared to baseline in blenderized watermelon trial; ˆ, $P < 0.05$ compared to baseline in SSB trial).

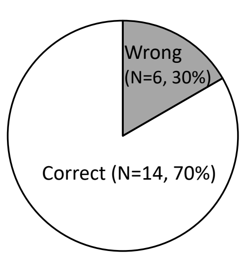

Fig. 4. Percentage of participants who correctly identified the odd sample in a triangle test.

Table 2
Sensory characteristics of blenderized watermelon with and without rind.

Sensory Characteristics	Blenderized watermelon, flesh only	Blenderized watermelon, flesh and rind
Color	5.40 ± 0.99	5.20 ± 1.11
Smell	4.85 ± 0.88	5.05 ± 0.76
Flavor	4.85 ± 1.39*	4.25 ± 1.16
Sweetness	4.75 ± 1.29*	4.05 ± 1.23
Mouthfeel	4.25 ± 1.59	3.90 ± 1.21
Good aftertaste	4.40 ± 1.27	4.05 ± 0.94
Acceptance	5.05 ± 1.32***	4.00 ± 1.30

Values are means ± SDs. N = 20. *$P < 0.05$; ***$P < 0.001$.

Watermelon contains a notable amount of L-citrulline, ranging from 1.0-3.5 mg/g fresh weight in the flesh and 0.8–1.5 mg/g fresh weight in the rind [38,39]. In the present study, the estimated L-citrulline content in an 8 oz (240 mL) sample of blenderized WM was approximately 225–689 mg. Kudo et al. [40] administered L-citrulline to obese/diabetic mice at a dose of 1 g/kg body weight per day for nine weeks—approximately twelve times the human equivalent dose based on a daily intake of 5 g for a 60 kg human—and observed significant reductions in food consumption following supplementation. To achieve

Table 3
Properties of blenderized watermelon with and without rind.

Properties	Blenderized watermelon, flesh only	Blenderized watermelon, flesh and rind
Color- redness	8.64 ± 1.75***	3.83 ± 0.70
pH	5.43 ± 0.09***	5.28 ± 0.05
Texture- firmness	146.40 ± 54.3*	1594.3 ± 562.7
Texture- consistency	1948.9 ± 179.5*	9317.9 ± 1888.6
Texture- cohesiveness	−57.09 ± 48.62*	−744.95 ± 314.39
Texture- viscosity	−7.16 ± 7.15*	−277.40 ± 93.73
Total soluble solids	7.50 ± 0.24***	5.00 ± 0.37

Values are means ± SDs. *$P < 0.05$; ***$P < 0.001$.

similar appetite-suppressing effects, overweight/obese adolescents would need approximately 4.17 g of L-citrulline per day [40]. Despite promising animal model results, no studies have yet examined the effect of L-citrulline on appetite response in humans, particularly adolescents. Future research is needed to confirm these mechanisms and establish safe and effective dosages for adolescents.

In the sensory evaluation, blenderized WM without rind was found to have greater flavor, sweetness, and overall acceptance compared to blenderized WM with rind. Overall acceptance was greater in blenderized WM without rind compared to blenderized WM with rind in the present study. Similarly, a study by Zhang et al. [41] observed an average greater acceptance score for blenderized WM without rind compared to blenderized WM with rind on a seven-point hedonic scale in adults. The triangle test in the current study demonstrated that most participants (70 %) correctly differentiated between blenderized WM with flesh only and blenderized WM with both flesh and rind. The study by Zhang et al. [41] also discovered that 91 % of adult participants could successfully differentiate between blenderized WM with and without rind. This suggests that both adults and children can successfully differentiate between the two samples.

A study conducted by Ramirez et al. [25] found that blenderized WM with up to 20 % added rind was deemed acceptable among panelists. The inclusion of 30 % rind received the lowest score in overall liking, suggesting a neutral (not negative) impact on consumer acceptance. Blenderized WM samples with 0 % and 10 % rind levels were given the highest scores for overall liking (6.9 and 6.6, respectively) based primarily on sweetness and having sufficient watermelon flavor [25]. Given these results, blenderized WM beverages containing up to 10 % rind may appeal to consumers, offering additional nutritional benefits and environmental advantages from consuming WM rind.

The entire watermelon fruit is edible yet its rind, which is rich in nutrients, is frequently discarded. Though WM rind is known to be a good source of dietary fiber and L-citrulline [20,42], it has also been reported to have appreciable amounts of phosphorus (135.24 mg/100 g), calcium (29.15 mg/100 g), sodium (12.65 mg/100 g), vitamin A (retinol, 52.13 mg/100 g), and vitamin C (ascorbic acid, 8.46 mg/100 g) [20]. These findings indicate that consumption of WM rind can contribute to RDA requirements and have led researchers to assess various methods of using powderized and fresh WM rind to harness the nutritional properties of this component while simultaneously decreasing solid waste [20,42]. In the context of sustainable food practices, consumption of WM rind emerges as an environmentally friendly strategy to mitigate food waste.

While blending rind with WM flesh is an easy method to boost rind consumption, it is worth noting that WM rind can also serve as a vegetable or a functional ingredient in cooking and baking. For instance, WM rind is commonly pickled and served as a condiment with meats or as a relish in the Southern U.S [43]. Furthermore, Naknaen et al. [42] utilized WM rind powder (WRP) as a substitute for wheat flour in cookies and reported that incorporating up to 20 % WRP resulted in an acceptable cookie with increased dietary fiber content, reduced glycemic index, and improved antioxidant levels. WM rind has also been dehydrated into a candy and incorporated into cake, with replacement of 5–10 % WRP for wheat flour resulting in an acceptable product [44]. More effort should be allocated towards developing, promoting, and employing methods that incorporate nutrient-dense WM rind into foods and beverages to reduce environmental waste. Additionally, assessing the palatability of frozen blenderized WM among children would be valuable to determine if it results in a more appealing and palatable product, thereby promoting increased consumption of this nutrient-dense food. The potential to augment consumption of WM rind remains promising.

In conclusion, the present study found that blenderized watermelon (WM) consumption resulted in lower postprandial glucose levels and greater feelings of fullness compared to sugar-sweetened beverage (SSB) consumption in overweight and obese adolescents. These findings suggest that blenderized WM not only helps stabilize postprandial glucose but also promotes satiety, making it a potentially beneficial alternative to SSBs. Choosing blenderized WM over SSBs and other refined-sugar-rich foods and beverages could offer a more nutritious and satisfying snack option for adolescents, contributing to healthier dietary habits and improved metabolic outcomes.

CRediT authorship contribution statement

Caitlin Rasmussen: Writing – original draft, Validation, Investigation, Data curation. **Martin Rosas:** Investigation, Data curation. **Isabella Gallardo:** Writing – original draft, Validation, Investigation, Data curation. **Anna J. Kwon:** Writing – review & editing, Data curation. **Hoa Luu:** Investigation, Data curation. **Changqi Liu:** Writing – review & editing, Data curation, Conceptualization. **Shirin Hooshmand:** Writing – review & editing, Conceptualization. **Mark Kern:** Writing – review & editing, Conceptualization. **Mee Young Hong:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Data availability statement

Data will be available from the principal corresponding author upon reasonable request.

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Declaration of competing interest

Authors disclose no conflict of interest.

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