

Research article

Effects of Coconut Cider Vinegar Gummy on Hunger, Satiety, and Sensory Acceptance in Overweight and Obese Individuals

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ABSTRACT

Consuming fruit-based vinegar offers various health benefits. Thailand exports coconut products to various countries around the world. As a result, vinegar products have been developed using coconut flower sap and further refined into gummy form for consumer convenience. Studies have found a relationship between the consuming high-acetic acid fermented vinegar and an increased feeling of fullness. However, it remains unclear about the effects of coconut cider vinegar on satiety due to limited study. This study aimed to study levels of hunger, satiety, fullness, and appetite after consuming coconut cider vinegar gummy and coconut cider vinegar vegan gummy, and sensory acceptance. The research comprised two phases: 1) Hunger-satiety assessment 2) Sensory evaluation phase. Seventy-seven subjects who had body mass index (BMI) between 23 - 30 kg/m², consuming at least two main meals per day, and who were not vegetarians, were included and divided into four groups: 1) General gummy product group (control group), 2) Coconut cider vinegar gummy group (CCV group), 3) Coconut cider vinegar vegan gummy group (CCV vegan group), and 4) Apple cider vinegar gummy group (Positive control group). Each group consumed the gummy product twice daily (6-8 pieces per time). The assessment of hunger, satiety, fullness, and appetite was conducted using Visual Analog Scales. In the sensory evaluation phase, participants from previous phase were continued. They received all four formulas of gummy to assess sensory acceptance in terms of color, aroma, taste, aftertaste, and overall preference by using a 9-point hedonic scale. Results indicated that hunger scores significantly decreased in the CCV, CCV vegan, and ACV groups. Fullness and appetite scores significantly decreased in all four groups. Satiety significantly increased in the CCV, CCV vegan, and ACV groups. Additionally, The Coconut cider vinegar vegan gummy received the highest aroma and taste scores.

Key words: coconut cider vinegar, gummy product, hunger, satiety, fullness, appetite, sensory acceptance.

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บทความวิจัย

ผลของการบริโภคผลิตภัณฑ์กัมมี่จากน้ำส้มสายชูหมักดอกมะพร้าว ต่อการเปลี่ยนแปลงระดับความทิว ความอิ่ม ความเต็มอิ่ม ความอยากอาหาร และการ ยอมรับทางประสาทสัมผัสในกลุ่มผู้มีภาวะน้ำหนักเกินและโรคอ้วน

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บทคัดย่อ

การบริโภคน้ำส้มสายชูหมักจากผลไม้มีประโยชน์ต่อสุขภาพหลายด้าน และประเทศไทยมีการส่งออกผลิตภัณฑ์จากมะพร้าวไปยังหลายประเทศทั่วโลก จึงได้มีแนวคิดพัฒนาผลิตภัณฑ์น้ำส้มสายชูจากดอกมะพร้าว และปรับรูปแบบให้อยู่ในรูปแบบกัมมี่เพื่อความสะดวกในการบริโภค มีการศึกษาที่พบว่าการบริโภคน้ำส้มสายชูหมักที่มีกรดอะซิติกสูงมีความสัมพันธ์กับความรู้สึกอิ่มที่เพิ่มขึ้น แต่อย่างไรก็ตามการศึกษาผลของน้ำส้มสายชูหมักจากดอกมะพร้าวยังมีอยู่อย่างจำกัด ดังนั้นการศึกษานี้มีวัตถุประสงค์เพื่อศึกษาระดับความทิว ความอิ่ม ความเต็มอิ่ม และความอยากอาหารจากการบริโภคน้ำส้มสายชูจากน้ำมะพร้าวในรูปแบบกัมมี่ และกัมมี่วีแกน รวมถึงทดสอบการยอมรับทางประสาทสัมผัส โดยการวิจัยแบ่งออกเป็น 2 ระยะ ได้แก่ 1) การประเมินความทิวและความอิ่ม 2) ระยะการประเมินการยอมรับทางประสาทสัมผัส การศึกษานี้มีอาสาสมัครจำนวน 77 คน เป็นผู้ที่มีค่าดัชนีมวลกาย (BMI) อยู่ระหว่าง 23 - 30 กก./ม² มีพฤติกรรมการบริโภคอาหารมื้อหลักอย่างน้อยวันละ 2 มื้อ และไม่รับประทานมังสวิรัติ โดยแบ่งออกเป็น 4 กลุ่ม ได้แก่ 1) กลุ่มควบคุม (กัมมี่ทั่วไป) 2) กลุ่มกัมมี่น้ำส้มสายชูหมักจากดอกมะพร้าว 3) กลุ่มกัมมี่น้ำส้มสายชูหมักจากดอกมะพร้าวสูตรวีแกน 4) กลุ่มกัมมี่น้ำส้มสายชูแอปเปิลไซเดอร์ โดยแต่ละกลุ่มบริโภคกัมมี่วันละ 2 ครั้ง ครั้งละ 6-8 ชิ้น โดยการประเมินความทิวและความอิ่มใช้แบบประเมินมาตราวัดระดับความทิวและความอิ่ม ในระยะการประเมินการยอมรับทางประสาทสัมผัส ผู้เข้าร่วมได้รับกัมมี่ทั้ง 4 สูตร เพื่อประเมินการยอมรับในด้านสี กลิ่น รสชาติ ความรู้สึกหลังกลิ่น และความชอบโดยรวมด้วยแบบประเมินความชอบ 9 ระดับ จากผลการศึกษาพบว่า คะแนนความทิวลดลงอย่างมีนัยสำคัญในกลุ่มกัมมี่น้ำส้มสายชูหมักจากดอกมะพร้าว กลุ่มกัมมี่น้ำส้มสายชูหมักจากดอกมะพร้าววีแกน และกลุ่มกัมมี่น้ำส้มสายชูแอปเปิลไซเดอร์ อีกทั้งคะแนนความอิ่มและความอยากอาหารลดลงอย่างมีนัยสำคัญในทั้ง 4 กลุ่ม กลุ่มกัมมี่น้ำส้มสายชูหมักจากดอกมะพร้าว กลุ่มกัมมี่น้ำส้มสายชูหมักจากดอกมะพร้าววีแกน และกลุ่มกัมมี่น้ำส้มสายชูแอปเปิลไซเดอร์ มีคะแนนความเต็มอิ่มเพิ่มขึ้นอย่างมีนัยสำคัญ นอกจากนี้กัมมี่น้ำส้มสายชูหมักจากดอกมะพร้าวสูตรวีแกนยังได้รับคะแนนความชอบด้านกลิ่นและรสชาติมากที่สุดอีกด้วย

คำสำคัญ: น้ำส้มสายชูหมักจากดอกมะพร้าว, ผลิตภัณฑ์กัมมี่, ความทิว, ความอิ่ม, ความเต็มอิ่ม, ความอยากอาหาร, การยอมรับทางประสาทสัมผัส

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INTRODUCTION

Vinegar has been used in medicine since the Hippocrates era as a disinfectant for wound curing, to relieve chronic cough, and to treat stomach aches¹. Vinegar is classified into three types: fermented vinegar, distilled vinegar, and artificial vinegar. Fermented vinegar is produced from fruits, or grains such as apples, grapes, sugarcane, and oats. The production process mainly involves two steps. The first step is fermentation using yeast in an anaerobic environment to convert sugar into alcohol. The second step is the oxidation of alcohol to acetic acid in the presence of air by acetic bacteria until a liquid is obtained, which is then distilled into vinegar with acetic acid as the main component. Fermented vinegar produced from different raw materials and components results in vinegar with unique aromas and flavors². Nowadays, Apple cider vinegar is popular among health-conscious consumers³. According to recent studies, it shows acetic acid and biochemical substances in fermented vinegar can control body weight, regulate blood and visceral fat⁴ and reduce body measurements⁵.

Thailand exports coconut products to various countries around the world, creating over ten billion baht annually for Thailand's economy. In 2018, the export of ready-made coconut milk products was the highest, with an export value of approximately 14,000 million baht. Key trading partners include the United States, the United Kingdom, Australia, Canada, the Netherlands, and Germany⁶. Continuous research and development in coconut processing have led to the development of fermented coconut water vinegar from coconut blossoms. Coconut sugar, known for its low glycemic index of 35⁷, making it

suitable for consumers who desire to control their sugar intake. Additionally, coconut blossom sap is rich in vitamin C, and vitamin E. In addition, Coconut water contains isovaleric acid and acetic acid, which give it a pungent, sour taste. In contrast, aged coconut water vinegar has phenylethyl acetate, isoamyl acetate, and benzaldehyde, contributing almond, banana, and pear-like aromas⁸. A relationship has been found between the consumption of high-acetic acid fermented vinegar and an increased feeling of fullness⁹. However, it remains unclear whether the reported effects of vinegar on satiety are due to the physiological action of short-chain fatty acids possibly through activation of FFA2 (GPR43) and FFA3 (GPR41)^{10, 11}, and effects of coconut water vinegar on satiety due to the limited study.

Anderson and colleagues¹² investigated the impact of consuming vinegar drinks versus vinegar pills on dental health. They found that the group consuming vinegar drinks showed 18% more tooth erosion compared to the control group that consumed the vinegar pills. Therefore, they advised diluting vinegar drink with water or avoiding direct contact with the mouth. Currently, Coconut cider vinegar is developed to gummy products to mitigate adverse effects from consumption and to enhance convenience for consumers. This includes expanding options for consumers by developing products in vegan formulations, which involves adjusting the product formulation from using gelatin, traditionally sourced from animals, to using pectin derived from plants. This adaptation allows individuals who are vegetarians or who avoid consuming animal products to enjoy the product.



This study aimed to evaluate the effects of coconut cider vinegar gummy and coconut cider vinegar vegan gummy on hunger, satiety, fullness, and appetite, as well as to assess sensory acceptance in terms of color, aroma, taste, aftertaste, and overall preference.

MATERIALS AND METHODS

All gummy products have been prepared and provided from Chiwadi Products Co., Ltd. One packet of gummies contains 6-8 pieces (12.5 grams). Each packet of control, coconut cider vinegar, coconut cider vinegar vegan, and apple cider vinegar gummies contain approximately 1,000 mg of cider vinegar, which contains 5% acetic acid. Additionally, all gummy products contain the same amount of sugar (8 grams).

The research has 2 phases: 1) Hunger-satiety assessment. 2) Sensory evaluation phase. 1) Hunger-satiety assessment.

The randomized, controlled clinical trial study was conducted between September 2023 and December 2023. The sample size was calculated using the formula: $n = \left[(Z_{\alpha/2} + Z_{\beta})^2 \times 2(\sigma)^2 \right] / (\mu_1 - \mu_2)^2$ ¹³ based on the mean changes in area under curve for satiety score after intervention in the control and intervention groups from the study by Ostman E, et al.⁹, which involved vinegar consumption. Taking into account a 52% drop-out rate, the final sample size was determined to be 25 participants per group. Individuals who were interested in the research project applied through announcements posted within Mahidol University, Rajvithi Campus, and via social media platforms. They were also asked to maintain their usual lifestyle, diet, and exercise routines as they had before joining the study. Individuals who had body mass

index (BMI) between 23 - 30 kg/m², consumed at least 2 main meals per day, and were not vegetarians were included. None of the individuals had underlying diseases such as asthma, cirrhosis, heart disease (heart failure, myocardial infarction), or cancer. Pregnant women, including those who planned to become pregnant within the next 6 months, or currently breastfeeding was excluded. People who consumed dietary supplements or hormones that affect weight loss, smoked, or consumed alcohol more than three times per week were excluded. At first, 204 participants were assessed for eligibility. A total of 89 participants were enrolled in the trial after being informed of the study's objectives, significance, procedures, and potential benefits. They were given time to decide before signing the informed consent form. Then, 77 Subjects were analyzed into 4 groups by a simple sampling method (drop out 13.48%): 1) General gummy product group (n=18), 2) Coconut cider vinegar gummy group (n=20), 3) Coconut water cider vegan gummy group (n=21), and 4) Apple cider vinegar gummy group (n=18) (**Figure 1**). Each group consumed the gummy product twice daily, one packet per session, 30-60 minutes before main meals, for a duration of 12 weeks. Additionally, the researchers requested that participants refrain from consuming weight loss drugs and any kind of supplements until the end of the study. Participants were instructed to keep the gummy sachets after consumption and return them to the researchers for assessing compliance. The assessment of hunger, satiety, fullness, and appetite was conducted using Visual Analog Scales (VAS)¹⁴. A reliable and validated visual analog scale incorporates a 100-mm line on a

sheet of paper, and participants are asked to mark a point on the line that corresponds to their response to the question, with end anchors of “not at all” and “extremely”. This tool was used to evaluate hunger and satiety at weeks 0, 6, and

12 (Figure 2). This research project has been approved by the Human Research Ethics Committee, Faculty of Public Health, Mahidol University. The research certification document is COA. No. MUPH 2023-101.

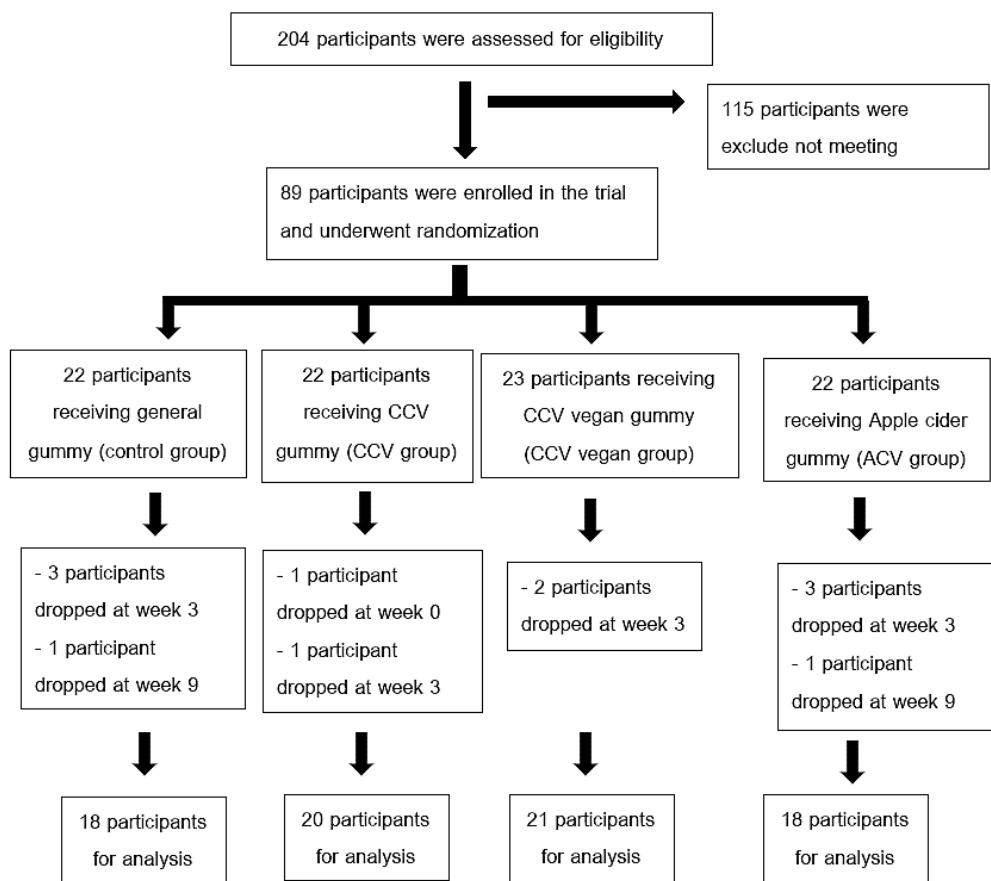


Figure 1. Conceptual framework of subject allocation.

Hunger-satiety assessment

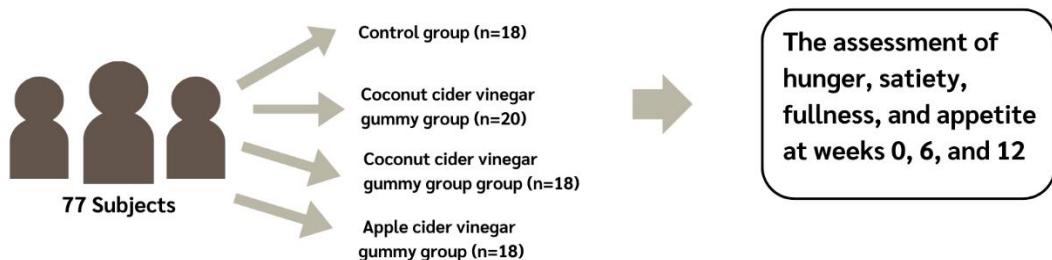


Figure 2. Hunger-satiety assessment.



2) Sensory evaluation

The researcher prepared 4 formulations:

1) General gummy, 2) Coconut water vinegar gummy, 3) Coconut water vinegar vegan gummy, and 4) Apple cider vinegar gummy. Seventy-seven individuals (21 men and 56 women; mean age: 41.01 ± 8.12) who participated in previous phase were continued. Participants received 1-2

pieces of each gummy formulas to assess sensory acceptance in terms of color, aroma, taste, aftertaste, and overall preference by using a 9-point hedonic scale (9= Like extremely, 5=Neither like nor dislike, 1=Dislike extremely) followed by **Table 1** and drank water 100 ml. for drinking after tasting. (**Figure 3**).

Sensory evaluation



Figure 3 Characteristics of the product interventions

Table 1. Grading criteria

Score	Grade
8.20-9.00	Like extremely
7.30-8.19	Like very much
6.40-7.29	Like moderately
5.50-6.39	Like slightly
4.60-5.49	Neither like nor dislike
3.70-4.59	Dislike slightly
2.80-3.69	Dislike moderately
1.90-2.79	Dislike very much
1.00-1.89	Dislike extremely

Class intervals for the 9-point hedonic scale were created by dividing the total score range (1-9, span of 8) into nine equal intervals of approximately 0.9 units each.

Data analysis using IBM SPSS Version 21.0 (IBM Corp., Armonk, NY, USA). Statistical

significance was set at a level of p -value < 0.05 . All data are presented as mean \pm standard error of mean (SEM). Characteristic baselines of participants were compared by using Chi-squared test. For quantitative data, the distribution was tested using the Shapiro-Wilk test. The color, aroma, taste, after taste, and overall preference scores of the four types of gummy products were analyzed using analysis of variance (ANOVA), and mean differences were compared using Duncan's Multiple Range Test. The scores of hunger, fullness, satiety, and appetite were analyzed within groups using One-Way Repeated Measures ANOVA. Pairwise comparisons were conducted using Duncan's New Multiple Range Test and Friedman Two-Way Analysis of Variance. Statistical comparisons between groups using One-Way ANOVA and Kruskal-Wallis One-Way Analysis of Variance.

RESULTS

The baseline characteristics of the sample group are shown in **Table 2**. The majority are female; the mean age ranged from 39.48 ± 1.90 to 42.75 ± 1.73 years for the baseline characteristics across the control, CCV, CCV

Vegan, and ACV groups. No significant differences were observed in age (p -value = 0.601), sex (p -value = 0.953), education (p -value = 0.218), occupation (p -value = 0.142), monthly salary (p -value = 0.845), or exercise frequency (p -value = 0.530).

Table 2 Baseline characteristics of the sample group¹.

Characteristic	Groups ²				p -value ³
	Control (n=18)	CCV (n=20)	CCV Vegan (n=21)	ACV (n=18)	
Age (years), mean \pm SD	41.67 ± 1.95	42.75 ± 1.73	39.48 ± 1.90	40.72 ± 1.69	0.601
Sex, n (%)					
Male	4 (22.2)	6 (30.0)	6 (28.6)	5 (27.8)	0.953
Female	14 (77.8)	14 (70.0)	15 (71.4)	13 (72.2)	
Education, n (%)					
\leq Diploma	5 (27.8)	6 (30.0)	2 (9.5)	1 (5.6)	0.218
Bachelor's degree	11 (61.1)	11 (55.0)	15 (71.4)	15 (83.3)	
\geq Master's degree	2 (11.1)	3 (15.0)	4 (19.1)	2 (11.1)	
Occupation, n (%)					
Government/University	3 (16.7)	4 (20.0)	3 (14.3)	4 (22.2)	0.142
Company employee	4 (22.2)	6 (30.0)	13 (61.9)	7 (38.9)	
Self-employed	10 (55.6)	7 (35.0)	4 (19.0)	5 (27.8)	
Other	1 (5.5)	3 (15.0)	1 (4.8)	2 (11.1)	
Monthly Salary (Baht), n (%)					
< 20,000	7 (38.9)	11 (55.0)	11 (52.4)	7 (38.9)	0.845
20,001–40,000	8 (44.4)	6 (30.0)	9 (42.9)	8 (44.4)	
> 40,000	3 (16.7)	3 (15.0)	1 (4.7)	3 (16.7)	
Exercise, n (%)					
Never	6 (33.3)	2 (10.0)	7 (33.3)	5 (27.8)	0.530
Sometimes	11 (61.1)	15 (75.0)	12 (57.1)	12 (66.7)	
Always	1 (5.6)	3 (15.0)	2 (9.6)	1 (5.5)	

¹ Values are expressed as mean \pm standard deviation (SD) for continuous variables and number (%) for categorical variables.

² CCV: Coconut Cider Vinegar; ACV: Apple Cider Vinegar.

³ The p -values were calculated using One-way ANOVA for continuous variables and Chi-square test for categorical variables.



Hunger-satiety assessment

The changes in levels of hunger, satiety, fullness, and appetite, classified by group and study duration, are shown in **Table 3**. When comparing before and after the experiment, the hunger scores decreased significantly in all groups. The mean differences (95% CI) were –13.40 (–27.44, 0.64) for the CCV group, –14.38 (–30.12, 1.36) for the CCV vegan group, and –28.50 (–54.77, –2.24) for the ACV group, indicating a greater reduction in hunger after consuming the products. The CCV group and the ACV group showed a significant reduction in hunger scores at week 6 compared to week 0. However, the CCV vegan group showed a reduction in hunger score, though the specific time could not be determined. The satiety and appetite scores reduced significantly in all four groups. The CCV group and the CCV vegan group reported significantly increased satiety at weeks 6 and 12 compared to before the experiment. The mean differences in satiety scores (95% CI) were 28.35 (13.82, 42.88) for the CCV group and 31.86 (12.84, 50.88) for the CCV vegan group, indicating a substantial improvement in satiety after product consumption. Meanwhile, the ACV group showed increased satiety at week 6 [mean difference (95% CI) = 21.00 (–2.76, 44.76)]. Additionally, all four groups experienced a significant decrease in appetite at weeks 6 and 12 compared to before the experiment. In contrast, all four groups experienced a significant increase in fullness. The CCV and CCV vegan groups reported significantly increased fullness at weeks 6 and 12 compared to before the experiment, while the ACV group reported increased fullness at week

6; Control group reported increased fullness at week 12.

Sensory analysis

The sensory acceptance test is interpreted through mean values with a scoring range as shown in **Table 4**. In the color comparison of different formulations, the CCV vegan formula received a score for color at 7.62 ± 1.51 points, which was significantly different from the control and CCV formulas ($p \leq 0.05$). In the aroma comparison of different formulations, the CCV vegan formula received the highest score for aroma at 7.45 ± 1.50 points, which was significantly different from the control, CCV, and ACV formulas ($p \leq 0.05$). In the taste comparison of different formulations, the CCV vegan formula received the highest liking score for taste at 7.56 ± 1.38 points, which was significantly different from the control, CCV, and ACV formula ($p \leq 0.05$). In the aftertaste comparison of different formulations, the CCV vegan formula received a score for aftertaste at 7.25 ± 1.46 points, which was significantly different from the CCV and ACV formulas ($p \leq 0.05$). In the overall preference comparison of different formulations, the CCV vegan formula received overall score at 7.45 ± 1.43 points, which was significantly different from the CCV and ACV formulas ($p \leq 0.05$).

Table 3 The changes in levels of hunger, satiety, fullness, and appetite, classified by group and study duration¹.

Variables	Study duration			Within-group mean difference Week 12-0 (95% CI)	p-value ²
	Week 0	Week 6	Week 12		
Hunger					
Control	58.78±5.51	42.75±6.09	40.83±6.60	-17.94 (-39.98, 4.09)	0.059
CCV	46.06±5.51	33.17±5.14*	32.65±5.13	-13.40 (-27.44, 0.64)	0.007
CCV Vegan	60.24±5.10	49.38±5.03	45.86±6.10	-14.38 (-30.12, 1.36)	0.027
ACV	54.67±6.72	30.39±5.53*	26.17±6.12	-28.50 (-54.77, -2.24)	0.002
<i>p-value</i> ³	0.281 ⁴	0.050	0.120 ⁵		
Fullness					
Control	68.00±4.95	82.40±3.93	81.47±3.73*	13.47 (2.59, 24.34)	0.017
CCV	54.11±6.56	76.22±4.58*	80.83±4.63*	26.72 (9.42, 44.02)	0.002
CCV Vegan	59.05±6.12	75.83±3.08*	82.65±2.40*	23.60 (6.30, 40.90)	0.002
ACV	56.06±6.61	76.65±4.45*	70.82±5.33	14.76 (-5.51, 35.04)	0.022
<i>p-value</i> ³	0.452	0.657	0.324		
Satiety					
Control	67.28±6.54	81.19±5.60	87.47±3.25	20.19 (1.52, 38.87)	0.052
CCV	54.65±6.33	79.22±4.74*	83.00±4.27*	28.35 (13.82, 42.88)	0.000
CCV Vegan	54.43±6.57	78.98±3.76*	86.29±2.72*	31.86 (12.84, 50.88)	0.001
ACV	56.67±7.37	81.61±4.27*	77.67±5.10	21.00 (-2.76, 44.76)	0.004
<i>p-value</i> ³	0.486	0.793	0.548		
Appetite					
Control	48.21±6.78	21.50±5.63*	25.07±6.35*	-23.14 (-36.95, -9.34)	0.000
CCV	47.05±5.10	17.68±4.44*	14.11±3.04*	-32.95 (-44.80, -21.09)	0.000
CCV Vegan	55.67±6.26	20.56±4.53*	25.39±4.57*	-30.28 (-46.17, -14.39)	0.000
ACV	50.75±4.96	23.66±5.68*	19.81±4.94*	-30.94 (-49.61, -12.26)	0.000
<i>p-value</i> ³	0.707	0.909	0.297		

¹ The values shown in the table are Mean±SEM.² The *p-value*² indicates there is a difference within the group.³ The *p-value*³ indicates there is a difference between groups.⁴ Values in regular font represent data with a normal distribution, and *p*-values are calculated using parametric tests.⁵ Values in italic font represent data with a non-normal distribution, and *p*-values are calculated using non-parametric tests.

*indicates that the value is significantly different when compared to the value at week 0.

Table 4 The changes in levels of hunger, satiety, fullness, and appetite, classified by group and study duration¹.

Types of gummies	Liking scores ³				
	Color ²	Aroma ²	Taste ²	After taste ²	Overall liking ²
Control	5.97±1.95 ^b	6.84±1.82 ^b	7.04±1.67 ^b	7.03±1.72 ^a	6.93±1.84 ^a
CCV	6.19±2.01 ^b	5.57±2.15 ^c	6.03±2.26 ^c	6.26±2.10 ^b	6.17±2.22 ^b
CCV Vegan	7.62±1.51 ^a	7.45±1.50 ^a	7.56±1.38 ^a	7.25±1.46 ^a	7.45±1.43 ^a
ACV	7.19±1.48 ^a	5.92±1.93 ^c	6.39±1.74 ^c	6.24±1.81 ^b	6.34±1.79 ^b

¹ The values shown in the table represent Mean ± SEM²The letters a-c indicate the mean values of data sets with different letters in the same column are significantly different from each other ($p \leq 0.05$)³The numbers in the table are preference scores based on a 9-Point Hedonic Scale (9= Like extremely, 5= Neither like nor dislike, 1= Dislike extremely)

DISCUSSION

This study aimed to evaluate the effects of CCV and CCV vegan gummies on subjective sensations of hunger, satiety, fullness, and appetite, along with sensory acceptance in terms of color, aroma, taste, aftertaste, and overall preference. The findings revealed that hunger levels significantly decreased in the CCV, CCV vegan, and ACV groups after the intervention, with reductions particularly evident at week 6 in the CCV and ACV groups. Satiety and appetite scores improved significantly in all groups, with the CCV and CCV vegan groups showing notable increases in satiety at both weeks 6 and 12. Fullness also increased significantly across all groups, with the most consistent improvements observed in the CCV and CCV vegan groups.

The finding aligns with the study by Ostman et al.⁹, which investigated the effects of vinegar on reducing blood glucose and insulin levels and enhancing the feeling of fullness after meals. In a sample of 12 healthy volunteers with a body mass index of $21.4 \pm 0.7 \text{ kg/m}^2$, participants were randomly assigned to consume white wine vinegar with varying acetic acid levels

of 18, 23, and 28 mmol, compared to a control group consuming white bread. Assessment of fullness showed that participants who consumed white wine vinegar experienced an increase in satiety that corresponded with the higher levels of acetic acid. This indicates that the acetic acid in vinegar contributes to an enhanced feeling of fullness. Moreover, the effect of 5% acetic acid coconut vinegar consumption in this study aligns with the study by Darzi J et al.¹⁵ that reported vinegar which contains 6% acetic acid significantly reduced quantitative and subjective measures of appetite.

Vinegar may influence appetite because acetic acid activates free fatty acid receptors that are found on GLP-1-secreting L cells, and GLP-1 (Glucagon-like peptide-1) plays a role in regulating appetite both directly and indirectly. The acetic acid in vinegar might stimulate GLP-1 release, potentially lowering food intake and reducing appetite^{16, 17}. Moreover, vinegar may be tasted beyond the oral cavity, within the gastrointestinal tract (GIT), following ingestion. Emerging evidence indicates that taste receptors and associated signaling molecules are

expressed throughout the GIT, particularly on enteroendocrine L cells in the small intestine. These cells are also responsible for secreting key appetite-regulating peptides, including glucagon-like peptide 1 (GLP-1) and peptide YY (PYY). This suggests that intraluminal taste sensing may contribute to the regulation of appetite and glycemic control, potentially offering a mechanistic explanation for the physiological effects observed following vinegar ingestion^{18, 19}. In addition, vinegar in this study is a solid form that involves chewing. Evidence indicates that chewing might reduce self-reported hunger and food intake, potentially by affecting gut hormone responses tied to feelings of fullness²⁰. While the findings are preliminary, they highlight the need for further research. Regarding feelings of fullness and reduced appetite, all four groups experienced a significant increase in fullness and a notable decrease in appetite. This effect may be because none of the groups altered their usual eating patterns, making it likely that adding the gummy product to meals enhanced feelings of fullness. Furthermore, this reduced the desire to consume additional food outside of main meals. When asked, participants in all four groups reported feeling more fullness after consuming gummy products, which prevented them from eating more during that meal.

It was found that the CCV Vegan formula received the highest preference scores in aroma and taste, which are interpreted in like moderately to like very much level. This is because the CCV vegan gummy product has a soft, smooth texture, providing a pleasant aftertaste due to the low quantity of starch. Additionally, coconut vinegar contains compounds such as phenylethyl acetate, isoamyl acetate, and benzaldehyde, which have aromas similar to almond, banana, or pear, providing a more pleasant fragrance compared to

fresh coconut water. Additionally, sensory evaluation indicates that aged vinegar tastes better⁸.

This study explores the use of coconut cider vinegar and its transformation into a gummy form, which is innovative and aligns with consumer trends toward functional and convenient health products. Moreover, study integrates both physiological outcomes (hunger, satiety, fullness, appetite) and sensory perception, offering a more comprehensive understanding of product acceptability and function. However, outcomes such as hunger, fullness, and sensory preferences were assessed through self-reported scales, which are subjective and susceptible to individual perception or expectation effects. The study should measure biological or hormonal markers (e.g., ghrelin, leptin), which could have strengthened conclusions on physiological satiety.

Conclusions

Coconut cider vinegar gummy and coconut cider vinegar vegan gummy effectively reduced hunger and appetite, while enhancing feelings of satiety and fullness over time particularly by weeks 6 and 12. These effects were most consistent in the coconut cider vinegar and coconut cider vinegar vegan groups, indicating their potential as functional foods for appetite regulation. Additionally, The Coconut cider vinegar vegan gummy received the highest aroma and taste scores, likely due to its smooth texture, low starch content, and pleasant fruity aromas from compounds in aged coconut vinegar.

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CONFLICT OF INTEREST

Chiwadi Products Co., Ltd. affirms that it is the proprietary owner of the coconut cider vinegar gummy product. The company developed the formulation and was solely responsible for manufacturing and supplying the product to the research team for use in the clinical trial. However, the company had no involvement in the clinical study, including its design, data collection, statistical analysis, or interpretation of the results.

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