



# Apple Cider Vinegar Effervescent Tablets on Gut Health, Obesity and User Experience: An Observation

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

**Background:** The escalating prevalence of obesity is a significant health concern, closely associated with non-communicable diseases like diabetes, hypertension, dyslipidemia, and coronary heart disease. Research indicates that apple cider vinegar (ACV) may aid in lowering blood glucose levels, total cholesterol, triglycerides, body weight, waist circumference, and BMI, as demonstrated in animal studies and clinical trials. The primary objective of the study is to assess the impact of apple cider vinegar effervescent tablets on overweight and obese individuals within a period of 30-days.

**Methods:** This observational study took place at the outpatient department of general medicine at Sudha Institute of Medical Science in Erode, involving 45 participants with abnormal weight. Participants consumed an apple cider vinegar effervescent tablet daily in the afternoon for 30 days,

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alongside mild exercise and a low-sugar diet recommendation. Anthropometric measurements and participant satisfaction data were collected on the 0th (baseline), 15th, and 30th days. Data analysis was conducted using Microsoft Excel, with descriptive statistics such as mean and percentage utilized.

**Results:** This study comprised 75.56% of participants aged between 18 and 40 years. 44.44% of participants fall into the overweight category. Additionally, 95.5% of participants expressed an interest in weight reduction. The results revealed that reductions of 1.13 cm in waist circumference, 1.07 cm in hip circumference, 1.46 kg in weight, and 0.58 kg/m<sup>2</sup> in BMI over the 30-day period. Following the 30-day consumption of ACV, improvements were observed in abnormal food intake and resolved issues such as digestion, appetite, constipation, cravings, and gas problems.

**Conclusion:** This study concluded that daily consumption of apple cider vinegar effervescent tablet has a positive impact on weight loss and alleviates issues related to digestion, appetite, constipation, cravings, and gas problems.

*Keywords: Obesity; apple cider vinegar; body weight and body mass index.*

## 1. INTRODUCTION

Overweight and obesity are characterized by an abnormal or excessive accumulation of fat that can negatively impact health. Body Mass Index (BMI), a widely used measure for adults, calculates weight in kilograms divided by the square of height in meters (kg/m<sup>2</sup>). The World Health Organization (WHO) defines overweight as a BMI greater than or equal to 25kg/m<sup>2</sup> and obesity as a BMI greater than or equal to 30kg/m<sup>2</sup>. Rates of overweight and obesity have been steadily rising, with a global increase in the prevalence of overweight or obese children and adolescents aged 5–19 from 4% to 18% between 1975 and 2016 [1]. As reported by the National Family Health Survey 2019–21, the prevalence of obesity and abdominal obesity stands at 13.85% and 57.71%, respectively [2]. Abdominal obesity is often assessed using waist circumference, with measurements above a specified threshold indicating an elevated risk of health issues associated with visceral fat. Genetically, Asian population tends to store more fat around the abdomen [3]. While obesity was previously considered an issue primarily in developed Western countries, it has now become a global epidemic, impacting regions worldwide, including South Asia. The rise of obesity is linked to non-communicable diseases (NCDs) such as diabetes, hypertension, dyslipidemia, and coronary heart disease [4,5]. In South Asian countries, including India, the obesity epidemic has emerged rapidly, with evidence indicating a higher risk for NCDs among those from the Indian subcontinent compared to Europeans [6]. Factors contributing to this increase include economic progress, urbanization, and a shift from traditional diets to Western-influenced diets high in saturated fats and refined sugars. Excessive white rice consumption and

inadequate physical activity also contribute to abdominal fat deposition among South Asians [7,8]. India, with a population of 1.2 billion, is estimated to have around 350 million people affected by obesity [9]. Effective strategies for managing obesity include energy intake restriction, increased physical activity, behavioral modifications, pharmacotherapy, and bariatric surgery [10]. In this context, apple cider vinegar (ACV), a plant-based product containing acetic acid, pectin, potassium, and various polyphenol compounds, has been studied for its potential benefits [11,12]. Animal studies and clinical trials suggest that ACV may contribute to reducing blood glucose levels, total cholesterol, triglycerides, fasting blood glucose, low-density lipoprotein (LDL), HbA1C, body weight, waist circumference, and BMI [13,14].

ACV liquid often presents the drawbacks of a sour and acidic taste, making it less palatable, less convenient to carry, and more susceptible to spills, especially when traveling. To address these challenges, ACV effervescent tablets are formulated with added flavors to enhance taste and overcome the issues of the liquid form. These tablets offer the advantage of a pre-determined dosage, simplifying intake for individuals. Consequently, ACV effervescent tablets are a more convenient option, providing a portable and flavorful alternative to traditional liquid ACV. This study aims to evaluate the effects of a 30-day consumption of an effervescent tablet containing apple cider vinegar on individuals with abnormal weight.

## 2. AIM

To evaluate the effects of apple cider vinegar effervescent tablets in overweight and obese individuals over a 30-day period.

### 3. OBJECTIVES

- To investigate changes in anthropometric measurements, including hip circumference, waist circumference, waist-hip ratio, weight, and BMI, before and after the ingestion of effervescent tablets containing apple cider vinegar during a 30-day timeframe.
- To understand the user experience with apple cider vinegar effervescent tablets.

### 4. METHODOLOGY

**Study design:** Observational study.

**Product used:** Apple cider vinegar effervescent tablets. Composition includes Pomegranate extract – 100mg, Apple cider vinegar – 700mg, Vitamin B12 – 1mcg, Vitamin B6 – 2mg and Beet root extract.

**Study site:** Data was collected from patients attending the outpatient of general medicine department at Sudha Institute of Medical Science in Erode, Tamil Nadu.

**Sampling technique:** Convenient sampling and those who consented.

**Inclusion criteria:** Individuals aged 18 to 60 with a BMI exceeding 25 kg/m<sup>2</sup> and patients diagnosed with lifestyle-related diseases such as diabetes mellitus and hyperlipidemia.

**Exclusion criteria:** Individuals taking four or more medications, those facing serious illnesses such as cancer or congestive cardiac failure, Non-consenters, those who have encountered heartburn attributed to vinegar, and special populations like pregnant and lactating women.

**Study procedure:** A specially designed questionnaire was used to collect demographics,

medical and medication history and the satisfaction levels. Anthropometric measurements were recorded by the researchers. The user experience survey covered such as food intake and issues like digestion, constipation, cravings, and gas-related concerns. The study involved 45 participants exhibiting abnormal weight. Based on BMI categories, participants were divided into four groups: overweight, obese class 1, obese class 2 and severe obesity. Participants consume an apple cider vinegar effervescent tablet daily in the afternoon for a period of 30 days. Mild basic exercise and a not too sugary diet were advised. Anthropometric measurements and participant satisfaction data following the intake of apple cider effervescent tablets were collected from participants on the 0<sup>th</sup> day (Baseline), as well as on the 15<sup>th</sup> and 30<sup>th</sup> days during the data collection period.

**Statistical analysis:** The data was entered and analyzed in a Microsoft Excel spreadsheet. Descriptive statistics such as mean and percentage were derived.

### 5. RESULTS

A total of 45 participants were involved in this study. Table 1 Demonstrated the distribution of participant ages, revealing a majority (37.78%) in the 18–30 years and 31–40 years age groups. Table 2 indicates that this study included 60% female participants and 40% male participants.

Table 3 Categorizes participants based on BMI, 80% of the participants were overweight and obese class 1 patients.

Table 4 Demonstrates that 11.11% of participants have thyroid problems, and 4.44% experience issues such as high blood pressure, Type 2 DM, and gastritis.

**Table 1. Age distribution of participants**

Age (in years)	Number of participants	Percentage of participants
18 – 30	17	37.78%
31 – 40	17	37.78%
41 – 50	6	13.33%
51 – 60	5	11.11%
<b>Total</b>	<b>45</b>	<b>100%</b>

**Table 2. Gender distribution of participants**

Gender	Number of participants	Percentage of participants
Male	18	40%
Female	27	60%
<b>Total</b>	<b>45</b>	<b>100%</b>

**Table 3. BMI based participant classification**

BMI Classification	Number of participants	Percentage of participants
Overweight	20	44.44%
Obese class 1	16	35.56%
Obese class 2	7	15.56%
Severe obesity	2	4.44%
<b>Total</b>	<b>45</b>	<b>100%</b>

**Table 4. Participant's current medical problem**

Current health problem	Number of participants	Percentage of participants
Thyroid	5	11.11%
Hypertension	2	4.44%
Type 2 Diabetes mellitus	2	4.44%
Gastritis	2	4.44%
Knee and hip pain	1	2.22%
Rheumatoid arthritis	1	2.22%
PCOD	1	2.22%
Wheezing	1	2.22%
<b>Total</b>	<b>15</b>	<b>33.31%</b>

**Table 5. Physical activity among study participants during baseline**

Physical activity	Number of participants	Percentage of participants
<b>Exercise</b>	12	26.6%
<b>Type of physical activity:</b>		
Walking	7	15.5%
Yoga	1	2.2%
Running	3	6.7%
Boxing	1	2.2%
<b>Total</b>	<b>12</b>	<b>26.6%</b>
<b>Timing of physical activity:</b>		
<30 minutes per day	6	13.3%
30-60 minutes per day	5	11.1%
>60 minutes per day	1	2.2%
<b>Total</b>	<b>12</b>	<b>26.6%</b>
<b>Jobs involving physical activity:</b>		
Heavy	3	6.67%
Moderate	17	37.78%
Little or No	25	55.55%
<b>Total</b>	<b>45</b>	<b>100%</b>

Table 5 Reveals that 26.6% of individuals engage in regular exercise, with 15.5% of individuals doing walking and 13.3% of them performing physical activities for less than 30 minutes per day. We advised to participants to have some basic exercise and maintain a low-sugar diet throughout the 30-day period.

Table 6 Demonstrates that 95.5% of participants expressed an interest in weight reduction. However, 20% employed home remedies, and 4.4% used anti-obesity drugs for weight loss. Additionally, 93.3% of participants considered weight gain to be a problem. No individuals taking isphagula husk and probiotics.

Table 7 demonstrated that food habits, accounting for 73.33% of participants, emerged as the primary factor contributing to obesity among the participants.

Table 8 Highlights a reduction in waist circumference, hip circumference, weight, and BMI after the 30-day consumption of apple cider vinegar effervescent tablets. However, no

significant decrease in waist-hip ratio was observed during this period.

Finally, Table 9 Demonstrates that decrease in food intake, appetite, and resolution of issues such as improper digestion, constipation, cravings, and gas-related concerns following the consumption of ACV effervescent tablets.

**Table 6. Participant’s history questionnaires and their psychology related to abnormal weight**

Questionnaires	Number of participants	Percentage of participants
History of taking isphagula husk	0	0%
History of taking probiotics	0	0%
History of taking any anti-obesity drugs	2	4.4%
Taking home remedies to lose weight like honey, lemon tea, fenugreek seed water	9	20%
Participants thought weight gain is a problem	42	93.3%
Participants interested in reducing weight	43	95.5%
Participants relatives or colleagues told that you are obese/overweight	39	8.6.6%

**Table 7. Reasoning of overweight/obese**

Reasoning for abnormal weight	Number of participants	Percentage of participants
Food habits	33	73.33%
Family history	21	46.67%
Lack of physical exercise	19	42.22%
Occupation	5	11.11%
After delivery	1	2.22%
PCOD	1	2.22%

**Table 8. Variation in Anthropometric measurements before and after ACV intake**

Anthropometric measurements	Number of days	Average value	Average differences (Baseline to 30 <sup>th</sup> day)	Percentage differences (Baseline to 30 <sup>th</sup> day)
Waist circumference (cm)	0th day	99.12	1.13	1.14%
	15th day	98.67		
	30th day	97.99		
Hip circumference (cm)	0th day	104.27	1.07	1.03%
	15th day	103.93		
	30th day	103.20		
Waist - Hip ratio	0th day	0.95	0.00	0.00%
	15th day	0.95		
	30th day	0.95		
Weight (kg)	0th day	78.90	1.46	1.85%
	15th day	78.27		
	30th day	77.44		
BMI (kg/m <sup>2</sup> )	0th day	31.09	0.58	1.87%
	15th day	30.84		
	30th day	30.51		

**Table 9. Patient satisfaction questionnaire**

Questions	Number of days	Number of participants	Percentage of participants
Abnormal food intake	0 <sup>th</sup> day	34	75.56%
	15 <sup>th</sup> day	9	2%
	30 <sup>th</sup> day	0	0%
Improper digestion	0 <sup>th</sup> day	7	15.56%
	15 <sup>th</sup> day	4	8.89%
	30 <sup>th</sup> day	0	0%
Abnormal appetite	0 <sup>th</sup> day	37	82.22%
	15 <sup>th</sup> day	9	20%
	30 <sup>th</sup> day	0	0%
Constipation problem	0 <sup>th</sup> day	14	31.11%
	15 <sup>th</sup> day	4	8.89%
	30 <sup>th</sup> day	0	0%
Gas crisis problem	0 <sup>th</sup> day	27	60%
	15 <sup>th</sup> day	5	11.11%
	30 <sup>th</sup> day	0	0%
Craving problem	0 <sup>th</sup> day	39	86.67%
	15 <sup>th</sup> day	4	8.89%
	30 <sup>th</sup> day	0	0%

## 6. DISCUSSION

This study comprises of 60% female subjects. The WHO report indicates a prevalence of overweight at 38%, with 9% among men and 40% among women, while obesity prevalence stands at 13%, with 11% among men and 15% among women in adults aged 18 years and above [15]. Women, in comparison to men, tend to have a higher percentage of body fat, which is distributed differently, with more adipose tissue in the hips and thighs [16].

11.11% of individuals in the study had thyroid related health issues. Hypothyroidism, characterized by an underactive thyroid, can result in a slowed metabolism, leading to weight gain and difficulty in weight loss. Hypothyroidism is associated with decreased thermogenesis, a lower metabolic rate, and has been linked to a higher body mass index (BMI) and a greater prevalence of obesity [17].

The findings of this study indicate that 93.3% of participants perceive obesity as the foremost health concern, 95.5% expressing an interest in weight loss, and 4.4% took anti-obesity medications for weight management. Kissin et al. [18] reported that 82% of individuals identified obesity as the primary health threat, 39% attempting weight loss, 65% adopting dietary and exercise regimens, and 14% utilizing prescribed medications for weight reduction [18].

The study results indicate that dietary habits are the predominant contributors to abnormal weight

among the participants. Major factors associated with obesity include irregular food consumption, lack of physical activity, and genetics [1]. Furthermore, only 26.6% of the study participants engaged in one or other physical activity daily. A study by Williamson et al. in 2005 concluded that individuals in the low-activity group were three to four times more likely to experience weight gain than those in the more active group [19].

The results of this study indicate a reduction in weight, BMI, waist circumference, hip circumference, and waist-hip ratio. In a study conducted by Kondo et al. in 2009, a double-blind study conducted in obese Japanese individuals noted a reduction in BMI, body weight, waist circumference, hip circumference, and waist-hip ratio among those who consumed vinegar over a 12-week period [20]. Similarly, a randomized controlled trial by Khezri et al. in 2018 found that apple cider vinegar, along with a restricted calorie diet, led to a decrease in appetite, body weight, BMI, hip circumference, waist circumference, and waist-hip ratio in overweight or obese individuals over a 12-week period [14].

Techavichian et al. in 2020 concluded that individuals consuming apple cider vinegar for 4 weeks experienced a reduction in waist circumference, hip circumference, and waist-hip ratio [21]. Jafarirad et al. in 2023 aimed to evaluate the long-term effects of apple cider vinegar consumption for 8 weeks on various health indicators in patients with type 2 diabetes

mellitus and found significant decreases in weight, BMI, waist circumference, hip circumference, and waist-hip ratio [22].

de Dios Lozano et al. 2012, this study was to evaluate the dietary effects of vinegar on body weight and blood metabolites of healthy rats fed with a conventional diet and of obese rats fed with a high-caloric diet. Twenty male Wistar rats 8 to 9 weeks of age with an average body weight (BW) of 152.5 g and both healthy and obese individual groups were included in this study. There were 2 groups of rats, one group was fed with conventional diet and another group was fed with the high caloric diet for 4-week than obese and normal rats further divided into 2 groups: control group (water treated) and interventional group (vinegar treated). This study results indicated that vinegar supplementation reduced weight in both healthy and obese rats as compared to control group rats [23].

The mechanisms driving the effects of vinegar encompass a reduction in lipogenesis achieved through a decrease in the transcripts of lipogenic genes in the liver, increased energy expenditure via the up regulation of peroxisome proliferator-activated receptor  $\alpha$  gene and fatty acid oxidation-related enzyme expression, and an increase in satiety coupled with a decrease in energy intake. These effects are attributed to vinegar's impact on lowering the glycemic index of foods [24-26].

The study participants experienced decreased appetite, reduced food intake and satisfied with their digestion problems, constipation, gas related experience in the 30day study period. ACV can enhance glycemic status through various mechanisms, including delaying gastric emptying, improving cellular glucose utilization and lipolysis, suppressing hepatic glucose production and lipogenesis, and facilitating insulin secretion [13]. A study by Hjorth et al. in 2020 concluded that apple vinegar can alleviate constipation problems faced by patients with schizophrenia treated with clozapine [27].

## 7. CONCLUSION

Consistent consumption of apple cider vinegar effervescent tablets led to a reduction in waist circumference, hip circumference, waist-hip ratio, weight, and BMI. Additionally, apple cider vinegar effervescent tablets were observed to reduce appetite, lower food intake, and resolve issues such as digestion problems, constipation, gas-

related concerns, and cravings over a 30-day period.

## CONSENT

As per international standards or university standards, Participants' written consent has been collected and preserved by the author(s).

## ETHICAL APPROVAL

Registration number is ECR/948/Inst/TN/2023/RR-22 and ethical approval from the Institutional Ethical Committee (IEC) at Sudha Institute of Medical Science.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Obesity and overweight. World Health Organization; 2024 Jan 26. Available: <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>
2. Gupta RD, Tamanna N, Siddika N, Haider SS, Apu EH, Haider MR. Obesity and abdominal obesity in Indian population: Findings from a nationally representative study of 698,286 participants. *Epidemiologia*. 2023 May 12;4(2):163–72. DOI:10.3390/epidemiologia4020017
3. Wang S, Liu Y, Li F, Jia H, Liu L, Xue F. A novel quantitative body shape score for detecting association between Obesity and hypertension in China. *BMC Public Health*. 2015 Jan 17; 15(1). DOI: 10.1186/s12889-014-1334-5
4. Jayawardena R, Byrne NM, Soares MJ, Katulanda P, Hills AP. Prevalence, trends and associated socio-economic factors of obesity in South Asia. *Obesity Facts*. 2013;6(5):405–14. DOI: 10.1159/000355598
5. Caballero B. The global epidemic of obesity: An overview. *Epidemiologic Reviews*. 2007 May 2; 29(1):1–5. DOI: 10.1093/epirev/mxm012

6. Misra A, Khurana L. Obesity-related non-communicable diseases: South Asians vs White Caucasians. *International Journal of Obesity*. 2010 Jul 20;35(2):167–87. DOI: 10.1038/ijo.2010.135
7. Williams R, Periasamy M. Genetic and environmental factors contributing to visceral adiposity in Asian populations. *Endocrinology and Metabolism*. 2020 Dec 31;35(4):681–95. DOI: 10.3803/enm.2020.772
8. Gupta RD, Tamanna N, Akonde M, Gavi S, Haider SS, Chakraborty PA. Prevalence and factors associated with abdominal obesity among Bangladeshi adults: Evidence from a Nationally Representative Survey. *Obesity Medicine*. 2022 Aug;33:100427. DOI: 10.1016/j.obmed.2022.100427
9. Ahirwar R, Mondal PR. Prevalence of obesity in India: A systematic review. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*. 2019 Jan;13(1):318–21. DOI: 10.1016/j.dsx.2018.08.032
10. The Practical Guide: Identification, evaluation, and treatment of overweight and obesity in adults: North American Association for the study of obesity: Free download, Borrow, and streaming. [Bethesda, Md.]: National Institutes of Health, National Heart, Lung, and Blood Institute, NHLBI Obesity Education Initiative, North American Association for the Study of Obesity; 1970 [cited 2024 Jan 26]. Available: <https://archive.org/details/practicalguideid00nort>
11. Rose V. Apple cider vinegar: History and folklore-composition-medical research-medicinal, cosmetic, and household uses-commercial and home production. *iUniverse*. 2006;164 p.
12. Shahidi F, McDonald J, Chandrasekara A, Zhong Y. Phytochemicals of foods, beverages and fruit vinegars: Chemistry and health effects. *Asia Pac J. Clin. Nutr*. 2008;17(Suppl 1):S380–2.
13. Kausar S, Abbas MA, Hajra Ahmad NY, Ahmed Z, Humayun N, Ashfaq H, et al. Effect of apple cider vinegar in type 2 diabetic patients with poor glycemic control: A randomized placebo controlled design. *Health Sci*. 2019;8(2):149–59.
14. Khezri SS, Saidpour A, Hosseinzadeh N, Amiri Z. Beneficial effects of apple cider vinegar on weight management, visceral adiposity index and lipid profile in overweight or obese subjects receiving restricted calorie diet: A randomized clinical trial. *Journal of Functional Foods*. 2018 Apr;43:95–102. DOI: 10.1016/j.jff.2018.02.003
15. WHO. Media Centre [Accessed December 3, 2020]: Obesity and overweight; 2016. Available: <http://www.who.int/mediacentre/factsheets/fs311/en/>
16. Manolopoulos KN, Karpe F, Frayn KN. Gluteofemoral body fat as a determinant of metabolic health. *Int J Obes*. 2010;34:949–959. DOI: 10.1038/ijo.2009.286
17. Danforth E, Jr, Horton ES, O'Connell M, Sims EA, Burger AG, Ingbar SH, et al. Dietary-induced alterations in thyroid hormone metabolism during overnutrition. *J Clin Invest*. 1979;64:1336–47.
18. Kissin R, Khoury L, Wallenborn G, Kothari SN. When the COVID-19 pandemic collides with the obesity epidemic in the United States: A national survey. *Surgery for Obesity and Related Diseases*. 2023 May;19(5):434–9. DOI: 10.1016/j.soard.2023.02.020
19. Williamson DF, Madans J, Anda RF, Kleinman JC, Kahn HS, and Byers T. Recreational physical activity and ten-year weight change in a US national cohort. *Int J Obes Relat Metab Disord*. 1993;17:279 – 286.
20. Kondo T, Kishi M, Fushimi T, Ugajin S, Kaga T. Vinegar intake reduces body weight, body fat mass, and serum triglyceride levels in obese Japanese subjects. *Bioscience, Biotechnology, and Biochemistry*. 2009 Aug 23;73(8):1837–43. DOI: 10.1271/bbb.90231
21. Maneerat Techavichian, Yanisa Thapcharoen, Suwimol Sapwarobol et al. Effect of cider vinegar consumption on anthropometry and body composition changes among individuals with Metabolic Syndrome. 2020;50(3):278-291.
22. Jafarirad S, Elahi M-R, Mansoori A, Khanzadeh A, Haghhighizadeh M-H. The improvement effect of apple cider vinegar as a functional food on anthropometric indices, blood glucose and lipid profile in diabetic patients: A randomized controlled clinical trial. *Frontiers in Clinical Diabetes and Healthcare*. 2023 Nov 13;4. DOI: 10.3389/fcdhc.2023.1288786



23. Juan de Dios Lozano. Supplementary effects of vinegar on body weight and blood metabolites in healthy rats fed conventional diets and obese rats fed high-caloric diets. *Journal of Medicinal Plants Research*. 2012 Jun 28;6(24). DOI: 10.5897/jmpr12.686
24. Yamashita H, Fujisawa K, Ito E, et al. Improvement of obesity and glucose tolerance by acetate in type 2 diabetic otsuka long-evans tokushima fatty (OLETF) rats. *Biosci Biotechnol Biochem*. 2007;71:1236–1243.
25. Yamashita H, Maruta H, Jozuka M, et al. Effects of acetate on lipid metabolism in muscles and adipose tissues of type 2 diabetic otsuka long-evans tokushima fatty (OLETF) rats. *Biosci Biotechnol Biochem*. 2009;73:570–576.
26. Kondo T, Kishi M, Fushimi T, et al. Acetic acid upregulates the expression of genes for fatty acid oxidation enzymes in liver to suppress body fat accumulation. *J Agric Food Chem*. 2009;57:5982–5986.
27. Hjorth P, Petersen SM, Launholt TL, Nielsen CT. Effect of apple vinegar intake on metabolic parameters and constipation in patients with schizophrenia treated with clozapine: A pilot study. *Nordic Journal of Psychiatry*. 2020 Aug 7;75(2):152–4. DOI: 10.1080/08039488.2020.1799432

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