

Abstract

- In 2017-2018, 42.2% of the adult population living in the US was obese (BMI \geq 30 kg/m²). This greatly increases risk for cardiovascular disease (CVD), which is the top cause of death in the United States.
- People with CVD are encouraged to reduce dietary saturated fat, and cholesterol in a DASH diet-style of eating.
- Substituting fat in recipes is difficult due to its important role in the cooking process, such as, heat transfer, tenderizing, and emulsification. Desserts, such as brownies, are traditionally high in saturated fats.
- Zucchini is a nutrient-dense squash that can be used as a fat-substitute in baked goods.
- This study concluded that zucchini brownies, resulting in reduced saturated fat, cholesterol, and calories, may be a palatable alternative to traditional brownies. These brownies align more closely with a heart healthy diet.

Introduction

- Prevalence:** Obesity is associated with increased risk for CVD, hypertension, and stroke. The most common form of CVD diagnosed is coronary artery disease (CAD). In 2017, 18.2 million adults had CAD. 1 in 4 deaths in the US are attributed to CVD.
- Nutritional recommendations:** For those with CVD, 5-6% of total energy intake should come from saturated fats. Cholesterol intake should be below 200 mg per day. The DASH diet is commonly prescribed to CVD patients. Dietary Approaches to Stopping Hypertension (DASH) emphasizes a reduction in dietary sodium by focusing on the high intake of fruits, vegetables, nuts, whole grains, lean protein, and low-fat dairy. Weight loss may also be recommended by calorie deficit.
- Health benefits:** A reduced fat DASH diet improves serum lipid levels (HDL, LDL, Total-C, etc.) and resting blood pressure. DASH diet also provides beneficial micro and macro nutrients.
- Role of fats in foods:** Saturated fats (SFs) have superior roles in heat transfer, tenderizing, and emulsification. SFs greatly improve texture and can be difficult to substitute.
- Zucchini is a nutrient-dense and low-calorie squash that can be used as a fat-substitute in baked goods.
- Study purpose:** Brownies, and other desserts, are usually high in SFs and cholesterol. The purpose of this experiment was to develop a palatable reduced fat brownie using zucchini as a fat substitute.



Figure 1. Zucchini brownie and control brownie Recipe Testing #1



Figure 2. Control brownie and Zucchini brownie Recipe Testing #2

Methods and Materials

- Design and Subjects:** To create a palatable reduced fat brownie, four testing attempts were to compare a traditional brownie (control) and a reduced fat zucchini brownie (experimental). The subjects (n=9) for this study included college students, their instructor, and two outside participants.
- Setting:** The study took place at Fontbonne University's food science laboratory.
- Recipe Formations:** The control brownie was a traditional full-fat brownie. The experimental formulations varied, with each testing attempt, in total fat, saturated fat, cholesterol, total calories, and zucchini preparation methods.
- Sensory and Objective Evaluation:** To evaluate sensory data, the control and experimental brownies, the subjects were asked to rate the color, flavor, texture, and appearance using a hedonic scale. The objective measure of brownie height was recorded after 3 of the 4 testing attempts. These sensory and object measures informed later formulations in attempt to create the most palatable reduced fat brownie.
- Data Analysis:** Data was examined through descriptive statistics, most notable, mean scores.
- Nutritional Analysis:** Nutritional analysis was completed using Cronometer.com.
- Materials:** 8x8 baking pans, large mixing bowls, medium sized mixing bowls, baking spatulas, measuring spoons, measuring cups, whisks, egg yolk separators, graders, chef's knives, cutting boards, cheesecloths, baking spray, refrigerator, microwave, conventional ovens, ruler

Results

- Testing #1:** The overall score for the control was 4.4 (for attempts 1-3) and 3.85 for the experimental. A common comment for the experimental brownie related to poor texture and appearance.
- Testing #2:** The overall score for the experimental was 4.0.
- Testing #3:** The overall score for the experimental brownies was 4.1 (batch 1) and 4.3 (batch 2). All values and comments were notably improved when compared to control. *Note: the hedonic scale was ranked from 1 to 5. Lower values may be associated more unpleasant tasting experiences, and vice-versa.*
- Testing #4:** The overall score for the control was 3.15 and the experimental brownies were 2.25 (batch 1) and 2.5 (batch 2). *Note: The hedonic scale and scorecard was changed for testing #4. Values close to 3 may indicate a more pleasant experience.*

Table 1. Nutritional Comparison between Brownie Types

Nutrient	Control (% DV)	Zucchini (% DV) with whole egg	Zucchini and egg white (% DV)
Calories (Kcals)	260	209	191
Total fat (g)	13.9 (21)	8.3 (13)	6.4 (10)
Saturated fat (g)	8.2 (41)	4.8 (24)	3.9 (19)
Cholesterol (mg)	68.6 (23)	34.3 (11)	10.2 (3)

Figure 3. American Nutrition Label of Control and the Highest Scored Zucchini Brownies

Control Brownies			Zucchini (Egg Whites) Brownies				
Nutrition Facts			Nutrition Facts				
Serving Size: 1 Serving			Serving Size: 1 Serving				
Amount Per Serving		% Daily Value*	Amount Per Serving		% Daily Value*		
Calories	260 kcal	13 %	Calories	191 kcal	10 %		
Total Fat	13.9 g	21 %	Total Fat	6.4 g	10 %		
Saturated Fat	8.2 g	41 %	Saturated Fat	3.9 g	19 %		
Trans Fat	0.4 g		Trans Fat	0.2 g			
Cholesterol	68.6 mg	23 %	Cholesterol	10.2 mg	3 %		
Sodium	96 mg	4 %	Sodium	88.9 mg	4 %		
Total Carbohydrate	33.9 g	11 %	Total Carbohydrate	34.3 g	11 %		
Dietary Fiber	1.8 g	7 %	Dietary Fiber	2 g	8 %		
Sugars	26.1 g		Sugars	26.4 g			
Protein	3.1 g	6 %	Protein	2.3 g	5 %		
Vitamin A	7 %	Vitamin C	0 %	Vitamin A	3 %	Vitamin C	5 %
Calcium	2 %	Iron	6 %	Calcium	2 %	Iron	6 %
* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.			* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.				
Full Info at cronometer.com			Full Info at cronometer.com				

Table 2. Sensory and Objective Scores for Control and Experimental Brownies

Sensory Component	Control (mean from testing #1-3)	Testing #1	Testing #2	Testing #3 (B1; B2)	Testing #4 (control; B1; B2)
Flavor	4.38	3.75	3.9	4.1; 4.1	3.2; 2.0; 2.4
Texture	4.25	3.88	3.4	3.7; 4.7	3.2; 1.6; 2.0
Color	4.5	3.25	4.3	4.3; 4.9	3.2; 2.8; 3.0
Appearance	4.5	4.5	4.3	4.4; 4.4	3.2; 2.8; 3.0
Overall	4.4	3.85	4.0	4.1; 4.3	3.15; 2.25; 2.5
Height (mm):	13	22	Not measured	17.5; 16.7	14.0; 17.0; 17.5

Discussion

- Zucchini can be used as a fat-substitute in baked goods, such as brownies.
- Reductions in saturated fat and cholesterol in zucchini brownies meet the recommendation set by the AHA and NLA.
- Use of zucchini aligns with DASH diet and may lead to health benefits.
- Limitations to this study include inconsistent use of hedonic ratings scales and scorecards from testing #1-3 and testing #4.
- Future research needs to examine other preparation methods, such as additional egg whites or additional zucchini moisture removal.

Conclusions

- The development of a flavorful reduced fat brownie using zucchini is possible.
- Controlling moisture content of zucchini is critical when using it in baked goods.
- Incorporating zucchini brownies into one's diet can be part of a heart healthy lifestyle.

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References

- Brown, A. C. (2008). Fats and Oils. In *Understanding food: Principles and preparation* (pp. 419-443). Singapore: Cengage Learning Asia Pte.
- Heart Disease Facts. (2020, September 08). Retrieved November 30, 2020, from <https://www.cdc.gov/heartdisease/facts.htm>
- Hooper, L., Abdelhamid, A. S., Jimoh, O. F., Bunn, D., & Skeaff, C. M. (2020). Effects of total fat intake on body fatness in adults. *Cochrane Database of Systematic Reviews*. doi:10.1002/14651858.cd013636
- Hooper, L., Martin, N., Abdelhamid, A., & Smith, G. D. (2015). Reduction in saturated fat intake for cardiovascular disease. *Cochrane Database of Systematic Reviews*. doi:10.1002/14651858.cd0111737
- Hussen, H. (2016). Using vegetable puree as a fat substitutes in cake. *International Journal of Nutrition and Food Sciences*, 5(4), 284-292. <http://doi.org/10.11648/j.ij.nfs.20160504.18>
- Kirkpatrick, C., Rhodes, K., & Smith, N. (n.d). The newest nutrition recommendations to prevent heart disease. *National Lipid Association*. https://www.lipid.org/sites/default/files/tearsheet_nutrition.pdf
- Prevalence of Obesity and Severe Obesity Among Adults: United States, 2017–2018. (2020, February 27). Retrieved October 13, 2020, from <https://www.cdc.gov/nchs/products/databriefs/db360.htm>
- Review of Recommendations for Dietary Fats and Cholesterol from Various Organizations. (2017). Retrieved 2020, from https://www.andeal.org/files/DLM_CHO_Review_201706.pdf
- Stervo, M., Lara, J., Chowdhury, S., Ashor, A., O'Gillon, C., & Mathers, J. C. (2015). Effects of the Dietary Approach to Stop Hypertension (DASH) diet on cardiovascular risk factors: a systematic review and meta-analysis. *The British journal of nutrition*, 113(1), 1-15. <https://doi.org/10.1017/S0007114514003341>