

**Title of Study:** Health benefits of mango supplementation as it relates to weight loss, body composition, and inflammation: a pilot study

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## INTRODUCTION

Obesity is a serious worldwide public health problem. In 2014, the World Health Organization (WHO) estimated that 2 billion adults worldwide are overweight and of these more than half a billion are obese.<sup>1</sup> From 2011 - 2012, the prevalence of obesity in the US alone was estimated to be at approximately 34.0% among adults and 16.9% of children and adolescents are classified as obese.<sup>2</sup> Health concerns related to obesity goes beyond the presence of excess body fat but also due to the potential complications and chronic diseases associated with obesity such as type 2 diabetes (T2DM) and heart disease.<sup>3</sup>

Lifestyle changes, such as limiting food intake and increasing exercise, are effective ways to reduce obesity but require discipline.<sup>4</sup> Additionally, drugs and surgical procedures are also available as treatments in reducing body fat; however, these options are expensive and often associated with undesirable side effects and nutritional deficiencies.<sup>4</sup> Therefore, identification of natural strategies that can reduce body fat also has the potential to decrease obesity-related health complications.

Dietary interventions rich in certain fruits and vegetables, containing numerous bioactive compounds, have demonstrated beneficial effects on body weight and maintaining blood sugar (glucose).<sup>5</sup> The mango fruit (*Mangifera indica L.*) provides a number of well-known bioactive compounds that include carotenoids, vitamins E and C, dietary fiber, and phenolic compounds, such as mangiferin and quercetin.<sup>6</sup> Findings from our recent study demonstrate that freeze-dried mango pulp supplementation reduced body fat, along with improvement in blood glucose and lipid profile, in mice fed high fat diet.<sup>7</sup> Additionally, in human studies, consumption of mango pulp, when compared to other fruits, favorably affected blood glucose after a meal in individuals with T2DM.<sup>8-9</sup> Although the glucose-lowering properties of mango have been demonstrated in

animal models, the effects of long-term (chronic) mango supplementation on body composition and blood glucose in obese adults have yet to be conducted. Therefore, the *objective* of this pilot study was to investigate the effects of 12-weeks of freeze-dried mango pulp supplementation on anthropometric measurements, clinical parameters, and body composition in obese individuals. We *hypothesized* that the incorporation of mango pulp into the diet of obese adults would reduce body fat and improve glucose parameters.

## **APPROACH**

Twenty (11 males and 9 females) obese (have a body mass index, BMI of 30 - 45 kg/m<sup>2</sup>) adults (20 to 50 years old) were enrolled in the study and received 10 g/d of freeze-dried mango pulp for 12 weeks. Anthropometrics, clinical parameters, and body composition, using dual-energy x-ray absorptiometry, were assessed at baseline and at the end of the study.

## **RESULTS**

### **Part I. Body Composition and Glucose Parameters**

The effects of 12 week mango supplementation on clinical parameters of obese individuals are discussed below. The findings of this study are also reported in a published manuscript (Evans SF, Meister M, Peterson S, Perkins-Veazie P, Clarke SL, Payton M, Smith BJ, Lucas EA. Mango supplementation improves blood glucose in obese individuals. *Nutrition and Metabolic Insights*. 2014, 7:77-84).<sup>10</sup> Additionally, the findings of this study were presented at several local and national meetings.

1. Evans S, Meister M, Peterson S, Perkins-Veazie, Clarke SL, Payton ME, Smith BJ, Lucas EA. Effects of mango supplementation on clinical parameters of obese individuals. Oklahoma State University Research Week, February 21, 2013, Stillwater, OK
2. Evans S, Meister M, Peterson S, Perkins-Veazie, Clarke SL, Payton ME, Smith BJ, Lucas EA. Effects of mango supplementation on clinical parameters of obese individuals. Oklahoma Research Day, University of Central Oklahoma, March 12, 2013, Edmond, OK.
3. Evans S, Meister M, Peterson S, Perkins-Veazie, Clarke SL, Payton ME, Smith BJ, Lucas EA. Effects of mango supplementation on clinical parameters of obese individuals. Experimental Biology, April 2013; Boston, MA.
4. Evans SF, Meister M, Peterson S, Perkins-Veazie P, Clarke SL, Payton M, Smith BJ, **Lucas EA**. Effects of mango supplementation on clinical parameters of obese individuals. Harold Hamm Diabetes Center Research Symposium, October 2013, Oklahoma City, OK.

*Body Weight and Composition, Hip and Waist Circumference (Table 1)*

After 12 weeks of mango supplementation, there were no significant changes in overall body weight, hip or waist circumference, waist to hip ratio, percent fat mass, lean mass, and bone mineral content in the study participants. However, there were differences by gender in hip circumference and BMI from baseline to final visits. Hip circumference was significantly lower in male subjects (-1.4 inches,  $P = 0.048$ ) but not female subjects after the 12 weeks of mango supplementation. BMI tended to be higher in female subjects (+0.9 kg/m<sup>2</sup>,  $P = 0.062$ ) after mango supplementation but not in male subjects.

### *Glucose and Hematological Parameters and Liver Enzymes (Table 2)*

Twelve week supplementation of mango significantly reduced overall blood glucose levels (-4.1 mg/dL,  $P < 0.000$ ) in obese individuals. The glucose-lowering effects of mango was observed in both male (-4.5 mg/dL,  $P = 0.018$ ) and female (-3.6 mg/dL,  $P = 0.003$ ) subjects (Figure 1 and Table 2). Along with the reduction in blood glucose levels, insulin levels in males (+2.2  $\mu$ U/mL,  $P = 0.032$ ) were significantly increased after 12 weeks of supplementation but not in female participants. After mango supplementation, there was no change in glycated hemoglobin (Hgb A1C, hemoglobin A1C), an indicator of long-term glucose control or in HOMA-IR, an indicator of insulin resistance (Table 2). There were also no significant differences in hematological parameters and liver enzymes from the 12 weeks of mango supplementation, which reflects no adverse effects to normal blood cell composition or liver function (*data not shown but reported in the published manuscript*).<sup>10</sup>

### *Dietary Intake and Physical Activity (data not shown but reported in the published manuscript)*<sup>10</sup>

From assessments of the 3-day food recalls and physical activity questionnaires, there were no differences in these parameters in the whole study group. More specifically, no significant differences were noted in either male or female dietary intake of macronutrients, saturated fat, total dietary fiber, vitamin C, or vitamin A. In addition, evaluation of physical activity revealed no overall change as well as no change in either male or female subjects regarding their daily or weekly physical activities, whether categorized as light, moderate, or heavy. There was also no significant difference that is apparent in time spent sleeping for either gender.

## **Conclusion**

Our findings indicate that regular consumption of freeze-dried mango by obese individuals does not negatively impact body weight but provides a positive effect on blood glucose. Future studies are warranted with a larger sample size to confirm our findings and to understand the mechanism by which mango consumption reduces blood glucose.

## **Part II: Lipid and Inflammatory Markers**

Blood samples from the same study participants were used to analyze blood lipids and inflammatory markers and presented below (Table 3). Preliminary statistical analyses indicate that there were no significant changes in lipid and inflammatory markers in obese individuals after 12 weeks of mango supplementation. There were also no significant changes when study participants were analyzed by gender.

**Table 1** Effects of 12-week Freeze-Dried Mango Supplementation on Body Weight and Composition and Waist and Hip Circumference of Obese Individuals<sup>1</sup>

Variables	Overall			Gender					
	All Subjects (n = 20)			Male (n = 11)			Female (n = 9)		
	Baseline	Final	<i>P</i> -value	Baseline	Final	<i>P</i> -value	Baseline	Final	<i>P</i> -value
Weight (lbs)	219 ± 33	220 ± 33	0.698	230 ± 30	228 ± 30	0.326	206 ± 34	209 ± 35	0.215
BMI (kg/m <sup>2</sup> )	34.6 ± 4.0	34.9 ± 4.3	0.257	34.2 ± 3.1	34.0 ± 3.4	0.351	35.1 ± 5.1	36.0 ± 5.1	<b>0.062</b>
Waist circumference (in)	43.8 ± 4.4	43.8 ± 3.6	0.931	44.9 ± 1.0	44.1 ± 1.2	0.326	42.5 ± 1.7	43.3 ± 1.1	0.339
Hip circumference (in)	46.4 ± 3.8	45.9 ± 4.2	0.366	45.3 ± 0.9	43.9 ± 0.8	<b>0.048*</b>	47.7 ± 1.6	48.3 ± 1.5	0.403
Waist:hip ratio	0.95 ± 0.07	0.96 ± 0.07	0.336	0.99 ± 0.04	1.00 ± 0.06	0.401	0.89 ± 0.07	0.90 ± 0.03	0.643
% Fat mass	36.4 ± 6.7	36.6 ± 7.04	0.586	32.1 ± 5.4	32.0 ± 5.4	0.855	41.7 ± 3.4	42.3 ± 4.0	0.318
Lean mass (kg)	60.33 ± 10.02	60.39 ± 10.06	0.899	67.30 ± 4.99	67.30 ± 5.47	1.000	51.82 ± 7.70	51.95 ± 7.58	0.884
BMC (g)	2662 ± 501.5	2668 ± 515.2	0.722	2946 ± 345	2945 ± 375	0.980	2315 ± 446	2330 ± 469	0.587

<sup>1</sup>Data are mean ± SE; BMI = body mass index, BMC = bone mineral content, BMD = bone mineral density.

\*indicates a statistically significant difference (*P* value ≤0.05) from baseline to final values.

**Table 2** Effects of 12-week Freeze-Dried Mango Supplementation on Glucose Parameters of Obese Individuals<sup>1</sup>

Variables	Overall			Gender					
	All Subjects (n = 20)			Male (n = 11)			Female (n = 9)		
	Baseline	Final	<i>P</i> -value	Baseline	Final	<i>P</i> -value	Baseline	Final	<i>P</i> -value
Glucose (mg/dL)	94.4 ± 7.2	90.3 ± 5.5	<0.000*	95.6 ± 7.4	91.1 ± 5.6	<b>0.018*</b>	92.9 ± 7.1	89.3 ± 5.7	<b>0.003*</b>
Hgb A1C (%)	5.3 ± 0.3	5.3 ± 0.3	0.970	5.3 ± 0.4	5.3 ± 0.4	0.427	5.2 ± 0.1	5.3 ± 0.2	0.361
Insulin (μU/mL)	14.5 ± 9.6	14.9 ± 7.9	0.847	10.1 ± 4.5	12.3 ± 1.8	<b>0.032*</b>	20.0 ± 12	18.0 ± 9.2	0.553
HOMA-IR	3.4 ± 2.2	3.3 ± 1.7	0.833	2.4 ± 1.0	2.7 ± 1.3	0.119	4.6 ± 2.6	4.0 ± 2.0	0.418

<sup>1</sup>Data are mean ± SE; Hgb A1C = hemoglobin A1C, HOMA-IR = Homeostasis Model of Assessment-Insulin Resistance.

\*Statistically different (*P* value ≤0.05) from baseline to final values.

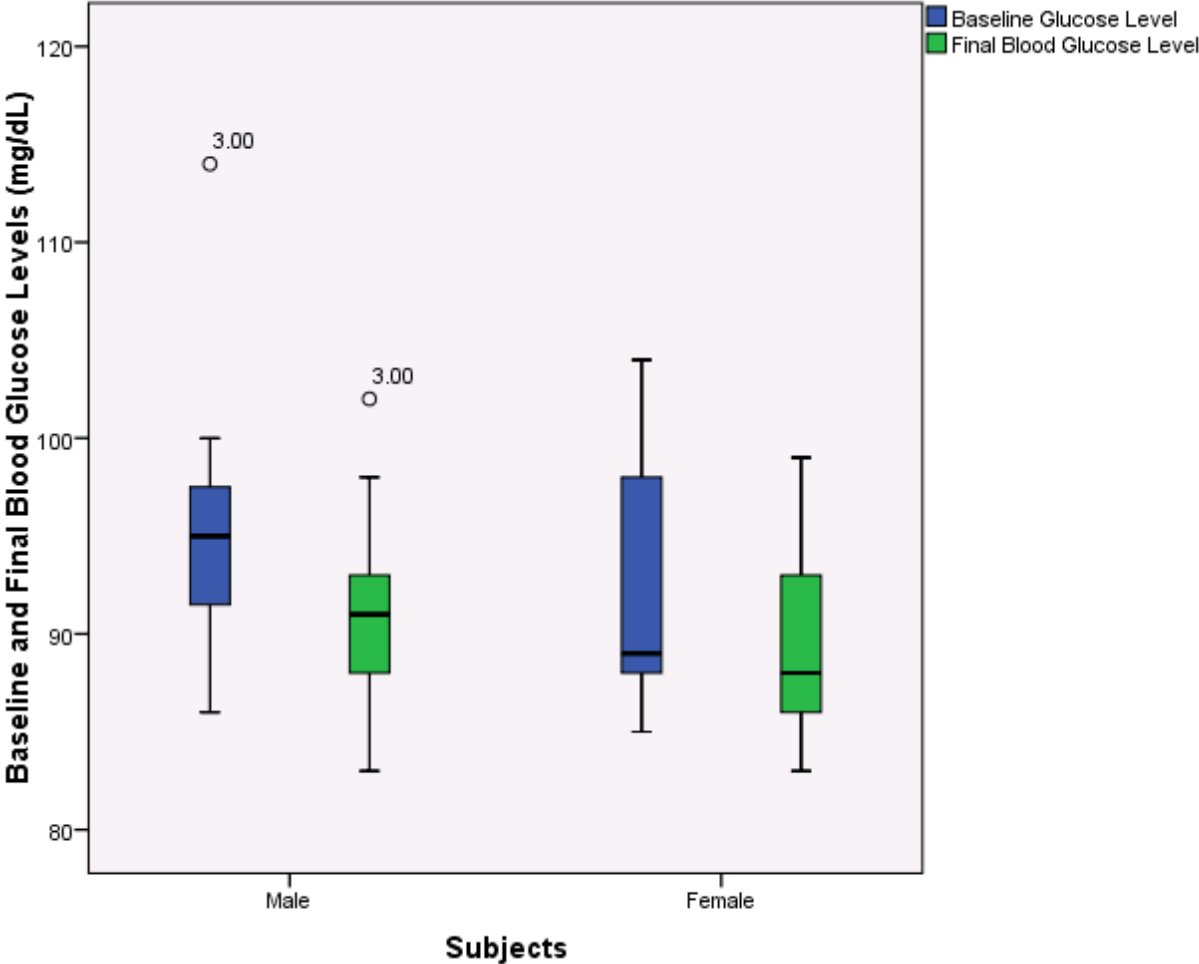


**Table 3** Effects of 12-week Freeze-Dried Mango Supplementation on Lipid, Inflammatory, and Antioxidant Markers of Obese Individuals<sup>1</sup>

Variables	Overall			Gender					
	All Subjects (n = 20)			Male (n = 11)			Female (n = 9)		
	Baseline	Final	<i>P</i> -value	Baseline	Final	<i>P</i> -value	Baseline	Final	<i>P</i> -value
<i>Lipids</i>									
Total cholesterol (mg/dL)	190.4 ± 7.2	185.9 ± 7.3	0.667	189.7 ± 9.1	184.7 ± 9.6	0.711	191.1 ± 12.0	187.3 ± 11.8	0.826
LDL cholesterol (mg/dL)	114.3 ± 6.8	112.4 ± 6.2	0.842	118.2 ± 8.6	116.9 ± 8.8	0.919	110.0 ± 11.3	107.0 ± 8.6	0.860
HDL cholesterol (mg/dL)	48.2 ± 2.8	48.2 ± 2.4	0.989	44.1 ± 2.9	44.4 ± 2.2	0.923	53.3 ± 4.9	52.8 ± 4.1	0.932
Triglycerides (mg/dL)	140.4 ± 14.7	121.3 ± 14.9	0.366	140.7 ± 18.3	117.3 ± 20.1	0.398	140.0 ± 25.0	126.2 ± 23.4	0.693
Leptin (ng/mL)	14.5 ± 2.1	15.5 ± 2.0	0.738	8.0 ± 1.8	10.5 ± 2.4	0.415	23.5 ± 1.3	22.4 ± 1.7	0.631
Adiponectin (ug/mL)	11.2 ± 2.7	11.5 ± 2.4	0.931	8.4 ± 1.0	9.4 ± 1.6	0.561	14.6 ± 6.0	13.8 ± 4.8	0.914
<i>Inflammatory markers</i>									
CRP (pg/mL)	7.0 ± 1.2	10.6 ± 2.4	0.187	7.0 ± 1.9	7.9 ± 2.1	0.753	7.0 ± 1.6	13.9 ± 4.5	0.169
IL6 (pg/mL)	24.9 ± 6.5	22.6 ± 2.9	0.747	20.6 ± 3.6	25.2 ± 4.3	0.423	31.4 ± 16.0	18.8 ± 3.1	0.453
IL10 (pg/mL)	28.8 ± 4.8	47.9 ± 17.9	0.311	24.9 ± 1.8	57.1 ± 29.8	0.297	34.6 ± 11.8	34.0 ± 6.5	0.969
IL1β (pg/mL)	11.0 ± 0.5	12.0 ± 1.2	0.467	11.4 ± 0.9	13.2 ± 1.8	0.390	10.3 ± 0.3	10.0 ± 0.7	0.719
IL17 (pg/mL)	27.8 ± 2.4	33.3 ± 5.1	0.329	29.6 ± 3.4	38.1 ± 8.1	0.353	24.7 ± 2.7	26.0 ± 2.8	0.737
TNF-α (p/mL)	14.1 ± 1.6	13.5 ± 1.1	0.744	14.0 ± 2.2	13.5 ± 1.1	0.822	14.2 ± 2.6	13.4 ± 2.2	0.831
MCP1 (pg/mL)	59.9 ± 4.6	63.7 ± 6.0	0.616	61.7 ± 4.6	66.0 ± 7.4	0.633	57.2 ± 9.6	60.3 ± 10.5	0.831
VEGF (p/mL)	39.8 ± 3.1	60.8 ± 17.3	0.244	41.9 ± 4.8	72.2 ± 28.5	0.309	36.8 ± 3.3	43.6 ± 7.1	0.408
<i>Antioxidant</i>									
SOD (U/mL)	1.07 ± 0.07	0.99 ± 0.04	0.318	1.12 ± 0.09	1.02 ± 0.05	0.375	1.01 ± 0.11	0.95 ± 0.06	0.651

<sup>1</sup>Data are mean ± SE . LDL- low density lipoprotein, HDL- high density lipoprotein, CRP- C-reactive protein, IL- interleukin, TNF- tumor necrosis factor, MCP- monocyte chemoattractant protein, VEGF- vascular endothelial growth factor, SOD- superoxide dismutase.

**Figure 1** Comparison of Fasting Blood Glucose Levels in Male and Female Obese Individuals After 12 weeks of Mango Supplementation.



Subject number 3 is an outlier in male subjects.

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