An Investigation of Grape Pomace as A Potential Functional Food Ingredient For Obesity Prevention and Weight Control

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Project Background and Objectives

Obesity is one of the top public health problems in the United States. Nutrient unbalanced diet is one of the major contributing factors of the high prevalence of obesity. Grape pomace (GP) is a renewable by-product from wine making, and is rich in fiber and polyphenols that were reported to be inversely associated with weight gain. We hypothesize that diet containing sufficient amount of GP will reduce the absorption of lipogenic food components, thus preventing weight gain. Therefore, the goal of this project is to explore the potential of GP as a functional food ingredient for weight loss and obesity prevention. This goal will be achieved through the accomplishment of three objectives: 1) investigating the fiber and polyphenol profile of the GP to be used, 2) in vitro evaluation of the effects of GP extract on the digestibility of macronutrients and the growth of probiotic bacteria using human digestive enzymes and probiotic bacteria, and 3) investigating the *in vivo* hypolipidemic effects of GP using rat model by monitoring the effects of GP inclusion on the total energy intake, weight change, macronutrient absorption, blood and fecal lipid profile, and fat deposition on the organs such as liver and heart. So far, the chemical compositions of GPs from 4 cultivars of wine grapes growing in North Carolina were characterized. Results indicate that GP has great potential as a source of dietary polyphenols, insoluble dietary fiber and healthy oil.

Activities

In the first stage of the project, following activities have been conducted to accomplish the Objective 1 to provide properly dried GP and the compositional data of GP for other objectives. This objective will be executed through the following Tasks. All measurements will be conducted in triplicate. (1) collection, dehydration and size reduction of grape pomaces (GPs), (2) determination of proximate composition and total polyphenol of GPs, (3) Identification of the profile of extractable polyphenols, (4) determination of total, insoluble, soluble dietary fiber and neutral and acid detergent fibers of dry GP powders.

During the second stage of the project, sufficient amount of polyphenol extract and soluble fiber will be prepared from ground GP powder. The effect of different fractions of GP extract on the activities of digestive enzymes and on the growth of intestinal bacteria will be evaluated by measuring the kinetics of enzymatic degradation of food components. The effect of GP extract and soluble fiber on the growth of gastrointestinal bacteria will be evaluated by determining the growth rates of the bacteria and production of acid.

During the third stage of the project, The in *vivo* hypoallergenic properties of GP will be investigated using rat model by testing the hypothesis that polyphenol and fiber rich GP functions as a satiety inducer and hypolipidemic agent to reduce total daily food and energy intake, inhibit intestinal macronutrient absorption, lower blood lipids, increase lipid and cholesterol/bile acid excretion in the feces, and reduce the fat content in organs such as liver and heart.

Evaluation Plan

Evaluation plans include evaluating the progress of project, value of GP for obesity prevention and weight loss, the impact of the proposed activities on building or strengthening the research capacity of NC A&T in nutrition.

Results

Table 1. Proximate composition of grape pomaces from different grape varieties (pomaces were dried at room temperature for two weeks)

	% Moisture	% Ash	% Protein	% Fat	% Carbohydrate
Muscadine Nobel	7.03±0.16	5.31±0.06	12.86±0.13	4.02±0.28	70.77
Muscadine Scuppernong	4.89±0.17	5.43±0.03	12.81±0.15	3.69±0.09	73.18
Cabernet Franc	5.16±0.40	5.93±0.28	14.19±0.55	5.03±0.34	69.69
Cabernet Sauvignon	5.05±0.21	5.90±0.30	13.91±0.54	6.53±0.12	68.61

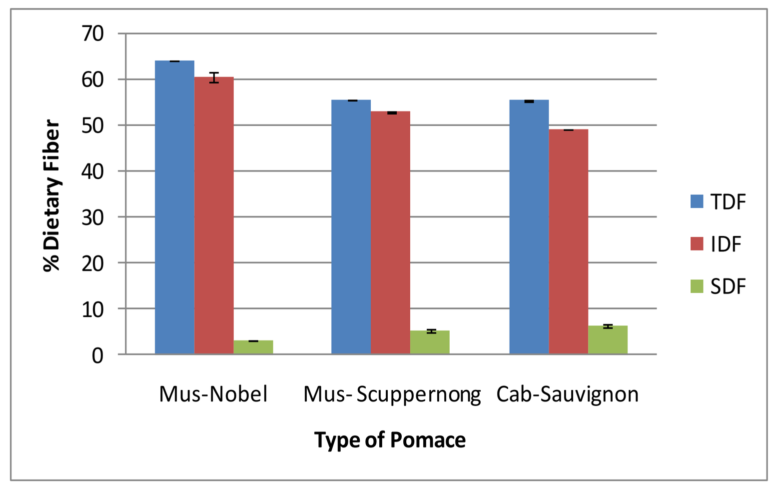

Fig.1 Total, insoluble and soluble dietary fiber (TDF, IDF and SDF) contents of grape pomaces

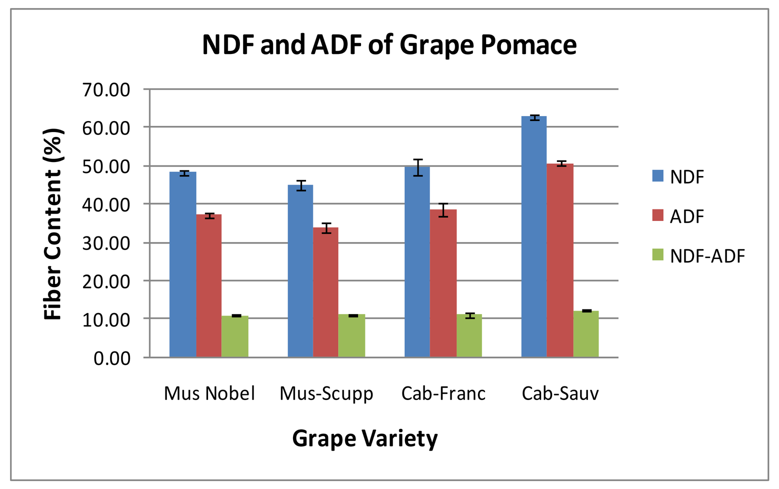

Fig.2 Neutral detergent fiber (NDF) and acid detergent fiber (ADF) of grape pomaces

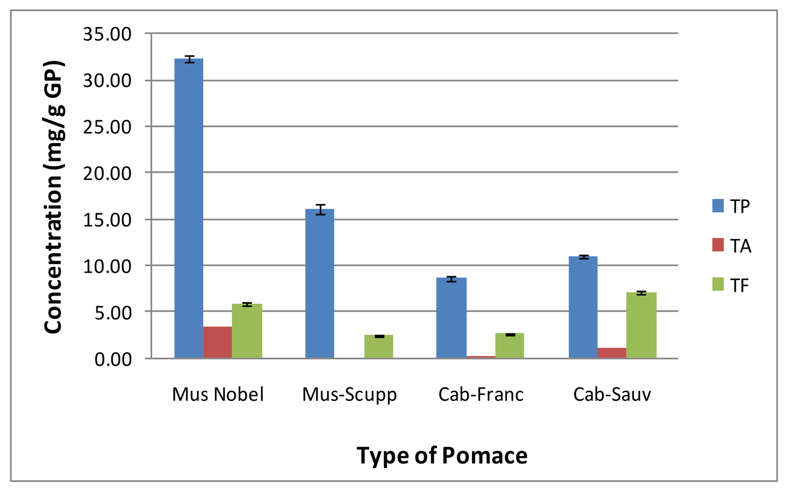

Fig.3 Phenolic composition of pomace from different grape cultivars (TP-total phenolics, TA-total anthocyanin, TF-total flavonoids)

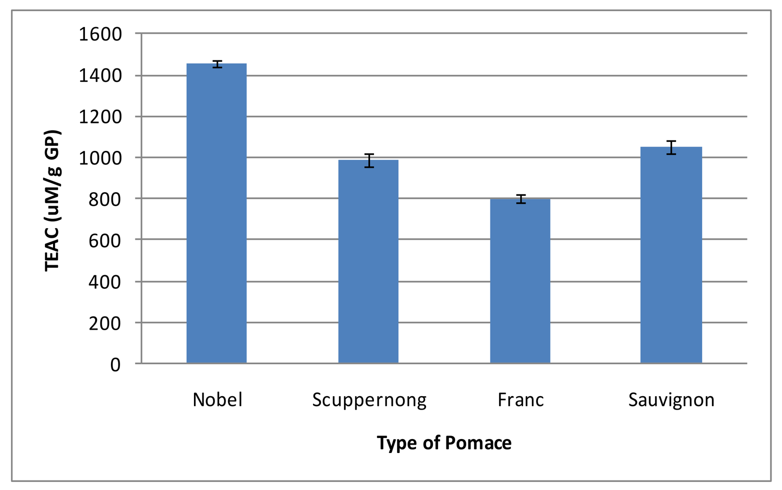

Fig.4 Comparison of antioxidant activities of pomace from different grape varieties

Table 3. Individual and total fatty acid contents in the oil extracts of grape seeds of four grape cultivars

Fatty Acid	FAME Fatty Acid (g/kg Oil) Mus Nobel	Mus Scuppernong	Cab Franc	Cab Sauvignon	Free Fatty Acid (g/kg Oil) Mus Nobel	Mus Scuppernong	Cab Franc	Cab Sauvignon
C14:0	0.14	0.14	0.28	0.35	0.01	0.01	0.01	0.01
C16:0	43.3	47.52	50.4	58.25	0.35	0.38	0.40	0.71
C18:0	27.5	42.72	32.8	33.50	0.33	0.43	0.38	0.66
C18:1	71.2	82.32	85.4	95.64	0.21	0.20	0.19	0.34
C18:2	270.3	515.03	379.9	493.57	0.49	0.37	0.52	1.49
C18:3	0.9	1.06	0.79	1.44	0.29	0.27	0.19	0.36
C20:0	0.51	1.32	0.71	1.06	0.05	0.08	0.43	0.05
TOTAL	**413.85**	**690.11**	**550.28**	**683.81**	**1.72**	**1.75**	**2.12**	**3.62**

Table 2 Fatty acid composition of grape seed oils of different grape cultivars

Fatty Acid	Grape Cultivars Muscadine Nobel	Muscadine Scuppernong	Cabernet Franc	Cabernet Sauvignon
C12:0	0.01	0.01	0.01	0.01
C14:0	0.03	0.02	0.05	0.05
C15:0	0.01	<0.01	0.01	0.01
C15:1	0.01	0.01	0.01	0.02
C16:0	10.40	6.88	9.11	8.51
C16:1	0.07	0.06	0.07	0.07
C17:0	0.06	0.05	0.04	0.04
C18:0	6.65	6.18	5.96	4.89
C18:1	17.19	11.91	15.50	13.97
C18:2	65.22	74.53	68.97	72.07
C18:3	0.22	0.15	0.14	0.21
C20:0	0.12	0.19	0.13	0.16
Saturated	17.23	13.30	15.23	13.59
Unsaturated	82.72	86.66	84.69	86.32
Monounsaturated	17.26	11.98	15.57	14.04
TOTAL	**100**	**99.99**	**100**	**100.00**

Summary of Results

Results indicated that GPs were rich in dietary fiber and polyphenols, but the composition of dietary fiber and polyphenols are variety and cultivar dependent. The high insoluble and non-digestible fiber content make GP a good source of dietary fiber in functional food development for weight control. Muscadine Nobel pomace had highest TP and TA, while Cabernet Sauvignon had highest TF. The antioxidant activities of the pomaces were in good agreement with the polyphenol contents, particularly, flavonoid content. In addition, grape seeds also contain 12.8-14.2% of lipid which is high in unsaturated fat (82.7-86.7%). This makes grape seed oil a good choice for salad dressing because it remain as liquid even at refrigeration temperature.

Expected Impacts

The results indicate that grape pomace can be used as a good source of dietary fiber, polyphenol and healthy fat in functional food development to fight obesity. Data obtained from this study provide fundamental information for the formulation of functional foods using grape pomace in terms of calculating the amount of pomace to be included in the formula and selection of proper pomace for specific product. Further research activity is undergoing to investigate the *in vitro* and *in vivo* hypolipidemic properties of grape pomace using digestive enzymes and rat model, respectively. The use of grape pomace as a functional food ingredient in new product development has potential to add value to this by-product, improve nutrition value & the health benefits of food products, lead better and less expensive functional foods for obesity prevention and weight control and have potential positive impacts on the profitability and sustainability of the food industry & small scale agricultural business such as wineries.

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