

Original Research Article

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Functional Properties of Apple Pomace Powder

Taru Negi* and Devina Vaidya

Department of Food Science and Technology, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP)

*Corresponding author

ABSTRACT

Keywords

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Apple pomace powder was analyzed for its functional properties which showed water holding capacity and fat absorption capacity of 3.39 g/g and 0.97 ml/g, respectively. Foam of apple pomace powder was not stable. Hypoglycemic potential of dietary fibers in managing diabetes is very well documented. In present study, the effect of apple pomace powder on α -amylase, glucose diffusion and glucose adsorption were studied by using *in vitro* studies. The mechanism by which dietary fiber of apple pomace powder could exerts hypoglycemic effect includes inhibiting amylase activity, glucose adsorption capacity and glucose diffusion retardation index. α -amylase inhibition ration in apple pomace powder was observed 80 per cent. Glucose diffusion retardation index (GDRI) was maximum at 30 min (69.23%) while found decreased after 30 minutes. Glucose adsorption capacity (GAC) of apple pomace powder increased gradually with increase of glucose concentration. All of these mechanisms contribute towards the rate of reduction of glucose adsorption in the intestine, as a result, decrease the postprandial serum glucose concentration.

Introduction

Apple pomace, main by-product of apple juice industry contains 66.40-78.20 per cent (wb) moisture and 9.50-22.00 per cent carbohydrates (Sun *et al.*, 2007). It can be considered as a raw material for extraction of dietary fiber, since it contains 78.20-89.80 per cent total dietary fiber content (Elleuch *et al.*, 2011). Dietary fiber is the remnants of the edible part of plants and analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the

human large intestine. It includes polysaccharides, oligosaccharides, lignin and associated plant substances (ICMR, 2009). It functions as a bulking agent and increases the intestinal mobility and moisture content of the faeces (Forsythe *et al.*, 1976). The apple fiber contained more total dietary fiber than wheat or oat bran (McKee and Latner, 2000). Apple fiber is among top five high fiber diets rich in cellulose, hemicelluloses, lignin and pectin contents with hypocholesterolemic effect (Ogino *et al.*, 2007; Osada *et al.*, 2006). The fiber rich diets have a positive effect on health as their ingestion has been related to decrease

prevalence of several diseases (Singh and Singh, 2015). It improves serum lipid concentration, lowers blood pressure, improves blood glucose control in diabetes, promote regularity, aids in weight loss and appears to improve immune function (Anderson *et al.*, 2009). In this study, we analyzed the hypoglycemic potential of apple pomace powder and determined the effect of apple pomace powder on glucose adsorption *in vitro*.

Materials and Methods

Material

Fresh apple pomace was procured from Himachal Pradesh Horticultural Produce Marketing and Processing Corporation Ltd (HPMC) Fruit Processing Plant, located at Parwanoo, Distt. Solan (HP). The pomace was dried in the cabinet drier at $50 \pm 2^\circ\text{C}$ for 24 h. Dried pomace was then ground in Willey grinder and passed through sieve of 30 mesh (500 μm). Apple pomace powder obtained after grinding used for further analysis.

Methods

Bulk density (g/cc)

A 50 mL graduated cylinder was filled with 20 g of sample followed by gentle tapping of the cylinder. The volume sample was read directly and results expressed as g/cc (Rana *et al.*, 2015).

Water hydration capacity (WHC)

Weighed quantity (5 g) of sample was transferred to a centrifuge tube (50 mL) and weighed the tube with sample. Then distilled water was added in unmeasured increments till the pasty consistency was achieved. It was followed by centrifugation at 4000 rpm for 10 min. Supernatant if any discarded and the tube was weighed again (Grover *et al.*, 2003).

Water hydration capacity was measured as mL of water absorbed by per g of material.

$$\text{WHC (g water/g solid)} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Initial weight}}$$

Fat binding capacity (FBC)

Weighed quantity of sample (0.5 g) was thoroughly mixed 3 g of soya oil in centrifuge tube (15mL) and allowed to stand for 30 min followed by centrifugation at 1610 rpm for 25 min. Then the volume of free oil was measured (Grover *et al.*, 2003). Fat absorption was expressed as the amount of oil bound by 100 g of sample.

$$\text{FBC (g oil /g solid)} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Initial weight}}$$

Swelling power and Solubility index

Sample (1 g) was taken in a test tube. 50 ml of distilled water was added and mixed properly. The slurry was heated at 85°C for 30 min in water bath. After cooling, the sample was centrifuged at 2,000 rpm for 15 min. The supernatant was collected in a dish and 5 mL of it was poured on tarred evaporating dish (B1) and was dried at 100°C for 4h and weighed again (A2) (Younis and Ahmad, 2015). Then, the weight of sediment was taken as (W2).

$$\text{Swelling power (\%)} = \frac{W2 - W1}{\text{Weight of sample}} \times 100$$

$$\text{Solubility index (\%)} = \frac{A2 - B1}{\text{Weight of sample}} \times 100$$

Foam Capacity (FC)

One gram of sample was mixed with 100 mL of distilled water and the suspension was

homogenised vigorously for 5 min by using a homogeniser. The homogenised suspension was immediately transferred to a 250 mL graduated cylinder and the foam volume was measured (Gannasin *et al.*, 2012)

$$FC (\%) = \frac{(\text{Volume after homogenisation} - \text{Volume before homogenisation}) \times 100}{(\text{Volume before homogenisation}) \text{ mL}}$$

Foam Stability (FS)

Foam stability (FS) was measured by measuring the foam volume after allowing the foam to stand for 1 hr (Ahmad *et al.*, 2016)

$$FS (\%) = \frac{\text{Foam volume after 1 h}}{\text{Initial foam volume}} \times 100$$

Emulsion Activity (EA)

A known quantity (7g) of sample preparation was suspended in 100 mL distilled water and added 100 mL of oil followed by emulsification of mixture in a homogenizer at 10,000 rpm for 1 min. The emulsion obtained was centrifuged at 1300 rpm for 5 min (Grover *et al.*, 2003). The emulsion activity was calculated using the following equation:

$$EA (\%) = \frac{\text{Height of emulsion layer}}{\text{Total emulsion layer}} \times 100$$

Emulsion Stability (ES)

A known quantity (7g) of sample preparation was suspended in 100 mL distilled water and added 100 mL of oil followed by emulsification of mixture in a homogenizer at 10,000 rpm for 1 min.

Heat emulsion at 80°C for 30 min and centrifuge at 1300 rpm for 5 min (Grover *et al.*, 2003). The emulsion stability was calculated using the following equation:

$$ES (\%) = \frac{\text{Height of remaining emulsion}}{\text{Total height of emulsion}} \times 100$$

α -amylase activity inhibition ration (α -AAIR)

1 g apple pomace was mixed with 25 ml of soluble starch (4g/100ml, pH 6.5) and 0.1 g of α -amylase. The mixture was dialyzed against distilled water at 37°C in a shaking water bath (Zheng and Li, 2018). The dialysate glucose content was determined after 60 min. A control test was carried out without sample, and α -AAIR was calculated by the following equation:

$$\alpha - AAIR (\%) = (Ac - As)/Ac \times 100$$

where Ac is the absorbance of the control and As is the absorbance of sample.

Glucose diffusion retardation index (GDRI)

Sample (0.25 g) was mixed with 12.5 mL of glucose solution (50 mmol L⁻¹) in a dialysis membrane with a cut-off molecular weight of 12,000. The mixture solution was dialyzed against 100 mL of distilled water. After 30, 60, and 120 min, the glucose content in the dialysate was measured using the glucose assay kit to determine the glucose diffusion rate. A control test was carried out (Younis and Ahmad, 2015). It is calculated as below:-

$$GDRI (\%) = 100 - \left[\frac{\text{Total glucose diffused from fiber sample}}{\text{Total glucose diffused from control sample}} \right] \times 100$$

Glucose adsorption capacity (GAC)

Sample (1g) was mixed with 100 mL of different glucose concentrations (50, 100, 200 mmol L⁻¹) and incubated at 37°C for 6 h. The sample was centrifuged at 4000 rpm for 20 min after glucose adsorption reached equilibrium. The amount of glucose retained

by sample was determined by measuring the supernatant glucose content using a glucose assay kit (Ma and Mu, 2016). Glucose adsorption capacity was calculated using the following formula:-

$$\text{GAC (mmol/g)} = \frac{G1 - G6}{\text{Weight of the sample}} \times \text{Volume of solution}$$

Where, G1 = Glucose concentration of original solution

G6 = Glucose concentration after 6 h.

Results and Discussion

The data presented in table 1 shows the bulk density of apple pomace powder i.e. 0.48 g/cc. Water holding capacity (WHC) and fat absorption capacity (FAC) were observed 3.39 and 0.97 ml/g respectively, whereas swelling power, solubility index, foaming capacity, emulsion activity, emulsion stability was 1265.20, 4.00, 2.00, 46.87 and 31.25 per cent respectively. Similar results were observed by Younis and Ahmad (2015). Foam stability was recorded zero due to negligible foam formation in apple pomace powder. The values recorded by Grover *et al.*, (2003) for foam activity, foam stability, emulsion activity and emulsion stability were 7.0 per cent, 0 per cent, 39.6 per cent and 38.4 per cent in apple pomace powder.

α -amylase inhibition ration was found 80 per cent in apple pomace powder (Table 1). It indicate that apple pomace powder was most effective inhibitor of amylase activity. The retardation of α -amylase activity might be due to possible reasons, such as capsulation of starch and enzyme by fibers, reduced accessibility of the enzyme to starch, the presence of inhibitors on fibers and the direct adsorption of enzyme on fibers leading to the decrease in amylase activity. The ability of apple pomace powder in lowering the activity of α -amylase might help in postponing the

release of glucose from starch, delaying the rate of glucose absorption, and therefore controlling the concentration of postprandial serum glucose.

The effect of apple pomace powder on glucose diffusion is presented in Figure 1. Dialysis membrane was monitored after 30, 60 and 120 min to check the movement of glucose across the membrane. In control, the glucose content in the dialysate was measured 2500, 1000 and 500 mg/l whereas in case of apple pomace powder the glucose content was found 7000, 4000 and 2000 mg/l. Glucose Diffusion Retardation Index (GDRI) is a useful in vitro index to predict the effect of a fiber on the delay in glucose absorption in the gastrointestinal tract (Lopez *et al.*, 1996). In the present study, it was observed that GDRI (Fig. 2) was maximum at 30 min (69.23%) and decreased on extension of dialysis period. The similar trend of GDRI was recorded by Ahmed *et al.*, (2011) in wheat bran, acarbose, oats, and psyllium husk. It was reported that apple pomace powder demonstrated significant inhibitory effect on movement of glucose into external solution across dialysis membrane compared to control. The reason may be the physical obstacle presented by fiber particle towards glucose molecules and the entrapment of glucose within the network formed by fibers (Ahmed *et al.*, 2011). This property of apple pomace powder might be useful for lowering the glycemic index by its incorporation in foods with high glycemic index.

Glucose adsorption capacity of apple pomace powder is presented in Figure 3. The fiber samples at different glucose concentrations were (50, 100 and 200 mmol/l) found to bind glucose at different levels (3.88, 8.61 and 18.33 mmol/g) respectively. The adsorption capacity of the apple pomace powder was directly proportional to the molar concentration of glucose.

Table.1 Functional properties of apple pomace powder

Functional Properties	Treatments (Mean ± SE)
Bulk density (BD) (g/cc)	0.48 ± 0.01
Water holding capacity (WHC) (g/g)	3.39 ± 0.01
Fat absorption capacity (FAC) (ml/g)	0.97 ± 0.02
Swelling Power (SP) (%)	1265.20 ± 0.01
Solubility index (SI) (%)	4.00 ± 0.57
Foam capacity (FC) (%)	2.00 ± 0.57
Foam stability (FS) (%)	NS
Emulsion activity (EA) (%)	46.87 ± 0.01
Emulsion stability (ES) (%)	31.25 ± 0.01
α- amylase inhibition ration (α-AAIR)	80 ± 0.02
NS= Not stable	

Fig.1 Effect of apple pomace powder on glucose diffusion

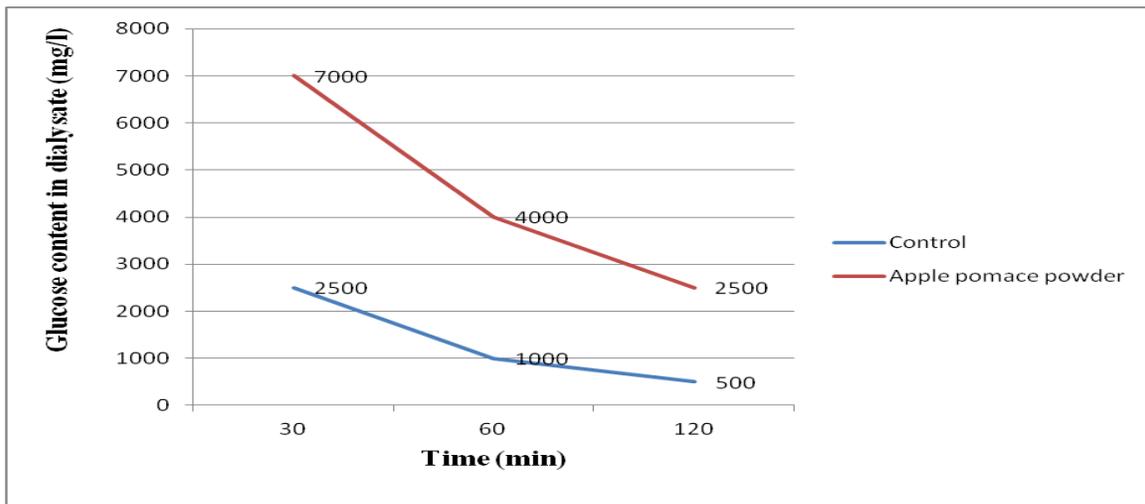


Fig.2 Glucose dialysis retardation index of apple pomace powder

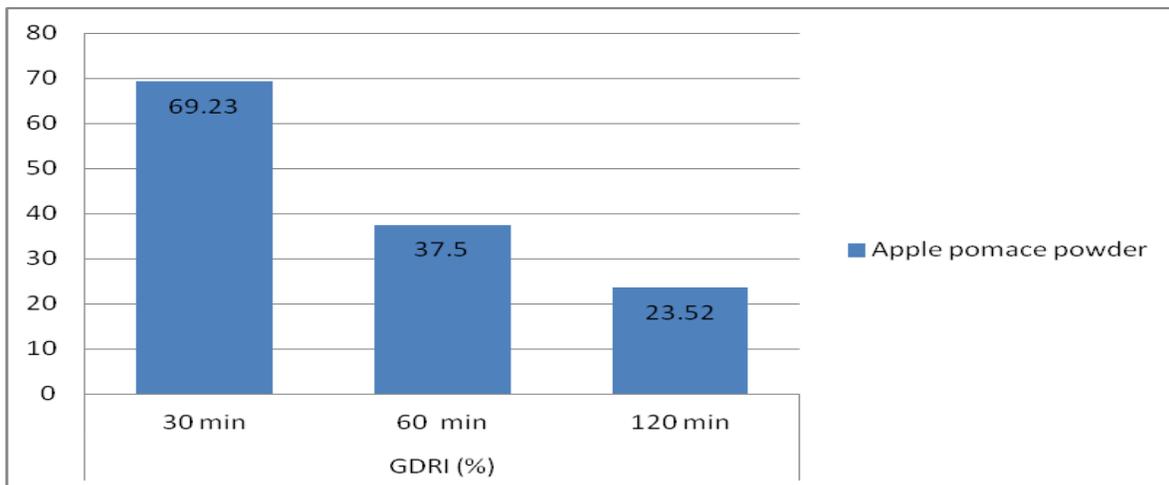
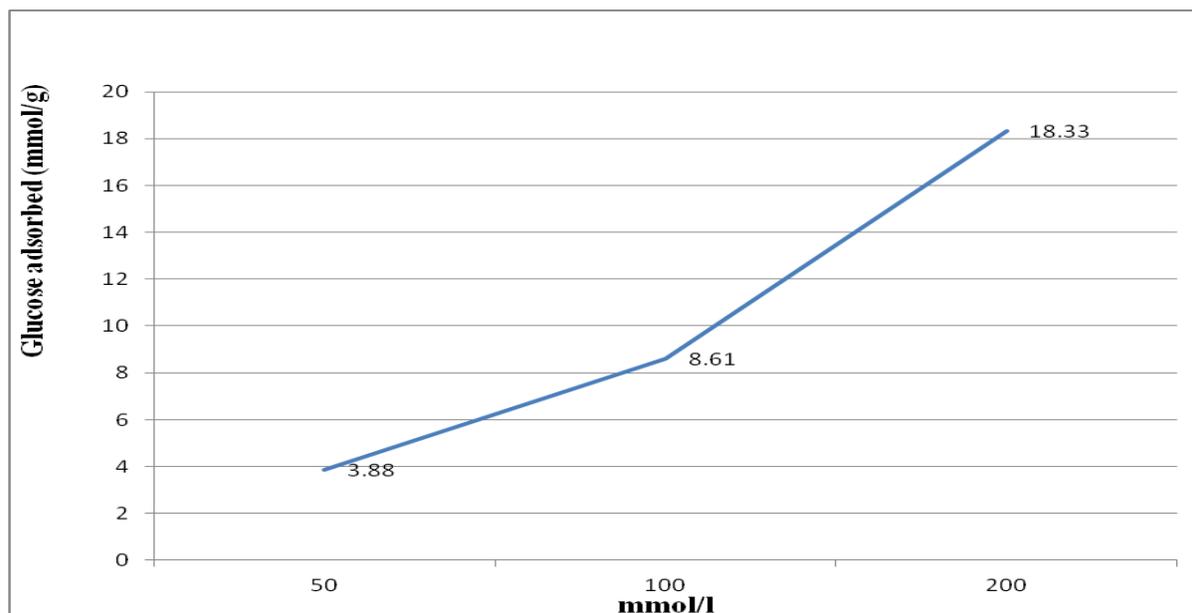


Fig.3 Glucose adsorption capacity of apple pomace powder



The result of this *in vitro* study indicates that the glucose adsorption capacity of fiber increased gradually when the glucose concentration increased. The sample could bind glucose even at lower concentration thereby reducing the amount of glucose available for transport across the intestinal lumen. This could help in lowering postprandial hyperglycemia. Similar trend was reported by Ma and Mu (2016) in dietary fiber of deoiled cumin.

From this research, it has been concluded that apple pomace powder has various versatile functional properties like water holding capacity, fat absorption capacity, swelling power, foam capacity and stability, glucose diffusion retardation index etc. This study demonstrated that apple pomace powder could effectively adsorb glucose, retard the glucose diffusion and inhibit the α -amylase activity which results in lowering the postprandial hyperglycemia. α -amylase inhibition ration was found 80 per cent in apple pomace powder. GDMI was maximum at 30 min (69.23%) thereafter the GDMI decreased significantly. It was interesting to

note that the adsorption of glucose by apple pomace powder increased with increase in glucose concentration. All of these mechanisms helps to lower the rate of glucose adsorption and as a result, decrease the postprandial serum glucose concentration. However, further *in vivo* studies are needed to analyze these observation.

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