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FUNCTIONAL AND ANTIOXIDANT CHARACTERISTICS OF FLOUR SUPPLEMENTED WITH AGRO-INDUSTRIAL WASTES FOR DIETARY INTERVENTIONS

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Abstract: Dietary fiber from apple pomace and mango peels is an enviable nutritional resource that also contributes to enhance technological characteristics to the food and thus can be used as a functional ingredient in dietary interventions. The core purpose of the present research was to find functional as well as antioxidant properties of the flour supplemented with apple pomace and mango peels. Different treatments (6-18%) prepared on a replacement basis with Apple Pomace powder (APP), Mango Peels Powder (MPP), and their blend in wheat flour, were investigated for their functional and antioxidant characteristics. Functional and antioxidant characteristics were found to be related positively on addition of powder from all sources except emulsion capacity and stability. The maximum water and fat absorption capacities (236.4 ± 1.04 and 123.02 ± 0.32%) were shown by 18% addition of MPP in wheat flour. Similarly, the addition of mango peels powders also significantly ($P \leq 0.05$) increased the antioxidant capability of the flour blends. The highest Total Phenolic Content(TPC), Total Flavonoid Content (TFC) and Free Radical Scavenging Activity (FRSA) were found in MPP supplemented blends and were even better than APP. The enhanced functional and antioxidant properties of the flour blends may be used to increase the nutritional and physiological properties of the dietary interventions.

Key Words: Antioxidant properties, Dietary interventions, Functional properties, Nutrition,Nutritional supplements, Dietary Fibers

INTRODUCTION

Nutrition is an input to and basis for health and development that monitors the status of the body through diet. In order to increase the health status of the society highly nutritious food products prepared by supplementation with inexpensive sources are needed. One solution to the menace is the incorporation of rich and economic supplies from the food waste resource in daily consumable commodities and the distribution of these products. This would result in enriched foods to avoid health security issues and will also offer solution towards the threat of environmental pollution (1). The modern uses of these waste products as functional dietary interventions are gaining importance (2). The waste products from apple and mango processing industries (apple pomace and mango peels) bear more dietary fiber, polyphenols, flavonoids and antioxidant value as compared to the relevant edible part (3).

Apple pomace and mango peels are abundantly packed with dietary fiber, which is considered beneficial in the reduction and treatment of certain ailments, such as hypercholesterolemia, some cancers, GI tract issues and cardiovascular diseases (4). Moreover, this fiber is a desirable property not only from a nutritional perspective but also to incorporate functional benefits and to enhance technological properties to the food (5,6). It is need of the time to increase the consumption by incorporation into the frequently consumed food. This may be helpful to overcome the fiber deficit as well as to increase the antioxidant potential of the product. This study could also be accommodating in the management of the several tons of offshoots produced every year (7). Furthermore, the enriched flours can be used to manufacture juices, jellies, puddings, custards and baked products, etc., for having great acceptance by consumers (8).

The studied characteristics of flours are important in the formulation and storage of food products and also in determining their physiological properties. The health effects and physiological characteristics of fiber-rich products are predictable on the basis of functional characteristics such as bulk density, water and oil holding capacities, emulsion capacity and stability and foaming capacity and stability etc. Hence, the current research study was designed to find the functional and antioxidant properties of the flour blend. The core objective was to analyze the effect of supplementation of different fiber sources from apple pomace and mango peels in the wheat flour.

MATERIALS AND METHODS

Procurement and preparation of materials

The waste material of the fruit industry i.e., apple pomace and mango peel was obtained from the local food processing industry from. The dry powders of apple pomace and mango peels were prepared by the method illustrated by Umbreen et al (6). In order to find out the suitable composition of supplemented flour blends, treatments were prepared on replacement basis (6, 12 and 18%) with Apple Pomace Powder (APP), Mango Peel Powder (MPP) and mixed blend (APMPP 50:50) in the wheat flour. The categories of treatments were T_0 (Wheat flour), T_1, T_2, T_3(APP), T_4, T_5, T_6 (MPP) and T_7, T_8, T_9 (APMPP).

Functional properties of supplemented flour blends

The flour blends were examined for functional characteristics (bulk density, water and oil holding capacities, emulsion capacity and stability and foaming capacity and stability) following respective procedures. The bulk density was analysed as described by Kaur *et al* (9). The Oil and water Absorption Capacities (OAC and WAC) were found out by the method of Salehifar and Fadaei(10). To determine emulsion capacity and stability and foaming capacity and stability, the method followed by Firebaugh and Daubert was used (11).

Antioxidant properties of supplemented flour blends

The samples were extracted with absolute methanol (12). The TPC of the sample was analyzed using the Folin-Ciocalteu reagent method and the content was calculated as mg of gallic acid equivalent (GAE)/g of extract. The TFC (mg) was obtained as catechin equivalent (CE)/g of extract. The FRSA of the flour blends was examined as half-maximal inhibitory concentration (IC_{50} value) and presented in μg mL^{-1} (13).

Statistical analysis

The samples of each treatment were determined in triplicate and their mean ± SEM has been given in result. The study was based upon complete randomized design and data were analyzed using SPSS 17. Analysis of variance was used to find the level of significance and the results were declared significant at *$P\leq0.05$.* The least significant difference (LSD) was used as a post hoc test to determine the difference between the means.

RESULTS &DISCUSSION

Bulk density

The highest bulk density value was observed in the blend containing 18% MPP (T_6), while the lowest was found in the blend with 18% replacement with APP (T_3) (Table 1). In accordance with the results obtained for APP addition, Collar and Angiolonialso observed a negative correlation between bulk density and the addition of higher levels of β-glucan barley in plain flour up to 40% and explained that this reduction may be helpful in increasing the fat binding capacity of the flour blend (14). Comparable results were also explained by Mepba*et al*, on the addition of plantain in wheat flour to form composite blends. It was found that higher bulk density is associated with thickening characteristics of the fiber showing that MPP can act as a good thickening agent (15).

Water absorption capacity

The mean values of Water Absorption Capacities (WAC) showed significant ($P \leq 0.05$) differences between the treatments (Table1). The highest value of WAC (236.4 ± 1.04%) was found for MPP supplementation at 18% (T_6) in the wheat flour, while the lowest value was exhibited by 100% wheat flour (T_0). Water absorption properties show the capacity of the food to combat the condition when less water is to be used in product as in dough. On the other hand, this property is linked with the fate of dietary fiber in the digestive tract and causes induction of fermentation. Furthermore, it is also responsible for fecal bulking of unfermented dietary fiber[16]. Moreover, in a study conducted by Ajila*et al,* it was also found that substitution of wheat flour with MPP resulted in increased WAC of dough from 60 to 68% by increasing peel powder from 5 to 20% (17).

Fat absorption capacity

The mean values for fat absorption capacity (FAC) of supplemented flour blends showed significant variations ($P \leq 0.05$) among treatments (Table 1). The highest FAC was possessed by T_6 and lowest by T_0 among all the treatments. The increased FAC on the addition of fiber sources in this research study can be due to the ability of the proteins in APP and MPP to bind fats. This property also plays an imperative role in making of bakery items(18). In compliance with the current study, Collar and Angiolonialso observed an increase in FAC on 40% substitution of flour with high β-glucan barley and explained that it can be helpful in the eradication of extra lipids from the intestine (14).

Emulsion capacity and stability

The emulsion capacity was found the highest in T_0, followed by T_4 with significant difference between treatments, showing the least value for flour supplemented with 18% apple pomace powder (T_3). However, the emulsion stability was observed to be the lowest in the case of wheat flour (T_0) compared to the flour blends supplemented with fruit waste fibers (Table 1). Lower emulsion capacities in flour blends may be credited to less protein levels and higher levels of fiber, which are negatively correlated with emulsion formation. The increased stability can be caused by exceptional water and fat binding properties that aids in the stabilization of emulsions by absorbing and binding with excessive water(19).

Foaming capacity and stability

The significant differences ($P \leq 0.05$) in foaming capacity were observed between the treatments with T_6 (18% MPP) at the highest level whereas, T_0 (100% wheat flour) was found to possess the lowest foaming capacity as well as stability. However, the highest foaming stability (69.57 ± 0.59%) was found for T_9 (18% APMPP) (Table 1). Foaming capacity is expected to be reliant upon the conformation of protein molecules. Furthermore, the foam capacity and stability are correlated with water-dispersible nitrogen and the food components having better foaming capacity and stability may be suitable to be used in baked items so, APP and MPP can be a fine source of fiber in baked products(20). Similarly, Baljeet*et al.* evaluated the addition of buckwheat flour in plain white flour and demonstrated that an increase in fiber content increased the foaming capacity and stability of the flour (21).

Antioxidant properties of supplemented flour blends

The Fig 1 (a-c) shows a significant difference ($P \leq 0.05$) between the treatments for antioxidant properties of the flour blends. Antioxidant capacities increased dose-dependently in all treatments irrespective of the supplementation. The highest TPC and TFC values were found in flour blends containing 18% MPP (T_6), while the FRSA in terms of IC_{50} values were observed to be the lowest in T_6 showing the highest antioxidant capacity. In compliance with the present results Ramadan *et al*. also described that wheat flour has lower antioxidant potential and to be used for the preparation of the food items, it is essential to supplement the flour with some better antioxidant source. Moreover, wheat flour is mainly used in baked items containing higher amounts of fats, which can be deteriorated by rancidity while storage. Therefore, supplementation with waste food resources especially mango peels can be an efficient and economic remedy to increase the shelf life as well as physiological properties of the dietary interventions (22).

CONCLUSION

The addition of APP and MPP resulted in increased functional as well as antioxidant characteristics of the wheat flour, particularly with MPP. This is indicative of the fact that supplementation of such economical resources in wheat flour can bring productive consequences towards the improvement of dietary interventions.

CONFLICTION OF INTEREST

The authors declare that they have no conflict of interests among them.

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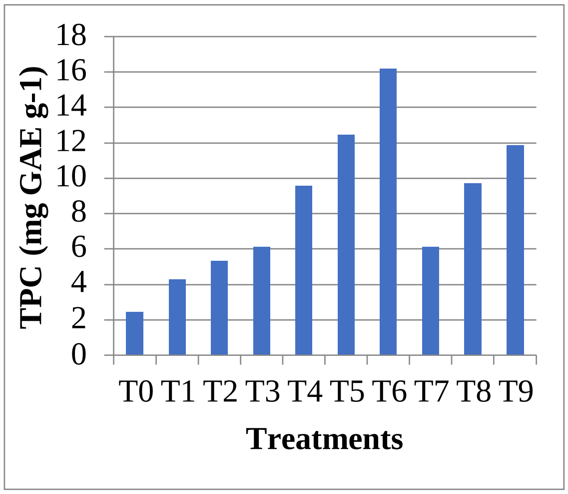
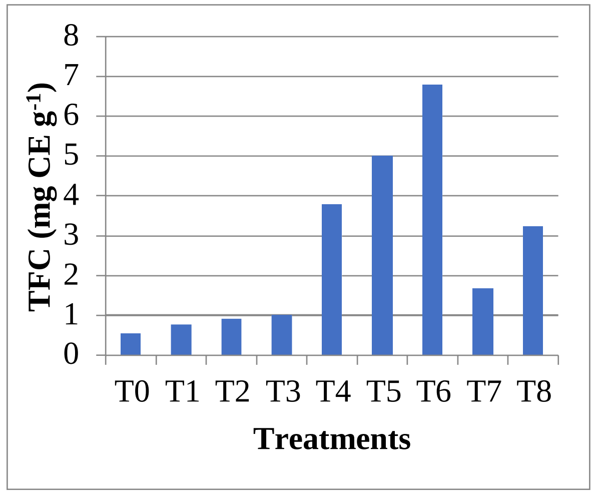
Table 1: Mean values for functional properties (± SEM) of different supplemented flour blends

Treatment	Bulk Density (g/cm^3)	Water Absorption Capacity (%)	Fat Absorption Capacity (%)	Emulsion Capacity (%)	Emulsion Stability (%)	Foaming Capacity (%)	Foaming Stability (%)
T_0	0.59 ± 0.02^{bcd}	159.47 ± 0.87^{h}	97.82 ± 0.56^{e}	34.1 ± 0.28^{a}	31.89 ± 0.12^{e}	40.79 ± 0.31^{d}	50.75 ± 0.33^{f}
T_1	0.57 ± 0.05^{de}	171.88 ± 0.73^{g}	101.15 ± 0.43^{de}	33.86 ± 0.18^{a}	39.48 ± 0.11^{cd}	43.22 ± 0.24^{cd}	53.44 ± 0.32^{ef}
T_2	0.543 ± 0.01^{ef}	183.45 ± 0.94^{f}	107.02 ± 0.66^{cd}	32.93 ± 0.22^{a}	40.73 ± 0.17^{bc}	45.62 ± 0.2^{abc}	56.92 ± 0.3^{def}
T_3	0.52 ± 0.04^{f}	197.33 ± 0.63^{e}	116.87 ± 0.79^{ab}	30.59 ± 0.16^{c}	43.32 ± 0.2^{abc}	48.51 ± 0.22^{ab}	60.26 ± 0.27^{cd}
T_4	0.61 ± 0.02^{bc}	208.14 ± 1.02^{d}	107.96 ± 0.42^{cd}	34.07 ± 0.11^{a}	42.74 ± 0.2^{abc}	44.06 ± 0.3^{bcd}	56.5 ± 0.41^{def}
T_5	0.62 ± 0.03^{ab}	221.05 ± 0.82^{bc}	112.62 ± 0.49^{bc}	33.63 ± 0.15^{a}	43.81 ± 0.21^{ab}	47.77 ± 0.2^{abc}	58.03 ± 0.26^{de}
T_6	0.65 ± 0.05^{a}	236.4 ± 1.04^{a}	123.02 ± 0.32^{a}	32.24 ± 0.2^{abc}	45.09 ± 0.13^{a}	$49.69 \pm 0.29_{a}$	64.91 ± 0.34^{bc}
T_7	0.57 ± 0.03^{cde}	201.84 ± 0.91^{de}	103.91 ± 0.71^{de}	33.77 ± 0.12^{a}	32.25 ± 0.21^{e}	43.58 ± 0.18^{cd}	55.51 ± 0.41^{def}
T_8	0.58 ± 0.01^{bcd}	211.51 ± 1.01^{cd}	108.44 ± 1.2^{cd}	32.64 ± 0.3^{ab}	34.38 ± 0.22^{e}	46 ± 0.3^{abc}	67.86 ± 0.43^{ab}
T_9	0.603 ± 0.02^{bcd}	226.86 ± 1.4^{ab}	120.03 ± 1.1^{a}	31.36 ± 0.23^{bc}	35.57 ± 0.19^{de}	48.62 ± 0.24^{ab}	69.57 ± 0.59^{a}

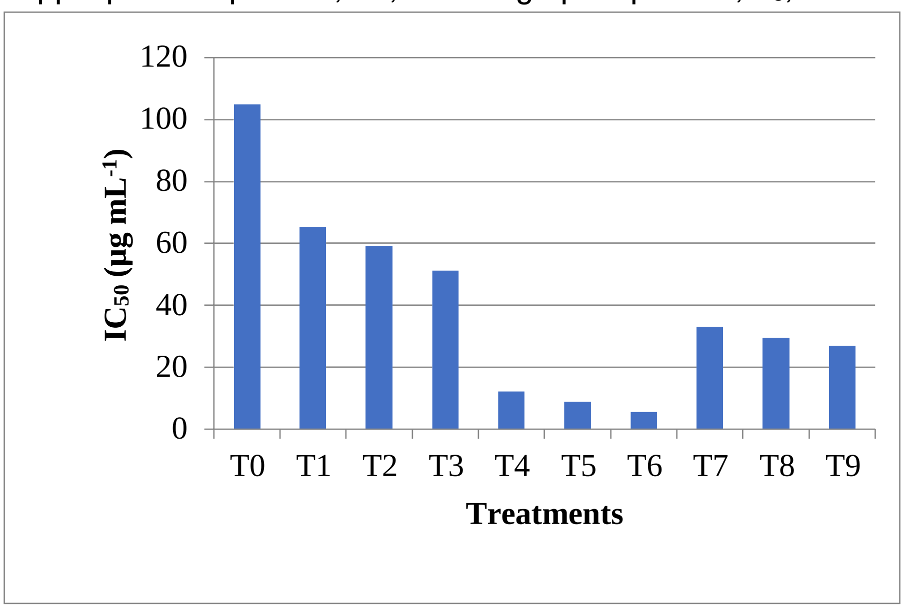
$^{a-f}$ Similar letters in a column show the no significant differences at P≤0.05. T_0;100% wheat flour, T_1;6% apple pomace powder, T_2;12% apple pomace powder, T_3;18% apple pomace powder, T4;6% mango peel powder, T_5;12% mango peel powder, T_6;18% mango peel powder, T_7;6% apple pomace and mango peel powder (50:50), T_8;12% apple pomace and mango peel powder (50:50), T_9;18% apple pomace and mango peel powder (50:50)

Figure. 1: Trends of antioxidant properties (TPC, TFC and IC_{50} values) for supplemented flour blends





TPC; Total phenolic content, TF, Total flavonoids content, IC_{50}; Half maximal inhibitory concentration, T_0;100% wheat flour, T_1;6% apple pomace powder, T_2;12% apple pomace powder, T_3;18% apple pomace powder, T4;6% mango peel powder, T_5;12% mango peel



powder, T_6;18% mango peel powder, T_7;6% apple pomace and mango peel powder (50:50), T_8;12% apple pomace and mango peel powder (50:50), T_9;18% apple pomace and mango peel powder (50:50)