Biological Sciences

Pak J Sci Ind Res 1999 42 (4) 184-187

Studies on Carrot Pulp as Source of Nutritional Dietary Fibre

Zia-ur-Rehman and Wazir Hussain Shah*

Biotechnology & Food Research Centre, PCSIR Laboratories Complex, Lahore-54600, Pakistan

(Received 01 August 1996; accepted 7 January 1998)

Effect of various blanching processes on the retention of different nutrients of carrot pulp was investigated. Each blanching process showed different behaviour on the retention of nutrients. Carrot pulp contained 5.1 - 5.6% protein, 1.1 - 1.5% lipids, 5.6 - 6.5% minerals and 15.6 - 19.7% soluble sugars. Non reducing sugars were almost two times more than reducing sugars in all carrot pulp products. Carotene and vitamin C were present in all pulp products but highest content of the two nutrients was observed in the pulp obtained from unblanched carrots. Hemicellulose and cellulose were found to be the two main predominant dietary fibre components of carrot pulps, while water holding capacity (WHC) of carrot pulps ranged from 10.3-13.9g water per gram organic matter. Considering dietary fibre components, WHC, Carotene and other nutrients, carrot pulp was found to be a good source of dietary fibre.

Key words : Carrot pulp, Blanching process, Dietary fibre components, Water holding capacity.

Introduction

After extraction of juice from carrot, about 30-50% of the weight is left in the form of pulp which is usually thrown away. Due to perishable nature, it ferments quickly and causes fly breeding nuisance, thus creating pollution and disposal problems. It contains sufficient quantity of nutrients such as proteins, soluble sugars, minerals and vitamins (Bao and Chang 1994) and can be utilized for some useful purpose. Significant amounts of hemicellulose and cellulose are also present in carrot pulp, which are the main components of dietary fibre (Hellendoorn 1975). Dietary fibre lowers serum cholesterol and helps in reducing the risk of heart attack and colon cancer (Burkitt 1971; Trowell 1972; Burkitt *et al* 1974; Kelsey 1978). High fibre diet prevents or relieves constipation in human due to absorption of water from the digestive tract (Hill 1974). Keeping in view the clinical beneficial effect of dietary fibre, nutritional value of the carrot pulp as dietary fibre ingredient should be evaluated. Different blanching treatments were tried for the extraction of maximum juice from carrots in our previous studies. These treatments can affect the retention of different nutrients of the carrot pulp products. Very little informaion is available in the literature regarding the nutritional quality of the carrot pulp. Therefore, present work was undertaken to study the effect of various blanching processes on the retention of nutrients, dietary fibre components and water holding capacity of the carrot pulp.

*Author for correspondence

Materials and Methods

Blanching process and production of carrot pulp. Fresh mature carrots of red variety free from blemishes were obtained, washed thoroughly and peeled after removing their heads and tails with a sharp knife manually. The carrots were cut longitudinally into two halves and then blanched according to the method of Stephens *et al* (1976). 5 kg cleaned carrots were heated for 5 min in 12.5l of various boiling solutions (Table 1), thoroughly drained and ground through a champion juicer (Plastaket Manufacturing Co, Lodi C.A.), equipped with a stainless steel screen. The pulp residue from the juicer was collected and dried at 60°C for 24 h. Pulp from unblanched carrots was used as control.

Chemical analysis. Total ash content of carrot pulp samples was determined with a muffle oven. Crude protein was estimated according to Micro-Kjeldahl method (A O A C 1990) whereas lipid content of samples was determined with *n*-hexane using Soxhlet method (Osborone and Voogi 1978). Total soluble sugars in carrot pulp were estimated by dinitrosalicylic acid method as described by Miller (1959). Carotene was estimated using the method of Valadone and Mummery (1959) after extracting it in petroleum ether and acetone mixture. Vitamin C in pulp was determined by spectrophotometer (Bajaj and Gurdeep 1981).

Neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose and hemicellulose contents in the pulp samples were determined according to the procedures described by Van

Soest *et al* (1991). The water holding capacity (WHC) of dried carrot pulp products was determined using the domestic suction procedure of McBurney *et al* (1985). All data was subjected to analysis of variance and standard deviation was calculated by the method of Steel and Torrie (1980). Duncan's multiple range test was used to determine significant difference ($P<0.05$).

Results and Discussion

Variable amount of pulp was produced after blanching and juicing carrots (Table 1) . Unblanched carrots produced 32.2% pulp whereas water and 0.05 N acetic acid blanched carrots produced 43.0 and 33.0% respectively. However, blanching in 0.05N acetic acid containing 0.2% $CaCl_2$ produced minimum amount of pulp i.e. 30.6%. It seems that texture of the whole carrots became more firm after blanching in acetic acid solutions containing $CaCl_2$ which might be responsible for maximum extraction of juice and minimum production of pulp.

Effect of blanching on the chemical composition of carrot pulp. Pulp from blanched carrots had significantly ($p<0.05$) higher proteins and lipid contents than that from unblanched carrots (Table 1). Unblanched carrot pulp contained 5.1% protein and 1.1% lipids whereas maximum amount of protein and lipid was 5.6 and 1.5% respectively in case of pulp obtained after blanching carrots in 0.05N acetic acid solution containing 0.2% $CaCl_2$.

It seems that more heat sensitive proteins were denatured and remained in the pulp after blanching and juicing processes as had already been reported (Munch *et al* 1986). The findings of Sethi (1990) also support our results that most of the lipid was retained in the pulp and less was extracted into the juice from blanched carrots.

Blanching processes also showed marked differences on the retention of minerals in different pulp products (Table 1). The amount of minerals in unblanched carrot pulp was 6.0% which was increased by 8.3% (6.0-6.5%) due to blanching of carrots in KCI or $CaCl_2$ solution. On the other hand, a decrease in mineral contents by 6.6% (6.0-5.6%) was observed on blanching carrots in citric acid or acetic acid solutions, which could be attributed to solubilization of some of the salts under acidic conditions. However, there was no change at all in the mineral contents of the pulp when carrots were blanched in acetic acid or citric acid solutions containing 0.2% $CaCl_2$.

Total water soluble nutrients. Unblanched and water blanched carrot pulps contained 44.3 and 39.0% water soluble nutrients respectively, whereas pulps obtained from the carrots blanched in KCl and $CaCl_2$ solutions retained 42.7 and 41.0% water soluble nutrients respectively (Table 1).Total water soluble nutrients in pulps from carrots blanched in organic acid solutions were comparatively less than that of water blanched carrot pulp. These results indicate that some portion of the salts was extracted into the juice as a result of blanching and juicing processes which ultimately affected adversely the retention of water soluble nutrients of carrot pulp.

Total water soluble sugars. Total water soluble sugars including reducing sugars of pulp from blanched carrots were significantly ($P<0.05$) higher than that from unblanched car-

Table 1

Effect of blanching on the yield and chemical composition of carrot pulp

Blanching treatment	Pulp yield (% age basis)	Chemical composition (% age DM)*						
		Protein	Lipids	Minerals (ash)	Total water soluble nutrients	Total water soluble sugar	Reducing sugars	Non reducing sugars
Unblanched	32.2(3.2)	5.1(1.1)	1.1(0.1)	6.0(1.3)	44.3(2.3)	15.6(1.8)	4.6(1.2)	11.0(1.6)
Distilled water	43.0(2.4)	5.5(1.3)	1.5(0.3)	6.1(0.9)	39.0(1.3)	19.7(1.1)	6.8(0.9)	13.7(1.9)
0.2% KCI solution	40.0(1.5)	5.3(1.1)	1.3(0.8)	6.5(0.8)	42.7(1.8)	17.3(1.5)	5.1(0.9)	12.2(2.0)
0.2% $CaCl_2$ solution	38.2(3.3)	5.4(1.7)	1.4(0.3)	6.5(1.6)	41.0(1.6)	16.9(2.7)	4.6(1.6)	12.3(1.1)
0.05N acetic acid solution	33.8(2.5)	5.2(1.4)	1.4(0.9)	5.6(1.2)	41.3(2.5)	16.7(2.1)	5.3(1.3)	14.4(1.8)
0.05N acetic acid + 0.2% $CaCl_2$	30.6(2.6)	5.6(0.8)	1.5(0.1)	6.0(2.3)	40.6(2.3)	16.0(1.5)	5.4(1.6)	10.6(1.2)
0.05N citric acid solution	34.8(1.9)	5.3(1.2)	1.2(0.2)	5.7(1.8)	40.0(1.6)	16.2(1.9)	5.4(1.3)	10.8(2.0)
0.05N citric acid +0.2% $CaCl_2$	32.8(1.5)	5.5(1.3)	1.3(0.7)	6.0(1.1)	41.0(1.1)	16.4(2.0)	5.5(1.4)	10.9(1.7)

* Average of three replicates along with standard deviations
DM, Dry matter basis.

rots (Table 1). Water blanched carrot pulp retained 19.7% total water soluble sugars and 6.0% reducing sugars whereas unblanched carrot pulp contained 15.6% total water soluble sugars and 4.6% reducing sugars. These results are consistent with the earlier reported work (A O A C 1990) that reducing sugars in blanched carrot pulp were comparatively higher than in raw carrot pulp. Our results also revealed that amount of non-reducing sugars was almost two times higher than reducing sugars in all carrot pulp products.

Effect of blanching on carotene and vitamin C contents of carrot pulp. After extraction of juice, most of the carotene and vitamin C contents were retained by the blanched carrot pulp (Table 2). However, blanching processes showed adverse effect on the retention of the two nutrients.

Table 2

Effect of blanching on carotene and vitamin C contents of carrot pulp (mg $100g^{-1}$ DM)*

Blanching treatment	Carotene	Vitamin C
Unblanched	112(±2.3)	21(±1.9)
Distilled water	85(±1.2)	17(±0.8)
0.2% KCI solution	91(±1.1)	18(±1.2)
0.2% $CaCI_2$ solution	88(±1.3)	18(±1.3)
0.05N acetic acid solution	92(±1.9)	18(±1.6)
0.05N acetic acid + 0.2 $CaCI_2$	80(±1.3)	16(±2.6)
0.04N citric acid	88(±2.2)	17(±2.1)
0.05N citric acid + 0.2% $CaCI_2$	85(±1.5)	17(±2.0)

* Average of three replicates along with standard deviations
DM, Dry matter basis.

The amount of carotene and Vitamin C in unblanched carrot pulp was 112 and 21 mg $100g^{-1}$ respectively whereas in blanched carrot pulp these ranged from 80-92 mg $100g^{-1}$ and 16-18 mg $100g^{-1}$ respectively.

It is evident from the results that minimum amount of carotene (80 mg $100g^{-1}$) and Vitamin C (16 mg $100g^{-1}$) was retained by the pulp obtained from carrots blanched in 0.05N acetic acid solution containing 0.2% $CaCl_2$.

Effect of blanching on dietary fibre components of carrot pulp. Table 3 shows the effect of blanching on the dietary fibre components of carrot pulp. Pulp from unblanched carrots contained 21.4% NDF and 14.8% ADF whereas cellulose and hemicellulose contents were 10.8 and 6.6% respectively. The amount of cellulose was significantly ($P<0.05$) higher than hemicellulose in all carrot pulp products. As a result of blanching in acidic solutions, cellulose and hemicellulose decreased by 36% (10.8 - 6.9%) and 12% (6.6 - 5.0%) respectively, thereby NDF and ADF of carrot pulp was also reduced by 15 and 24% respectively. However, blanching in KCl or $CaCl_2$ solutions had little effect on dietary fibre components. Blanching in water did not show any effect on cellulose and hemicellulose.

Effect of blanching on water holding capcity of carrot pulp. Water holding capacity (WHC) of the pulp from unblanched and water blanched carrots was 12.8 and 13.9 g per gram organic matter (Table 3). With the exception of water blanching, other blanching processes adversely affected the WHC of the pulps because most of the pectic substances might have been partially removed due to decomposition of pectin into pectic acid in the presence of organic acids/inor-

Table 3

Effect of blanching on the dietary fibre components and water holding capacity (WHC) of carrot pulp

Blanching treatment	Dietary fibre components (% age)*				WHC**
	NDF	ADF	Cellulose	Hemicellulose	
Unblanched	21.4(1.3)	14.80(1.2)	10.83(0.3)	6.60(0.7)	12.8(0.2)
Distilled water	21.15(1.6)	14.20(1.3)	10.60(0.5)	6.55(1.3)	13.9(0.4)
0.2% KCI solution	20.20(1.5)	14.20(1.7)	10.05(1.6)	5.90(1.9)	11.6(0.3)
0.2% $CaCl_2$ solution	20.90(2.1)	14.40(1.9)	20.20(1.1)	6.00(2.0)	11.7(0.1)
0.05N acetic acid solution	18.77(2.2)	13.35(1.8)	8.15(0.7)	6.22(1.6)	10.8(0.7)
0.05N acetic acid + 0.2% $CaCl_2$	18.16(1.9)	12.66(1.3)	6.90(0.6)	6.01(1.1)	10.3(0.3)
0.05N citric acid solution	19.06(1.7)	11.20(0.9)	9.37(1.8)	5.80(1.3)	11.9(0.2)
0.05N citric acid +0.2% $CaCl_2$	19.07(1.6)	12.06(1.2)	8.31(1.7)	6.01(1.2)	12.1(0.6)

* Average of three replicates alongwith standard deviation
WHC, Water Holding Capcity
** (gram water per gram organic matter)

ganic salts. A substantial amount of decrease in the cellulose and hemicellulose might be another factor for lowering the water holding capacity of the fibre. Cellulose, hemicellulose and many other pectic substances play an important role in absorption of water.

In fact, WHC is the amount of water, a unit (g water per gram organic matter) of dry dietary fibre absorbed (Southgate 1978) which reflects the ability to swell and increase stool weight and to dilute colonic content (Robertson *et al* 1980). Carrot pulp contains most of the pectic substances alongwith cellulose and hemicellulose which might account for its high WHC. The findings of McBurney *et al* (1985) revealed that WHC of dietary fibre is responsible to reduce cholestrol level in human blood.

Conclusion

It is apparent from these studies that different blanching processes affected retention of nutrients in carrot pulp to various extent. Blanching processes also showed significant effect on the yield of carrot pulp. Water blanched carrots produced maximum amount of pulp. Pulps obtained from blanched carrots retained higher amounts of protein, lipids and soluble sugars than that of unblanched carrots. However, non-reducing sugars were about two times more than reducing sugars in all carrot pulp products. Unblanched carrot pulp retained 112 mg $100g^{-1}$ carotene and 210mg $100g^{-1}$ vitamin C while blanching showed adverse effect on the retention of these two nutrients. All the carrot pulp products contained significant amount of hemicellulose and cellulose and had a water holding capacity ranging from 10.3 - 13.9g water per gram organic matter. Keeping in view these results, it may be concluded that carrot pulp will not only absorb water from the digestive tract but it will also provide nutrients such as carotene, minerals and soluble sugars to the body. Therefore, it may be considered very good source of dietary fibre.

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