Physicochemical, microbiological and sensory properties of low fat yoghurt fortified with carrot powder

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Abstract: Yoghurt is considered as a healthy food and incorporating carrot powder will make it even healthier. Carrot powder is a good source of beta carotene and provitamin A. The objective of this study was to determine the effects of adding carrot powder on the physicochemical, microbiological and sensory properties of low fat plain yoghurt. Plain and carrot yoghurt were prepared in the laboratory scale production using low fat milk. Carrot yoghurt was prepared by blending low fat milk with 1%, 2% and 3% carrot powder before fermentation. Physicochemical analysis revealed a decrease in pH value and an increase in titratable acidity, viscosity and total soluble solids with the increase of carrot powder. On the other hand, protein content decreased with the increase of carrot powder. In terms of the lightness (L*) and the redness (a*), 3% carrot yoghurt had low values of lightness while it had higher values of redness. Microbial count showed the significant difference between the 3% carrot yoghurt and 1% and 2% carrot yoghurt. There was a significant difference on the sensory scores of colour and aroma of carrot yoghurt and plain yoghurt as the carrot yoghurt got higher scores than plain yoghurt. There was no significant difference ($p<0.05$) between the acceptability of the plain yoghurt, 1% and 2% carrot yoghurt and a significant difference was there between 3%. Thus, fortifying yoghurt with 1% and 2% carrot powder produced acceptable yoghurt with beneficial health effects.

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1 Introduction

Yoghurt is one of the most popular fermented dairy products which has a wide acceptance worldwide and is considered as a healthy food due to its high digestibility and bioavailability of nutrients[1]. It can be recommended to the people with lactose intolerance, gastrointestinal disorders such as inflammatory bowel disease and irritable bowel disease, and aids in immune function and weight control[2,3]. Carrot (*Dascus carota* L.) is one of the more commonly used vegetables for human nutrition. It is rich in beta carotene, ascorbic acid, tocopherol and classified as vitaminized food[4]. The intake of carrot as potent antioxidants, appear to be associated with better health. It is not only preventing vitamin A deficiency but also cancer and other diet related human diseases[5]. Carrots are good source of iron and vitamins A and C but lack in protein and fat. Yoghurt is rich in protein and fat but is deficient in iron and vitamin C, therefore blending yoghurt with carrot powder will produce a nutritionally rich food[6]. As consumers move towards functional foods with specific health benefits, blending yoghurt with carrot powder will provide consumers with a nutritionally balanced food. In efforts to offer variety and competition in the market, new research is currently in progress on the use of carrot

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juice in yoghurt industry[7,8]. The results of Salwa et al.[5] highlighted the possibility of processing yoghurt with 15% carrot juice.

However, there have been no published reports on the effects of carrot powder on the physicochemical, microbiological and sensory properties of low fat yoghurt. Therefore, the objective of this research paper was to examine the effects of adding carrot powder on the physicochemical, microbiological and sensory properties of low fat plain yoghurt. The study is important because it deals with two nutritionally rich food: yoghurt and carrots. The results of this study showed that fortifying yoghurt with 1% and 2% carrot powder produced acceptable yoghurt with beneficial health effects.

2 Materials and methods

2.1 Materials

Low fat milk, a product of Clover South Africa (RSA), plain yoghurt, and powdered milk, products of Clover RSA, carrots and Maizena (refined corn flour) were obtained from a retail shop in Thohoyandou, South Africa.

2.2 Methods

2.2.1 Drying of carrots

Carrots were first washed with tap water to remove dirt. The carrots were then shredded into very fine strips using a cooking cutter. The shredded carrots were blanched in water containing sodium bisulphite at 90°C for one minute. After blanching the shredded carrots were cooled and then excess water was drained prior to drying.

The shredded carrots were then put into an oven drier, set at the temperature of 54°C. Carrots were placed on dryer trays and left there for 22 h until they were completely dry. The dried carrots were ground into powder using a hammer mill (D-55122 model) and then packaged into stainless steel jar. Three samples of yoghurt with varying concentration of carrot powder were made. The concentrations were 1% (1 g of carrot powder per 100 mL of milk), 2% (2 g of carrot powder per 100 mL of milk and 3% (3 g of carrot powder per 100 mL of milk carrot powder). The control was also made which did not have carrot powder.

2.2.2 Production of yoghurt

Low fat milk (2%) was used in the production of yoghurt. Yoghurt was made by dissolving milk powder (2.5%) and stabilizer (0.8%) in milk in 4 different glass jars. Then carrot powder was added according to the composition of the samples (0, 1%, 2%, and 3%) in the four glass jars. The mixtures were heated in a water bath at 85°C for 30 minutes, cooled to approximately 42°C, inoculated with plain yoghurt sample which had live cultures and the mixtures were incubated at 42°C for 22 h and stored at 4°C for 5 h before testing.

2.2.3 Physicochemical properties of yoghurt

The pH was determined using the method of Vargas et al.[9]. A Brookfield viscometer [Brookfield Model RVD E230, USA] was used to measure the viscosity of the samples. Test samples were subjected to shear rate spindle speed of 50 r/min, with a spindle size 5 mm and at a constant temperature of 28°C for 5 min. All viscosity measurements were expressed in centipoises seconds (cPs), performed in triplicate. Titratable acidity (TA) was determined using the AOAC (1990) method. A refractometer (Atago automatic, Smart 1, Model 1620, Attago Co Ltd, Japan) was used to measure the total soluble solids (TSS) of the yoghurts at 25°C. For colour, a Hunter lab (Colorflex, VA, Model 45/0, USA) was used to measure the L, a*, and b* colour parameters at 25°C. Protein content was determined by formol titration. Although proteins are too weak to be titrated directly with alkali, if formalin is added, it reacts with the $–NH_2$ groups to form the methylene-amino ($-N{=}CH_2$) group, and the carboxyl group will then be available for titration[10].

2.2.4 Microbial analysis of yoghurt

The microbiological analysis (total plate count, coliform, yeast and mould was carried out according to Harrigan[11] with a slight modification.

2.2.5 Sensory evaluation of yoghurt

A panel of judges drawn from the University of Venda community assessed the sensory quality of yoghurts. Sensory evaluation of plain and carrot yoghurt was carried out to determine their organoleptic characteristics in terms of their colour, aroma, taste, texture and overall acceptance. A nine point hedonic scale, varying from dislike extremely (score 1) to like extremely (score 9) was used[12]. A total of 50 panelists from the University of Venda community, including university students and staff participated in the study. Errors due to bias were reduced by not including on the panel those persons who were directly involved with the preparation of samples during the sensory evaluation of yoghurts. To avoid bias, samples were also coded so that the panelists could not identify them. The sample presentation order was randomized among and within assessors[13]. The panel of judges was chosen based on their willingness, availability and motivation.

2.2.5 Statistical analysis

Triplicate analysis of yoghurt was done. Data analysis was conducted using SPSS 17.0 statistical software[14]. Data were statistically tested using analysis of variance (ANOVA) and Tukey (p<0.05) to determine if a statistical difference existed (p<0.05) and the least significance difference was used for means comparison.

3 Results and discussion

3.1 Colour of plain and carrot yoghurt

The data revealed that there was a significant difference between the colour of fresh carrots and the carrot powder (Table 1). The Lightness, redness and yellowness values were high in fresh carrots as compared to carrot powder.

Table 1 Colour analysis of raw carrots and carrot powder

Sample	Colour		
	L *	a*	b*
Raw carrots	33.35^{a}	28.74^{a}	42.74^{a}
Carrot powder	8.84^{b}	8.62^{b}	8.32^{b}

Note: Mean values in the same column with different superscripts are significantly different from each other (p<0.05). The same below.

The colour of carrot yoghurt is shown in Table 2, lightness decreased as the concentration of carrot powder increased while the redness increased due to the red colour of carrots. Yellowness also increased with the increase of carrot powder. The colour of carrots was greatly affected by the oven drying method which was used, as shown by results. The orange colour is attributed to the carotenoids in carrots and these are heat sensitive. Oven drying is not an effective method of drying carrots as a result the redness and yellowness values decreased.

According to Howard et al.[15], the lightness of carrot is affected by processing temperatures with higher temperatures causing darker colours. This was reflected by the low lightness values of the carrot powder as compared to fresh carrots. Yoghurt colour was affected by the addition of carrot powder. The control had a higher lightness value compared to the other samples. The control had lower a* and b* which represent redness and yellowness and this was in agreement with the values obtained by Hashim et al.[16]. With the addition of carrot powder, the lightness decreased while the redness and yellowness increased. This was due to the colour of carrots which is orange. With increase in carrot powder, the redness and yellowness increased showing the increase in the concentration of colour pigments with increase in carrot powder. The carrot with 3% carrot powder had high a* and b* values.

Table 2 Colour analysis of carrot yoghurt

Treatment	Colour		
	L *	a*	b*
Control	94.50^{a}	-0.9^{a}	7.81^{a}
1%	89.17^{b}	4.80^{b}	15.84^{b}
2%	86.40^{b}	8.12^{b}	17.75^{b-c}
3%	80.14^{c}	12.9^{c}	19.0^{c}

3.2 pH values and titratable acidity of yoghurts

Table 2 shows that the pH values decreased with increase of carrot powder while the acidity increased with increase in carrot powder. The decrease in pH values in all samples might have been due to competition amongst the various organisms present in the fermented yoghurt samples such that they inhibited the fermentation process until one organism became dominant and out-competed the others by a process of natural selection and succession[17].

Table 3 Physicochemical analysis results of carrot yoghurt

Treatment	pH values	Titratable acidity	Total soluble solids (brix)	Protein content/%
Control	4.33^{a}	0.94^{a}	7.64^{a}	4.93^{a}
1%	4.32^{a-b}	0.94^{a}	8.36^{b}	3.63^{b}
2%	4.30^{b}	0.97^{a}	8.75^{b}	3.42^{b}
3%	4.27^{c}	1.01^{b}	10.36^{b}	2.95^{c}

This could be as a result of the ability of these organisms to produce a high quantity of organic acids and the ability to live within the acidic environment[18]. The low pH values obtained in all yoghurt samples is important since most bacteria, including the pathogenic organisms, do not survive in low pH environment. This imparts microbial safety as well as increases the shelf life of the final product[19]. The 3% carrot powder had the highest acidity compared to the other samples because of the sugars from the dried carrots which increased the fermentation by the lactic acid bacteria[5]. The increase in titratable acidity is important to avoid proliferation of undesirable organisms resulting in poor fermentation. The decreased pH values and simultaneous high titratable acidity of the plain and carrot yoghurts could be attributed to the starter culture's activity, such as post acidification due to formation of lactic acid or growth of the bacteria used during fermentation[12,20].

3.3 Total solids

The total soluble solids increased as the amount of carrot powder increased with increase in carrot powder concentration (Table 3). Carrots contain carbohydrates which include reducing sugars such as glucose and fructose. These contribute to the total soluble solids in carrot yoghurt. Increase in carrot powder increased the total soluble solids as expected. The total soluble solids also contributed to the increase in fermentation which led to the decrease in pH values and increase in acidity as the carrot powder concentration increased. According to Tamime and Robinson[21], consistency of yoghurts improves when the content of milk total solids increases from 12%-20%, and a small difference in consistency is achieved when the content of total solids varies from 16%-20%. Similarly, Shaker et al.[22] indicated that the increase in viscosity of yoghurt with highest fat content may be due to increase of total solids of the milk which has a significant effect on the firmness of yoghurt gel and decreasing degree of syneresis.

3.4 Protein content

The protein content of carrot yoghurt decreased with increase in carrot powder (Table 3). Comparing the protein content of the control with the carrot yoghurt, the carrot yoghurt had lower protein content. According to Salwa et al.[5], the protein content decreased with increase in carrot juice because of the inhibitory effect of carrot on the proteolytic organisms that could harbour breakdown of proteins. The increase in protein content in yoghurt depends on the proteolytic activity of lactic acid bacteria which hydrolyses proteins (caseins) into peptides and amino acids[23].

3.5 Apparent viscosity

The viscosity of carrot yoghurt increased with increase in carrot powder (Table 4). The viscosity increased with addition of carrot powder but the difference was insignificant between control, 1% and 3% and between 2%, 3% and 1% carrot yoghurt.

Table 4 Viscosity of the yoghurt samples

Treatment	Viscosity (cPs) 05 spindle at 50 r/min at 28°C
Control	2879^{a}
1%	3092^{b}
2%	3407^{c}
3%	3494^{c}

The increase in viscosity may be due to the absorption of moisture by the carrot powder in yoghurt. According to Sendra et al.[24], increase in orange fibre in powder form increased viscosity because of water absorption and strengthens the gel structure. Labropoulos et al.[25] showed that gel strength and apparent viscosity were the highest for yoghurt made from milk preheated at 82°C/30 min, followed by milk preheated at 63°C/30 min, while milk preheated by a UHT process (149°C/3.3 s) produced yoghurt with the lowest gel strength and apparent viscosity.

3.6 Microbiological characteristics

Table 5 shows total viable count of yoghurts. There was no significant difference in bacterial count between the control and 1% carrot yoghurt, while there was significant difference between 3% carrot yoghurt with the other samples. The high microbial count in 3% carrot yoghurt could be due to the high energy sources supplied by the carrot powder. The reasons for the low bacteria count are probably due to inhibitory effect by lactic acid produced during fermentation[26]. Tamine and Robinson[21] reported that yoghurt should contain 10^7 viable cells of lactic acid bacteria per millilitre. The lower carbon source occurring during fermentation eventually leads to low viable counts[26].

Table 5 Microbial count in carrot yoghurt

Treatment	Total bacterial	Yeast and mould	Coliform
Control	5.4281^{a}	5.1461^{a}	ND
1%	5.4297^{a}	5.2175^{b}	ND
2%	5.4315^{a}	5.2201^{b}	ND
3%	5.4472^{a}	5.2279^{b}	ND

Note: Average bacterial counts Log10 (CFU/g); ND = Not detected.

There was significant difference in mould and yeast counts of the control and 1%, 2 %and 3% carrot yoghurt because they recorded high count. An increase in acidity or reduction in potential oxygen during the fermentation process may have provided a suitable state for growth of yeasts and moulds[27,28]. Growth of mould and yeast was used as indicator of spoilage and acceptability of the product. Several studies have reported contamination of yoghurts by yeast and mould and their growth have been identified as primary contaminants in yoghurt[29-31]. Yeasts are a major cause of spoilage of yoghurt and fermented milks in which the low pH provides a selective environment for their growth[32]. Yoghurts produced under conditions of good manufacturing practices should contain no more than 10^8 yeast cells and should have a shelf life of 3-4 weeks at 5°C. However, yoghurts having initial counts of >100 CFU/g tend to spoil quickly. Yeasty and fermented off-flavours and gassy appearance are often detected when yeasts grow to 10^5-10^6 CFU/g. Coliforms viable cells were not detected in all yoghurts. This is in agreement with the study of Sengupta et al.[28] where absence of coliform was reported in fresh and fortified yoghurts at zero time and on the seventh day of storage. Coliforms were used as an indicator of the general hygiene of the production process and packaging material, as the presence of coliform in food is an indication of unsanitary conditions of processing and feacal pollution, which is of public health concern[33,34]. Many workers reported on the survival of coliforms if present, in yoghurt to a maximum of three days[26]. It has been found that carrot has an inhibitory effect on the coliform organisms[18].

3.7 Sensory evaluation

The mean scores of sensory attributes of plain and carrot yoghurt are presented in Table 7. There was no significant (p>0.05) difference between the colour and taste of both yoghurts. The mean colour score for 3% carrot yoghurt had highest score (7.9). This was comparable to plain yoghurt (7.0) with the lowest score indicating that the colors for both yoghurts were equally liked extremely. Consumers liked the orange reddish colour imparted by the carrot powder and creamy whiteness of the plain yoghurt. However, the taste of both yoghurts was neither liked nor disliked, having a mean scores ranging from 4.0 to 4.5 (Table 7). Salwa et al.[5] found that yoghurt fortified with carrot juice had a sweet taste from the carrot juice but with carrot powder, the sweet taste was not there. The texture for 3% had a significant difference compared to the other samples as most consumers did not like it.

Table 6 Organoleptic examination of plain and carrot yoghurt (*n*=50)

Treatment	Attributes				
	Colour	Aroma	Taste	Texture	Overall acceptability
Control	7^a	5.5^a	4^a	6^a	6^a
1%	7.4^a	6.7^b	4.5^a	5.3^a	6^a
2%	7.7^a	6.8^b	4.3^a	5.1^a	5.4^{ab}
3%	7.9^a	5^a	4.2^a	4^b	5^b

It may be due to high amounts of carrot powder which increased hardness and could no longer be related to the yoghurt consumers are used to. Flavour and texture are the most pronounced factors that influence the quality and acceptance of yoghurt and related fermented milk[35]. Many parameters affect flavour, body and texture of yoghurt such as the starter culture, incubation temperature, processing conditions and compositional properties of the milk base[21,22,25,35]. The overall acceptability for the control, 1% and 2% was insignificant while there was a significant difference between 3% and control. This may be attributed to the texture of the 3% which made it different from the rest of the samples. Hashim et al.[13] found out that texture affected the rheological properties of yoghurt fortified with 4.5% date fibre such that it got low overall acceptability scores.

4 Conclusions

Fortifying yoghurt or dairy products with carrot powder is of great interest to improve the functionality of foods with health benefits. The addition of carrot powder to yoghurt would complement its healthy characteristics. The results highlighted the possibility of processing yoghurt with 1% and 2% carrot powder as these showed good characteristics of organoleptic examination. The developed product was evaluated and proved to be of good quality. Further researches on the effect of carrot powder on the nutritional composition will help to show if the nutrients from the carrot powder will still be available after combining the powder with yoghurt. There is also a need to study the effects of carrot powder on the shelf life of yoghurt. Carrots have antimicrobial properties which may help increase the shelf life of yoghurt. Carrot powder failed to induce a sweet taste in the yoghurt, so there has to be researches to improve the taste of carrot yoghurt or sweetening carrot yoghurt with sweeteners to improve the taste. In selecting carrot powder, there is need to use powder with high nutritional content from freeze drying or other best drying methods such as fluidized bed drying.

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