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PROCESSING PINEAPPLE PULP INTO DIETARY FIBRE SUPPLEMENT

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ABSTRACT

Several tonnes of conventionally consumed dietary fibre-containing fruit components are discarded as wastes in the processing of fruits into fruit juices, resulting in the loss of food nutrients and the increased production of organic waste. A study was done to investigate the processing of pineapple pulp waste from a processing plant, into a powdered product to be used as a dietary fibre supplement. The proximate composition and the functional properties of the raw material and final product were determined. The pasting characteristics or properties of wheat flour fortified with the product up to 20 % were also determined using a viscoamylograph. The wheat flour fortified at 10 % level was used to prepare cookies and muffins after which it was subject to a performance test. Proximate analysis of the product showed crude fibre content of about 30 %; crude protein: 8.5 %; crude fat: 1.5 %; total ash: 5.2 %, and ascorbic acid: 20 mg/100 g. The fat and water absorption capacities were 2.5 g/g and 2.0 g/g of product respectively. The foaming and gelation capacities of the product were found to be 2.8 % and 12 %, respectively. Changes in the pasting characteristics of the whole-wheat flour with the 10% level of fortification were not statistically significant. Acceptance levels of the cookies and muffins made from the composite flour were high and much preference was shown for samples from the fortified flour compared to samples from whole-wheat flour without fortification. This study demonstrated a potential way of harnessing pineapple pulp, a dietary fibre source, which is lost in fruit processing. This will improve the economic value to pineapple, which is widely cultivated in Ghana. It also demonstrated a way of increasing the dietary fibre content of some popular foods to help increase the fibre intake and health of the general population.

Key words: dietary fibre, pineapple pulp, supplement

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INTRODUCTION

Pineapple (*Ananas comosus*) is a tropical fruit which may be enjoyed whole and fresh, juiced or canned. The fruit is now of high economic importance. It is exported in large quantities to other non-pineapple growing regions of the world. Pineapple juice is also popular and enjoyed the world over. In terms of nutritional value, pineapple is loaded with vitamins and minerals and especially rich in vitamin C and manganese. In the production of pineapple juice, the pulp left behind either goes to other uses or is regarded as waste material. In a lot of pineapple juice manufacturing industries in Ghana, the pulp is not put to any beneficial use and is discarded as waste. The pulp, as a matter of fact, is rich in fibre, which is essential for human health. All this waste fibre could be used to boost dietary fibre content of foods.

Dietary fibre is a group of food components which is resistant to hydrolysis by human digestive enzymes and necessary for promoting good health [1]. It is known to enhance digestive process, stimulates bowel movements, lowers cholesterol, and exerts a positive influence on blood sugar levels [2]. There is a suggestion that dietary fibre would also influence the occurrence of breast cancer [3]. The importance of dietary fibre in the prevention of diabetes mellitus, obesity, coronary heart diseases, colon cancer and diverticular diseases among others, has caused more awareness on the essence of consuming foods with high fibre content [4, 5]. Birch and Parker [6] classified dietary fibre chemically as cellulose, hemicellulose and lignin constituents of foods. The major natural sources of dietary fibre are fruits and vegetables [7, 8, 9].

Pineapple (*Ananas comosus*) fruits are good sources of dietary fibre. There are two groups of dietary fibre – soluble and insoluble dietary fibre [10]. Cellulose, for an example, is an insoluble dietary fibre in fruits and vegetables [10]. Both soluble and insoluble dietary fibre have different physiological effects. The soluble dietary fibre is concerned with lowering cholesterol and glucose regulation. The insoluble dietary fibre is concerned with water absorption and intestinal regulation [10]. The benefits of the two types of fibre are both crucial to the body. According to Schneeman [10] a 30 - 50 % soluble dietary fibre to 70 – 50 % insoluble dietary fibre is ideal to maintain good health.

Dietary fibre in fruits and vegetables is considered one of the most common functional ingredient in food systems as a filler, fat substitute, binder and stabilizer [11]. Fruits have a more balanced dietary fibre profile in terms of soluble and insoluble dietary fibre as compared to fibre from cereal brans which have been widely used as a fibre supplement in various food applications. Cereal dietary fibre is however, low in soluble dietary fibre [3]. The soluble dietary fibre content of pineapple is 0.5± 0.03 g/100g and insoluble fibre has been found to be 2.3 ± 0.12 g/100g. The soluble dietary fibre content of pineapple is 17.8 % ± 0.74 of the total dietary fibre [10].

In the pineapple fruit, the fibre is contained in the pulp of the fruit which comprises the core and the fruit part. In Ghana, the pulp is usually discarded when the fruit is processed into juice, but consumed when the fruit is sliced and eaten in chunks, such as in fruit salads.

In Ghana, valuable amounts of dietary fibre are lost when pineapple fruits are processed into fruit juice. The residual pulp, which forms about 30% of the whole pineapple fruit is lost (Athena Foods, Tema, Ghana, 2006, personal communication). Information from unpublished data available at the Animal Science Department, University of Ghana indicates that the dried pulp contains about 23 % and 48 % acid and neutral detergent fibre, respectively, and about 1 % lignin. In recent times several of the diseases, which could be prevented by adequate fibre in the diet, are emerging in the population. Many people seem to prefer taking fruit juices and less fibrous foods to whole fruits and vegetables. There is a need to develop fibre-rich products to supplement the diet. Work on this research was completed a couple of years ago, however, in April 2010 in South Africa, the Eastern Cape pineapple waste beneficiation project came out with a dietary fibre powder with superior water retention and binding properties (Sunspray food ingredients, South Africa).

Apart from the loss of valuable the dietary fibre, another issue that justify the development of fibre-rich products is waste management. Recovering the fibre for edible uses increases the economic value of pineapple processing and decreases waste. The latter also lessens the pollution effect of pineapple processing. Waste pineapple pulp in Ghana is transported to landfills and left in the open air. There is putrefaction and fermentation which produces foul smell, breeding flies and polluting the environment.

A factor which may have negative effects in the food applications of this dietary fibre is the well – known low pH of pineapples [11]. This challenge needs to be addressed for better quality dietary fibre, if pineapple pulp dietary fibre is to have non- limiting applications in the food industry. Possible applications in the food industry may be found in the meat processing, dairy and baking industries due to binding or water absorption properties of fibre.

The main objective of this study was to process pineapple pulp declared as waste in juice extraction, into a dietary fibre supplement. Specifically, a process was developed for the product, and the product characteristics (including functional properties) were determined.

MATERIALS AND METHODS

Pineapple pulp waste was donated by Athena Foods, Tema, Ghana. Soft wheat flour was purchased from a local market. Food grade calcium hydroxide (BDH Chemical Ltd., Poole England) was also acquired.

Product Preparation

The pineapple pulp sample was cleaned of pineapple peels and other extraneous matter. Proximate analysis was then conducted. All determinations were carried out in triplicate.

Sub- samples of the cleaned pulp were soaked in varying concentrations of food – grade calcium hydroxide for 15 minutes, followed by 15 minutes soaking in water, to modify the pH of the pulp. The pulp (1000 g) was soaked in 2000 ml of the Ca $(OH)_2$ solution. All determinations were carried out in triplicate. The concentration of the solution was varied from 0.01 M - 0.1 M to obtain a desired close to neutral pH.

Dehydration

The samples were then dehydrated and hammer-milled into the final product (Figure 1). The following drying methods were investigated: freeze-drying, vacuum-oven drying, air-oven drying, and drum drying.

For freeze-drying, the samples were freeze-dried in a laboratory freeze dryer (Edwards, model L4KR, Crawley, England). The pressure and temperature inside the vacuum chamber was 0.05 mbar and -20^{o}C. The product final temperature during secondary drying was about 38^{o}C.

Samples were also dried in an air oven at 70^{o}C for 7 hours.
Vacuum oven drying was carried out at 50^{o}C at 20 mbar for 24 hours

Physico-chemical characteristics of product

Proximate analysis was done on the dehydrated pineapple pulp products using the standard analytical methods indicated: Crude protein (A.O.A.C. method 977.02) [12], Crude fat (A.O.A.C. method 920.39), Crude fibre (A.O.A.C. method 930.10), Total ash (A.O.A.C. method 930.05), Ascorbic acid (A.O.A.C. method 967.21a), and Calcium as described by Pearson [13].

Water and oil absorption capacities were determined by the method of Beuchat [14]. It was modified as follows: One (1) gram of product was weighed into a centrifuge tube and 10ml distilled water or oil (approximately 28^{o} C) added. The mixture was stirred for 30 seconds, and allowed to stand for 30 minutes and then centrifuged at 5000 x g for 10 minutes, using a Denley centrifuge. The volume of the supernatant was then measured in a 10 ml graduated measuring cylinder and converted into weights using the density of the water or oil. The water/oil absorption capacity was then expressed as the percentage of the initial sample weight.

Gelation capacity was determined by the method of Coffman and Gracia [15]. Sample suspensions (2 – 20 %) were prepared in 5ml distilled water and heated for one (1) hour in a boiling water bath. This was followed by a rapid cooling, under running cold water, to room temperature and further cooling at 4 ^{o}C for 2 hours. The tubes were then inverted to observe the slope or fall of the samples for determining the least gelation concentration.

Foaming capacity was determined by the method of Sathe and Salunkhe [16], and modified as follows: Two (2) gram-sample of the product was homogenized with 100 ml distilled water in a high-speed homogenizer (HSE model) set at high speed for 1 minute. The resulting liquid and foam was then poured into a 250 ml graduating cylinder within 10 seconds. The total volume was noted. The increase in volume before whipping was expressed as the foaming capacity.

Pasting characteristics of wheat flour fortified with the pineapple pulp product were determined as follows: Wheat flour samples were fortified with the pineapple pulp product at 5%, 10%, and 20%. The pasting characteristics of the samples were determined using a Brabender Viscoamylograph (Brabender, Duisburg, Germany) equipped with a 500 cmg sensitive cartridge. The viscosity of the samples were continuously monitored upon heating from 25 ^{o}C at a rate of 1.5 ^{o}C /min to 95 ^{o}C, held for 30 minutes and cooled to 50 ^{o}C for 15 minutes. Brabender Viscoamylograph indices were measured.

Microbiological Analysis

Microbiological analyses were conducted on the pineapple pulp product using standard microbiological procedures; total viable count, coliform count, yeast and mold count. Plate count Agar, Violet Red Bile Agar and Malt Extract Agar were the media used for the analyses.

Sensory Analysis

To determine the optimum pineapple pulp concentration experimentation was done with 5%, 10%, 20 % by weight dried pineapple pulp in wheat flour and used to prepare muffins and cookies. The best cookies and muffin samples were those containing the pineapple pulp product at 10 % concentration. Hence flour with 10% pineapple pulp powder and the other without the pineapple pulp product (control), were used to prepare cookies and muffins. This was done to investigate consumer acceptance of pineapple pulp-fortified baked goods. Twenty-four (24) panellists were each presented with two different coded samples of cookies and muffins with and without pineapple pulp and instructed to indicate on questionnaires which product they preferred in a simple paired preference test.

RESULTS

The data on the chemical composition of the waste pineapple pulp, as determined, are presented in Table 1. Crude fibre and protein contents were very substantial. There was also high amount of Vitamin C. The high moisture content suggests a poor juice extraction rate. The moisture of dietary fibre concentrates depends primarily on the intensity of the pulp dehydration during the processing. From Table 1, pineapple pulp is high in total fibre (about 30%) , which proves it is an adequate source of dietary fibre. The fresh pulp was acidic, with a pH of 3.6; it had a sharp unpleasant acidic taste.

Figure 1 shows the flow diagram of the process used. As the concentration increased, the pH also increased and the corresponding pHs with the concentrations was as presented in Table 2. An alkaline concentration of 0.05M was considered appropriate in the final product development. A linear relationship was observed between the concentration of Ca $(OH)_2$ used and the calcium content of the product. That is, as the Ca $(OH)_2$ concentration increased, the calcium content also increased. This suggests the possibility of fortifying the product with essential micronutrients. The sugar content of the pulp is an advantage when the product is intended for sweet food applications. If this is not desired, there will be the need for alcohol extraction in order to obtain a product with a bland taste. This process step will lead to avoidance of browning by caramelization reactions upon heating.

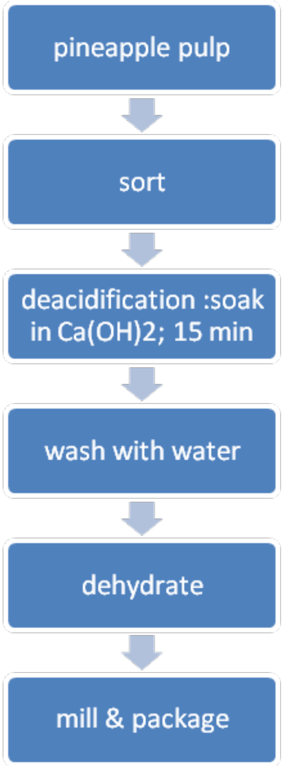

Figure 1: Flow chart for the production of the dehydrated pineapple pulp

Dehydration

All drying methods used, were able to adequately dehydrate the pulp. The dehydrated products had a sweet taste. The different methods however, differently affected the process and product characteristics. The freeze-drying method had a low dehydration rate.

The freeze-drying took a longer time to dehydrate the product: after 48 hours of drying, the moisture content of about 20 % was recorded, however, the original colour (slightly yellow) and the pineapple flavour of the pulp were conserved**.** The vacuum drying time was shorter compared to the freeze-drying and yielded a product of lower moisture content after 18 hours. In the process, the pulp was subjected to high temperatures which caused non-enzymatic browning (Maillard reactions) that were responsible for the darkening of the product [17]. The most desirable and practical drying operation and product was obtained with the air-oven drying after drying for 7 hours at $70^{o}C$ The product was well-dried (moisture of about 8 %), with golden-brown colour and a substantial level of pineapple flavour. Of course, even the golden brown colour might pose a problem for food applications where a fibre supplement of

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neutral colour is desired. The product developed an unpleasant odour when the air-oven drying was done below 60 ^{o}C. Presented in Table 1 are the chemical analyses data on the air-oven dried product. There was a good concentration of the nutrients, except ascorbic acid, which was low. The high fibre content makes the product a concentrated source of dietary fibre.

Physico-chemical characteristics

The fat and water absorption properties of the oven-dried product suggest that the product could be used in fatty foods and emulsion systems without making them soggy with water or fat. The foaming capacity was low and unstable. The small amount of proteins and the presence of excess alkali may have accounted for the foaming observed. Excess alkali may affect the product and ought to be completely washed out. The least concentration at which the product would gelatinise was 12 %. Below this concentration, the product would not gel. The gelling concentration is high and does not make the product a good thickening agent for food systems.

Presented in Figure 2 are the amylograms of the whole, fortified wheat flour samples. The addition of the dehydrated pulp product reduced the pasting properties of the wheat flour. The whole (100 %) wheat flour had the highest peak viscosity of 460 BU and the values for the 5%, 10% and 20% levels of fortification were 380 BU, 320 BU and 115 BU, respectively. Thus, the higher the level of fortification, the lower the peak viscosity of the wheat flour.

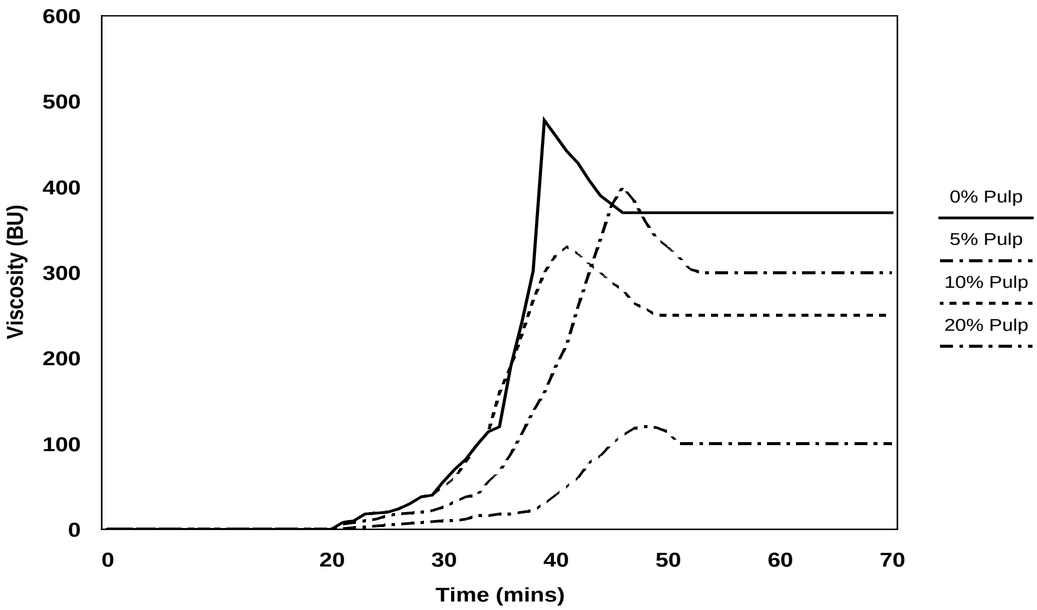

Figure 2: Visco-amylograms of wheat flour sample fortified with dehydrated pineapple pulp

Microbiology

Twelve (12) colony-forming units per gram sample (cfu/g) were counted in the total plate count, but the total coliform count was zero. Ten (10) cfu/g were also counted on the malt extract agar plates. Generally, the microbial load of the dehydrated pulp was low, and the absence of coliforms suggests the product could be safe for human consumption. It may however be more appropriate to sterilize the raw pulp after the alkalization before the final dehydration to increase the microbial safety, even though the vitamin C content would be affected.

Sensory Analysis

The paired preference results showed that panellists preferred baked goods with pineapple pulp fortification to the plain samples. Seventy two percent (72%) of the panellists preferred test muffins to the control muffins while 60 % preferred test cookies to the control. Some of the reasons given for the preferences were: the pineapple flavour in the test samples; the sponginess, softness, better mouth-feel, and nicer yellow colour of the muffins from the fortified flour, and the higher crispiness and pleasant flavour of the cookies from the fortified flour. These are indications that the dehydrated pulp could be used to increase the fibre contents baked goods and other foods. It could have farther-reaching applications when the pulp has undergone even further appropriate processing.

CONCLUSION

The study has shown the feasibility of harnessing the pineapple pulp, a typical waste product in pineapple juice production in Ghana, for edible use. A safe and acceptable powdered pineapple pulp product could be obtained as a nutraceutical to fortify wheat flour as well as other appropriate food products. This would go to improve the fibre content of popular foodssuch as muffins and cookies. Processing of the pineapple pulp into this product will increase the economic value of local pineapples. The pineapple pulp dietary fibre product itself could also be fortified with essential micronutrients to be used as a food supplement. Production of food supplements with micronutrient fortification would be an interesting focus for further research.

Table 1: Proximate characteristics of processed and unprocessed pineapple pulp dietary fibre

Chemical constituents	Composition (g/100g)	
	Unprocessed pulp	Processed pulp (Air-oven dried)
Moisture	66.0 ± 3.00	8.1 ± 0.20
Crude protein	3.7 ± 0.02	8.51 ± 0.18
Crude fat	0.47 ± 0.03	1.48 ± 0.04
Crude fibre	12.5 ± 0.13	29.86 ± 0.61
Total ash	3.16 ± 0.05	5.18 ± 0.07
Ascorbic acid	54.5 ± 1.20	20.4 ± 0.50

Table 2: Corresponding pHs with the varying strength of Ca $(OH)_2$

Strength of Ca $(OH)_2$ [M] for alkalization	Corresponding pH of pineapple after washing
0.00	3.64 ± 0.04
0.01	3.80 ± 0.15
0.05	6.46 ± 0.21
0.10	7.28 ± 0.06

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