academicJournals

Vol. 8(6), pp. 305-310, June 2014
DOI: 10.5897/AJFS2014.1165
Article Number: 9B56DDF45992
ISSN 1996-0794

http://www.academicjournals.org/AJFS

African Journal of Food Science

Full Length Research Paper

Dietary fibre, ascorbic acid and proximate composition of tropical underutilised fruits

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Received 12 April, 2014; Accepted 19 May, 2014

The current surge in the prevalence of chronic diseases has necessitated the call for the increased consumption of fruits to curtail the phenomenon. The dietary fibre fractions, ascorbic acid and proximate composition of edible portions of four underutilised fruits namely; *Annona muricata* (soursop), *Irvingia gabonensis* (African mango), *Artocarpus altilis* (breadfruit) and *Annona squamosa* (sweetsop) were studied. Dietary fibre fractions were determined by an enzymatic-gravimetric method, ascorbic acid by titrimetry while proximate compositions were also by standard methods. Total dietary fibre obtained for the samples was least in sweetsop (11.50 g/100 g) and highest in African mango pulp (22.70 g/100 g). The soluble fractions ranged from 2.28 (soursop) to 7.35 g/100 g (African mango seeds) while the insoluble fractions ranged from 8.01 (breadfruit) to 18.00 g/100 g (African mango pulp); obtained fractions being higher than that reported for most fibre-rich foods. Ascorbic acid content of fruit mesocarps ranged from 20.33 (sweetsop) to 63.67 mg/100 g (soursop). Proximate contents were in the range of 2.63 - 6.71, 2.44 - 4.00 and 0.65 - 23.24% for protein, ash and carbohydrate, respectively. The findings suggest these underutilised fruits may serve as rich sources of dietary fibre and ascorbic acid to significantly impact health of consumers in the treatment and prevention of chronic diseases. The appreciable ash and carbohydrate content will significantly supplement the overall nutrient needs of consumers. Thus, these fruits could be exploited for optimum health benefits of the populace.

Key words: Dietary fibre, ascorbic acid, proximate composition, underutilised fruits.

INTRODUCTION

Modernisation has resulted in a ‘nutrition transition’ where consumers now prefer well refined diets rich in fats and animal products but low in fibre to unrefined diets high in fibre (WHO, 2005). Chronic diseases are on the rise as a result and now cause three times more deaths than HIV/AIDS, tuberculosis and malaria combined. In West Africa, one in four people suffer from a chronic disease (Anonymous, 2006). The growing adverse effect of this ‘nutrition transition’ has necessitated the call for increased consumption of diverse fruits and vegetables especially that of the underutilised species (Padulosi et al., 2006) as they are potential sources of health-beneficial (bioactive) compounds such as antioxidant vitamins, polyphenols and dietary fibre. These bioactive compounds are known to have inverse relationships with the risk of many chronic diseases (Lee and Kadar, 2000;

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FAO/ WHO, 2004; Anderson et al., 2009).

Dietary fibre is available in two fractions, soluble and insoluble with the sum of the two referred to as total dietary fibre. It refers to the complex mixture of organic constituents of foods especially those of plant origin that are non-digestible by enzymes in the human digestive tract but may be digested by microflora in the large intestine and which have one or more physiological effects associated with their intake (Champ et al., 2003; Anonymous, 2007). Epidemiological studies showed that there is an inverse relationship between the intake of the different fibre fractions and risk of chronic diseases including obesity, hypertension, diverticular disease, constipation, haemorrhoids and coronary heart diseases (Anderson et al., 2009). Thus, a daily consumption of 21-38 g of total dietary fibre has been recommended to achieve the associated health benefits (Anderson et al., 2010).

Antioxidant vitamins on the other hand, refer to naturally-occurring vitamins with appreciable antioxidant (free radical scavenging) activity. One such antioxidant of importance in fruits is vitamin C, otherwise referred to as L-ascorbic acid (the active form of vitamin C) (Lee and Kadar, 2000).

In Ghana, there are a number of tree fruits that remain underutilised despite their potential for use as food in solving food security challenges and also for therapeutic purposes (Abebrese et al., 2007). They include *Diospyros mespiliformis, Irvingia gabonensis, Detarium microcarpum, Tamarindus indica, Artocarpus altilis* and the *Annona* species.

However, there is limited data on the dietary fibre composition, ascorbic acid and other chemical constituents of most of these underutilised fruits to substantiate any associated health claims– invariably, limiting their use. Thus, investigating the dietary fibre and vitamin C content in addition to determining the proximate composition of these fruits will provide relevant information for the health-conscious consumer as well as provide data for further studies aimed at enlarging the nation's food basket for optimum health.

This study, therefore, aimed at determining the dietary fibre fractions, ascorbic acid content and proximate composition of edible portions of four underutilised fruits namely; *Annona squamosa* (sweetsop pulp), *Annona muricata* (soursop pulp), *Irvingia gabonensis* (African mango - pulp and seeds) and *Artocarpus altilis* (breadfruit pulp).

MATERIALS AND METHODS

Source of materials

Commercially mature fruits of *I. gabonensis* and *A. altilis* were obtained from the Kwame Nkrumah University of Science and Technology (KNUST) campus whereas those of *A. muricata* and *A. squamosa* were purchased from the local markets in Accra and Kumasi. All chemicals used were analytical grade reagents.

Sample preparation

Fruits were sorted, washed under running water, dried and then weighed. The average weights were1267, 195, 415 and 177 g for breadfruit, African mango, soursop and sweetsop, respectively. The sampling was repeated– one for the proximate determinations and the other for the dietary fibre and vitamin C analysis. In all, about 70 African mangoes, 10 breadfruits, 20 soursop and 40 sweetsop fruits were selected for use. The samples were peeled and where applicable, the seeds removed from the pulp. The pulp of African mango and breadfruit were reduced to a thickness of about 0.2 mm with a laboratory slicer (Model ART NO.S-727, China) while the African mango seeds were reduced to a similar thickness with a stainless steel knife. Samples to be analysed for proximate composition were immediately processed. Approximately 150 g each of those for dietary fibre and vitamin C analysis were bagged in pre-weighed zip-lock pouches and then frozen for 2 - 5 days at -20°C prior to freeze-drying.

The stored samples were freeze-dried in a vacuum freeze-drier (Model YK – 118 - 50, True Ten Industrial Co. Ltd, Taiwan) for 44 h prior to the various determinations. The freeze-dried samples were then milled (Thomas scientific mini-miller; Model 3383-L70), sieved with an impact lab test sieve of pore-size 400/425 µm (Model BS410 – 1:2000) and bagged in zip-lock pouches. About 10 g each of the bagged samples were then stored at about 8°C prior to the dietary fibre analysis and the rest stored at -20°C for the vitamin C analysis.

Dietary fibre analysis (soluble and insoluble fractions)

The soluble and insoluble dietary fibre fractions were determined by the AOAC 991.43 enzymatic-gravimetric method (AOAC, 1995) and total fibre determined by the sum of the two fractions. In brief, one gram of each freeze-dried sample was weighed into a 600 ml beaker in duplicate. The samples were then subjected to sequential enzymatic digestion by heat-stable α-amylase, protease and amyloglucosidase at 95-100, 60 and 60°C, respectively.

The resultant solution was filtered for insoluble dietary fibre (IDF), and the residue washed with warm distilled water. For soluble dietary fibre (SDF) determination, the combined solution of filtrate and water washings (from the IDF determination) was precipitated with 4 volumes of 95% ethanol. The precipitate was then filtered and dried. Both SDF and IDF residues were corrected for protein, ash and blank, in their final calculations.

Determination of ascorbic acid content

The method as described by Okiei et al. (2009) was followed. About 5 g each of freeze-dried samples was blended with 100 ml of 20% trichloroacetic acid (TCA) diluted twofold with 0.5% oxalic acid solution (33.3 ml TCA + 66.6 ml oxalic acid). The mixture was topped up with oxalic acid solution to 250 ml. The contents were well mixed, allowed to settle and the filtrate used as extract. To 17 ml of 0.5% oxalic acid in a volumetric flask, 3 ml of 20% TCA was added and the resulting solution used as blank. About 5 ml of each extract and blank was pipetted and 5 ml of 4% potassium iodide, 2 ml of 3% acetic acid and 3 drops of 1% starch indicator, sequentially added and mixed. The resultant solutions were individually titrated against 0.01% N-bromosuccinamide solution with continuous shaking until a permanent bluish-purple colour was observed. The vitamin C content (mg/100g) of each extract was calculated as:

$$(\text{Test Titre} - \text{Blank titre}) \times 0.1 \times 0.99 \times \frac{\text{Total volume of extract}}{\text{Volume of extract used}} \times \frac{100}{\text{W}}$$

Where, *W* is the weight of each sample used.

Proximate determinations

The proximate analysis was done on the fresh fruit samples. About

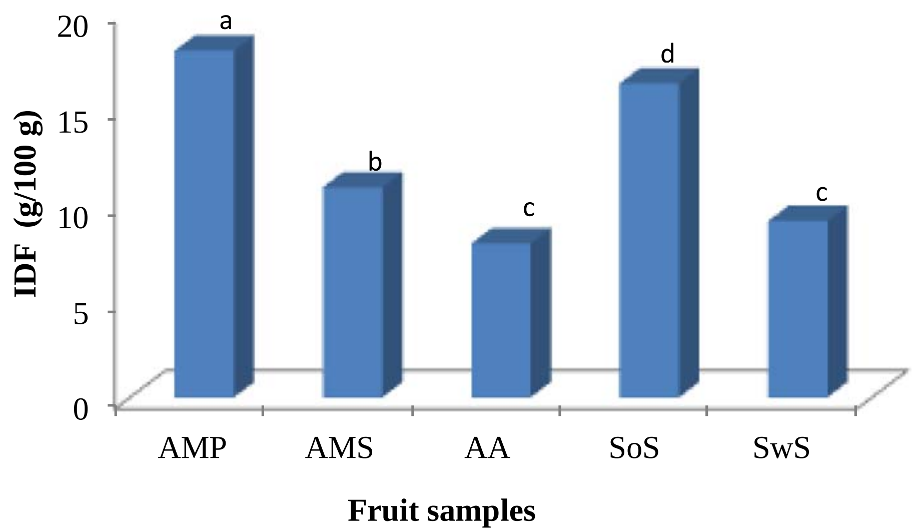

Figure 1. Insoluble dietary fibre (IDF) fractions of four underutilised fruits. a-d: Plots with different alphabets are significantly different at $P < 0.05$; AMP- African mango pulp; AMS- African mango seeds; AA- breadfruit; SoS- soursop; SwS- sweetsop.

100 g of each of the samples were used for the determinations. The AOAC (1997) protocol was employed for the determination of moisture, ash and fat while the method described by Kirk and Sawyer (1991) was followed for crude fibre and protein analysis. The carbohydrate composition of the samples was determined by difference (100 - the sum of the other five determinations).

Statistical analysis

Statistical significance tests were performed using SPSS (v.20, IBM SPSS Statistics, US) at $p < 0.05$

RESULTS AND DISCUSSION

Dietary fibre

The insoluble dietary fibre (IDF) fraction ranged from 8.01 g/100 g for breadfruit to 18.00 g/100 g for African mango pulp (Figure 1). Consumption of foods high in IDF has inverse relationships with the risk of diverticular disease, constipation, haemorrhoids and appendicitis (Champ et al., 2003; Anonymous, 2007). As compared to the IDF content of some acclaimed IDF-rich foods (Li et al., 2002), the results indicate that the studied fruits may contribute significantly to the dietary needs of consumers. Furthermore, these underutilised fruits also compared favourably with the IDF composition of some common fruits reported by Li et al. (2002). The relatively high IDF fraction of the studied fruits confers on them potential health benefits associated with the consumption of IDF - rich foods as aforementioned especially when consumed unrefined.

The soluble dietary fibre (SDF) fractions of the samples ranged from 2.28 g/100 g for soursop to 7.35 g/100 g for African mango seeds (Figure 2). These fractions compared favourably with some common fruits (Li et al., 2002) indicating the advantage of the studied underutilised fruits in their overall contribution to the soluble fibre needs of consumers. Anderson et al. (2009, 2010) recommends a minimum intake of 6 g/day of SDF to achieve metabolic effects such as glycaemic control, lowering of LDL blood cholesterol and reduction in the risk of coronary heart diseases. In accordance with this recommendation, the potential health benefits associated with consumption of the studied fruits, especially, soursop (with 5.34 g/100 g) and African mango (pulp with 4.71 g/100 g; seeds with 7.35 g/100 g) cannot be overemphasised.

SDF intake is also recommended in the treatment of obesity and diabetics (Anderson et al., 2009). The high SDF obtained for African mango seeds (7.35 g/100 g) therefore, corroborates the health benefits derived from its consumption reported by Ngondi et al. (2005) in treating obesity and stabilising blood glucose levels in diabetics.

As expected from their soluble and insoluble fibre fractions, the samples showed high total dietary fibre (TDF) contents with soursop, having the least TDF of 11.50 g/100 g. The percent daily values (% DV) of dietary fibre from these underutilised fruits were in the range, 46 – 91, based on a 2000 calorie diet (25 g/day of fibre, FDA 2009) (Table 1). These findings therefore suggest the potential of the underutilised fruits to contribute significantly to consumers meeting the RDA for fibre when incorporated into diets. Also, the high TDF composition of the studied fruits (11.50–22.70 g/100 g) indicates their potential of being exploited as functional foods and in food formulations, for the prevention and treatment of some non-communicable diseases. This is in relation to the

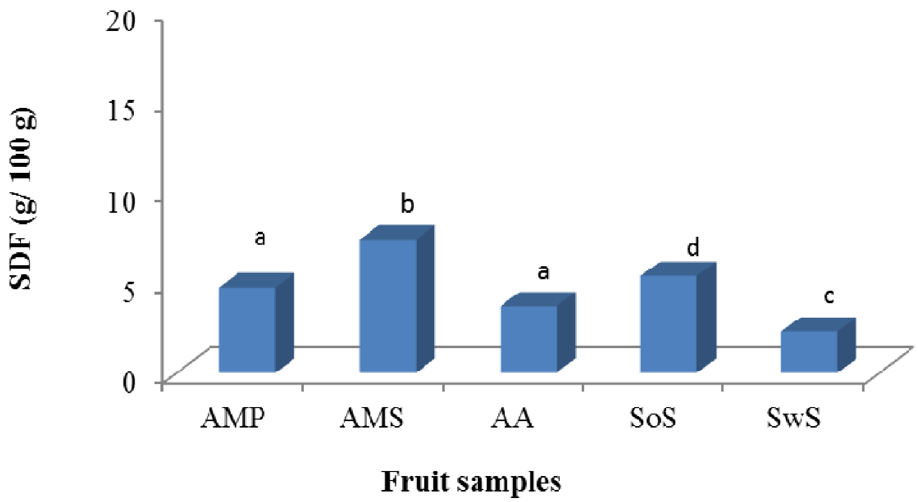

Figure 2. Soluble dietary fibre (SDF) fractions of four underutilised fruits. a-d: Plots with different alphabets are significantly different at *P* < 0.05; AMP- African mango pulp; AMS- African mango seeds; AA- breadfruit; SoS- soursop; SwS- sweetsop.

Table 1. Percent daily value (% DV) of dietary fibre from four underutilised fruits.

Fruit	Total dietary fibre (g/ 100 g)	DV* (%)
African mango pulp	22.7	91
African mango seed	18.3	73
Breadfruit	11.7	47
Soursop	21.6	86
Sweetsop	11.5	46

*: DV (%) based on a 2000 calorie diet.

European Union (2006) recommendation for foods with TDF content of 6 g/100 g or more, to be labelled as high in fibre for health and nutritional claims.

Ascorbic acid content

The analysis of all the fruit mesocarps showed considerable but varying quantities of ascorbic acid with values ranging from 20.33 mg/100 g for sweetsop to 63.67 mg/100 g for soursop (Figure 3). The African mango seeds had a low ascorbic acid content of 1.00 mg/100 g. The ascorbic acid content of soursop and breadfruit were higher than that reported for some Brazilian (Vera de Rosso, 2013) and Hawaiian (Meilleur et al., 2004) varieties, respectively. That for sweetsop (20.33 mg/100g) and African mango pulp (29.33 mg/100 g) were relatively lower than that reported for other varieties by Pinto et al. (2005) (30 mg/100 g) and Okiei et al. (2009) (36.13 mg/100 g), respectively. According to Lee and Kadar (2000), the variances may be attributed to varietal differences and pre-harvest environmental conditions.

However, as compared to the ascorbic acid content as reported by Lee and Kadar (2000) for some readily available fruits such as banana (15.3 mg/100 g) and watermelon (8.0 mg/100 g), the underutilised fruits showed a higher potential to significantly complement the daily vitamin C requirements of consumers when incorpo-rated into diets. Vitamin C (primarily ascorbic acid), which must be supplied daily with a recommended allowance of 40 - 60 mg, has been associated with therapeutic benefits including mainte-nance and protection of skin and teeth as well as the prevention of scurvy, in addition to being an antioxidant. Phytochemical screening of the fruits revealed other phytochemicals/antioxidants including tannins, saponins, glycosides and flavonoids, which also possibly contributed to fairly high antioxidant activities in the range of 60.56 - 75.45% (unpublished data). Thus, the high level of ascorbic acid and antioxidant activity of the studied fruits further indicates the potential health benefits of the fruits.

Due to their heat sensitivity and high volatility, vitamin C is preferred in foods that require little heat application and or processing which puts soursop, sweetsop and African mango at an advantage as they are relished as raw-eaten snacks. The importance of these studied fruits in treating vitamin C deficiency-related ailments is further shown especially for soursop which has an ascorbic acid content that is comparable to that of fruits acclaimed as high vitamin C sources (Lee and Kadar, 2000). Thus, the underutilised fruits show a high potential in their use as alternative vitamin C sources especially in communities where they are abundant in the wild.

Proximate composition

The proximate composition of the fresh fruits is outlined in Table 2. The fruits generally had high moisture contents

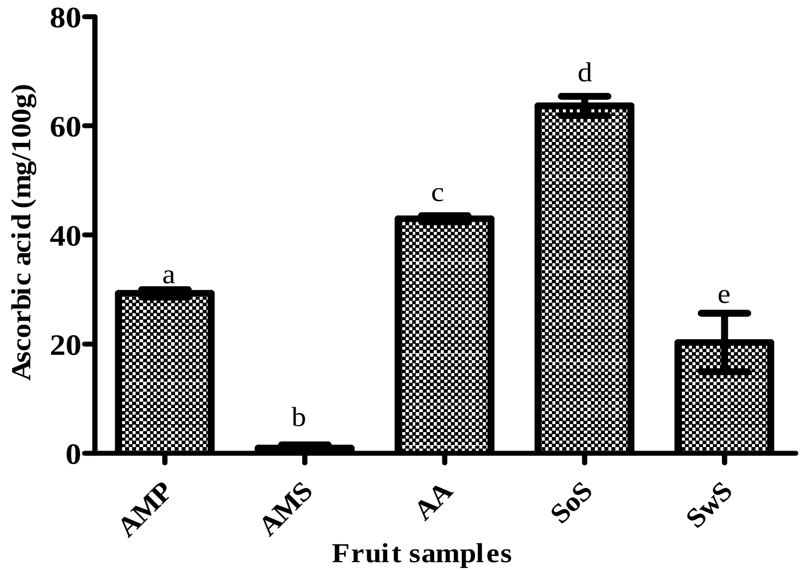

Figure 3. The ascorbic acid content of edible portions of four underutilised fruits. a-e: Plots with different alphabets indicated on top are significantly different (*P* < 0.05); AMP- African mango pulp; AMS- African mango seeds; AA- breadfruit; SoS- soursop; SwS- sweetsop.

Table 2. Proximate composition (% mean) of edible portions of four underutilised fruits.

Proximate	Fruit samples				
	African mango pulp	**African mango seeds**	**Breadfruit pulp**	**Soursop pulp**	**Sweetsop pulp**
Moisture	84.07 ± 0.51^{d}	40.20 ± 3.69^{a}	67.89 ± 0.51^{b}	82.37 ± 0.26^{d}	73.19 ± 0.81^{c}
Ash	2.97 ± 0.47^{b}	2.44 ± 0.07^{a}	2.64 ± 0.02^{ab}	4.00 ± 0.03^{c}	3.07 ± 0.25^{b}
Protein	2.63 ± 0.11^{a}	6.71 ± 0.07^{d}	2.87 ± 0.14^{a}	4.61 ± 0.36^{c}	3.26 ± 0.18^{b}
Fat	2.84 ± 0.17^{ab}	13.90 ± 0.58^{d}	2.60 ± 0.41^{b}	3.55 ± 0.09^{c}	3.30 ± 0.17^{ac}
Crude fibre	4.15 ± 0.34^{a}	13.51 ± 2.15^{b}	2.09 ± 0.29^{c}	4.81 ± 0.33^{a}	4.35 ± 0.12^{a}
Carbohydrates	3.33 ± 0.91^{a}	23.24 ± 5.20^{c}	21.92 ± 0.78^{c}	0.65 ± 0.29^{a}	12.83 ± 0.83^{b}

Values are Mean ± SD. Values in the same row with different alphabets are significantly different (*P* < 0.05).

which ranged from 40.20% for African mango seeds (hull included) to 84.07% for African mango pulp. Moisture content of foods gives an indication of the available dry matter and plays a major role in determining the propensity of the food to spoil (Appiah et al., 2011). The high moisture content observed in the pulp of the *Annona* species (soursop and sweetsop) and African mango reflects the limited shelf-life of these climacteric fruits and thus, the need for value addition of the fruits to extend their shelf-life. The fruits may therefore be tapped in the commercial production of juices, jams and jellies.

The percentage ash contents of the samples ranged from 2.44 (African mango seeds) to 4.00 (soursop) with significant variations (*P* < 0.05) for soursop and African mango pulp and seeds while breadfruit, African mango pulp and sweetsop had similar values. Crude ash gives an approximate measure of the total mineral composition of foods. Thus, the relatively high ash values obtained suggest considerable mineral composition of these underutilised fruits and a potential for the studied fruits to contribute to the total health of consumers.

The fruits had considerable protein content with values from 2.63% for African mango pulp to 6.71% for Africa mango seeds. The samples varied significantly (*P* < 0.05) from one another except for breadfruit and African mango pulp which statistically had similar protein contents. Although fruits are generally not regarded as protein sources, our findings suggests the potential for the studied fruits to contribute to the protein needs of consumers especially, the rural-poor.

Fat content of the samples were high ranging from 2.60% for breadfruit to 13.90% for African mango seeds. Plant fats according to Leakay et al. (2005) and Ainge and Brown (2001), predominantly constitute unsaturated fatty acids and generally lack the much dreaded trans-fats. Thus, the considerable fat contents obtained in the studied fruits may not necessarily pose any health threats to consumers but rather serve as healthy fat sources for optimum health.

The study also revealed considerable crude fibre contents of the fruits with values ranging from 2.09% for breadfruit to 13.51% for African mango seeds. Crude fibre measures one-half to one-seventh of the total dietary fibre component of foods (Anderson et al., 2010). Thus, considering the health benefits derived from dietary fibre as elaborated by Champ et al. (2003), the high crude fibre content observed in the studied fruits is desirable and also corroborates the obtained high TDF composition of the fruits.

The carbohydrate content of the samples ranged from 0.65 (soursop) to 23.24% (African mango seeds) on fresh weight basis. The high carbohydrate content of the African mango seeds supports their indigenous use as soup/sauce thickeners. This attribute can be tapped by industry for their use in the production of flour. The same may be true for sweetsop and breadfruit as suggested by Nwokocha and Williams (2009) and Ragone (2011), respectively. The high carbohydrate content also suggests the potential of the fruits as energy-rich sources in diets of consumers. Generally, the studied fruits showed considerable protein, ash, fat and carbohydrate contents signifying their potential to contribute to the basic nutrient needs of consumers.

Conclusion

The underutilised fruits in the present study had high dietary fibre content in the order: African mango pulp > soursop > African mango seeds > breadfruit pulp > sweetsop pulp. The findings indicate that these fruits could provide up to 91% daily value of dietary fibre suggesting their consumption may significantly influence health of consumers. Also, these fruits could be exploited in diets to prevent and/or treat diet-related chronic diseases. The fruit mesocarps also showed appreciable ascorbic acid, carbohydrate, protein and ash contents, indicating their potential to contribute to the overall nutrient needs of consumers. Therefore, these underutilised fruits could be used in providing much needed fibre, ascorbic acid and carbohydrates in the diets of consumers.

Conflict of Interests

The authors do not have any conflict of interests.

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