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Bioactive compounds rich squash from mulberry (*Morus* sp.) for nutritional security

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The health benefits of fruits and vegetables are attributed mainly to the presence of some photochemicals such as vitamins, polyphenols, flavanoids, flavanols, anthocynins etc., which are usually referred as antioxidants. Besides commercial fruits, the consumption of hitherto underutilized fruits is also gaining importance owing to their antioxidant content and consequent health benefits (Pande and Akoh, 2010). One of the potential underutilized fruit with immense untapped potential could be mulberry. Mulberry (*Morus* sp.) is widely distributed in the temperate, subtropical, or tropical regions of the world and can grow in a wide range of climatic, topographical, and soil conditions. Mulberry is a fast growing deciduous woody perennial plant and is able to tolerate adverse climatic conditions of arid regions. The aim of studying such underutilized crops is their conservation as potential source of antioxidant and agronomic advancement for economic upliftment of the local farming community. One of the possible ways to popularize the cultivation of such underutilized crops could be the development of technology for value addition through processing (Netzel *et al.*, 2007), which in turn would also help regulate the availability of such antioxidant rich sources for consumption for a longer duration. The main objective of the present investigation was to design alternative use of mulberry, other than the fresh consumption by developing new antioxidant rich beverages.

Keywords: Mulberry, underutilized fruit, value addition, phytochemicals, antioxidants.

Material and methods

The present study was undertaken at Central Institute for Arid Horticulture (CIAH), Bikaner. The fruits of mulberry genotypes CIAH Mulberry Selection-1 and CIAH Mulberry Selection-2 (henceforth will be mentioned as CIAH M-1 and CIAH M-2) were collected at full maturity from germplasm block of CIAH research farm. The genotype CIAH M-1 and M-2 are purple red and greenish white in colour at maturity, respectively. The squash contained 25% mulberry juice with 45% total soluble solids and 1% acidity. Before serving, squashes were diluted three times with water. The contents of antioxidant and antioxidant activities were estimated following standard methods. The sensory evaluation of the prepared products was carried out as per the method described by Attri *et al.* (1998). The products in coded form were given to the panel of judges and were asked to give score (out of 10) each for various characters *viz.*, colour and appearance, body/texture, flavour/aroma, taste and overall quality.

Results and discussion

Bio-active compounds rich beverage 'squash' was prepared from the mulberry genotypes 'CIAH M-1' and 'CIAH M-2'. Various antioxidant attributes of the squashes have been given in table 1. A significant variation in such attributes of both squashes was recorded. One serve of the fruit beverage (100 ml) prepared from CIAH M-1 contained 29.8 mg phenol, 12.6 mg flavonoids, while total antioxidant activities were found to be 98 mMTE. However, genotype CIAH M-2 had registered lower values for all the antioxidant attributes except ascorbic acid (Table 1). Antioxidant capacity in mulberry was higher in genotype with dark fruits *i.e.* CIAH M-1, which is in concurrence with the findings of Usenik *et al.* (2008), wherein, they observed higher antioxidant values in dark fruited sweet cherry varieties. The significant variation in the antioxidant attributes of genotypes used may be due to the variation in their genetic makeup and difference in the plant physiology.

In the present study, the relative antioxidant ability of the mulberry fruits was investigated through some *in vitro* models such as antioxidant capacity by CUPRAC, FRAP, and radical scavenging activity using, α, α-diphenyl-β-picrylhydrazyl (DPPH) method as no single method to test the total antioxidant capacity of foods fully considers, at the same time, the activity of all antioxidant compounds (Netzel *et al.*, 2007). The average antioxidant activities were 36.3 to 98.5 as determined by the CUPRAC and FRAP assays (Table 2). Similarly, upon sensory evaluation, the squash prepared from CIAH M-1 adjudged better over the CIAH M-2 (Fig. 1). The fruit squash was found to be acceptable in terms of taste, flavour and appearance among the testers. The results of the investigation shows that mulberry squash, in particular, of dark fruited genotype are good sources of antioxidants and the antioxidant capacities of them are comparable with other research findings (Tosun and Ustun, 2003; Netzel *et al.*, 2007; Pande and Akoh, 2010).

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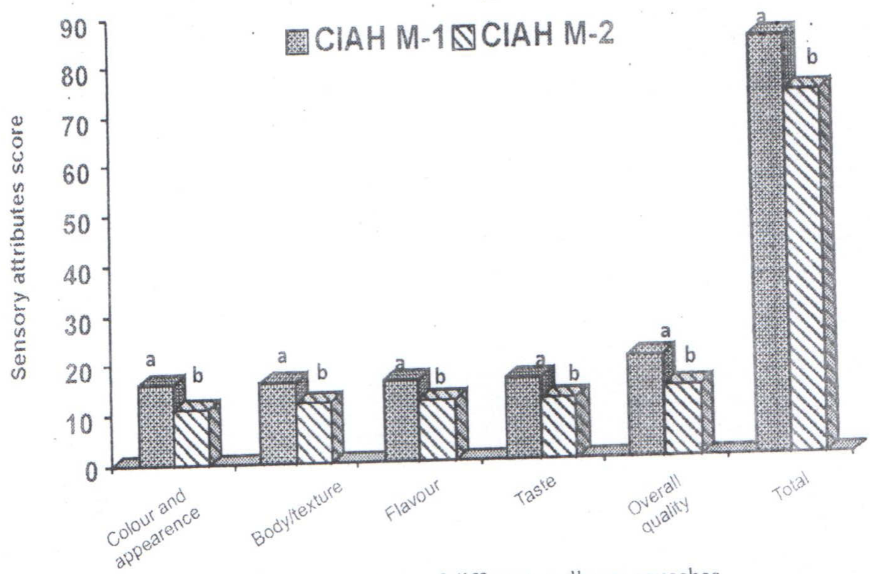

Figure 1 Sensory analysis of different mulberry squashes

Values followed by the same letter are not significantly different (P < 0.05).

Table 1 Antioxidant properties of mulberry squashes per serve

Antioxidant attributes	Genotypes	
	CIAH M-1	CIAH- M2
Ascorbic acid (mg100 ml^{-1})	1.5a	1.9a
Total phenolics (mg100 ml^{-1})	29.8a	23.2b
o-dihydric phenol (mg100 ml^{-1})	1.8a	1.6b
Total flavonoids (mg100 ml^{-1})	12.6a	10.4a
Flavanol (mg100 ml^{-1})	2.9a	2.8a

Values followed by the same letter in a row are not significantly different (P < 0.05).

Table 2 Total antioxidant activities of mulberry squash (per serve) as measured by various assays

Total antioxidant activities	Genotypes	
	CIAH M-1	CIAH- M2
CUPRAC (μM TE 100 ml^{1})	98.5a	42.8b
FRAP (μM TE 100 ml^{-1})	55.7a	36.3b
DPPH inhibition (%)	78.6a	69.2b

Values followed by the same letter in a row are not significantly different (P < 0.05).

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