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ANTIOXIDANT CAPACITY AND SELECTED PROPERTIES OF BEETROOT JAMS PREPARED BY REPLACING REFINED SUGAR BY DIFFERENT NATURAL SWEETENERS

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Abstract
Epidemiological studies have indicated that people who consume fruits and vegetables regularly have lesser risk of suffering from chronic health ailments compared to those do not consume fruits and vegetables. Research indicates that the reason might be the presence of antioxidants and plant metabolites which neutralise the free radicals. Antioxidant intake has a role in shaping the health of a person. There is a dramatic rise in sugar consumption in recent times, and is becoming a health risk. So scientists are searching for a healthier alternative to the refined sugar. Jam was selected for study as it is commonly consumed by many people. Beetroot jam was prepared by using sweeteners such as jaggery, honey, raisins and dates and in various combinations instead of sugar. Four different variations were developed. This jam was tested for antioxidant capacity using DPPH method. IC 50 value of the samples was estimated. The pH of the jams ranged from 5.12 to 5.66. Brix value of the jam samples ranged from 44.3 to 62.2 per cent. The shelf life of the sample was found to be nine months under refrigerated conditions. The results of the study show that the antioxidant capacity of the beetroot jam samples was comparable to that of standard ascorbic acid. So the beetroot jams developed are a good source of antioxidants. Beetroot jams provide a easier way of increasing antioxidant intake in daily life as beetroot jams are rich in antioxidants compared to regular jams.

Keywords: Dates, honey, jaggery, raisins, DPPH method, IC 50

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1. INTRODUCTION

Epidemiological studies have shown that plant based diets reduce the risk of development of chronic diseases like diabetes, cardiovascular diseases, neurological disorders and age related degeneration. This beneficial effect of plant based diet has been partly attributed to the presence of antioxidants. The term antioxidant capacity refers to the collective ability of all antioxidants of a food to neutralize the free radicals. Studies have indicated that production of free radical in the human body is accelerated by a diet high in sugar. Antioxidants are needed to neutralize these free radicals. The ability of the body to neutralize these free radicals can decide the health and vigour of a person. The resulting oxidative stress can be an etiological factor for chronic degenerative diseases (Chung *et. al*. 2009).

Sugar is an integral part of daily diet of many people. Sugars enhance sweetness. There is a tremendous increase in sugar consumption particularly refined sugars. A study by Seema Gulati and Anoop Misra (2014) has revealed that the per capita total sugar consumption of Indians exceeds that of global average. Though there has been a decline in the consumption of traditions sugars, there is a significant rise in consumption of sugar sweetened beverages like fruit drinks and aerated drinks.

According to nutritionists high sugar consumption is a cause of concern as it can increase the health risk. According to scientific research, the risk is due to increase in energy consumption along with no micronutrient intake rather than due to consumption of sugar *per se*. So there is a need to replace low nutrient dense sweeteners by high nutrient dense sweeteners. This can reduce the health risks without

considerably compromising on taste. To achieve this, refined sugar can be replaced by other sweetening agents like jaggery and honey which contain a mixture of different simple sugars along with a small amount of minerals.

Jaggery provides 1480±9 KJ of energy 107 mg Calcium, 4.63 mg iron, 74 mg phosphorus, 488 mg potassium, 25 mg sodium per 100g. It has 84 g total free sugar per 100g which consists of 22 g fructose, 3.8 g glucose, 58 g sucrose. In addition it also provides 127 mg of polyphenols per 100g. (Longvah *et. al.* 2017). The composition, color, aroma, and flavor of honey depend on the flowers foraged by bees that produced the honey. Honey contains about 80% sugars. It consists of 38 per cent fructose, 31 per cent glucose and 9 per cent disaccharides such as sucrose, maltose, isomaltose, maltulose, turanose and kojibiose. Honey also provides traces of B vitamins such as riboflavin, niacin, folic acid, pantothenic acid and vitamin B6. It also contains vitamin C, calcium, zinc, potassium, phosphorous, magnesium, selenium, chromium and manganese. The main group of antioxidants in honey are the flavonoids of which one, pinocembrin, is unique to honey and bee propolis. Ascorbic acid, catalase and selenium are other antioxidant constituents in Honey. Generally speaking, the darker the honey, the greater is its antioxidising properties.(Joel Loveridge 2001).

Raisins (dried, golden *(Vitis vinifera*) provides (per 100g) 1241 KJ of energy, 28 µg of Lutein, 3.5 µg of Zeaxanthin and 272 µg Total Carotenoids, 913 mg of copper, 93 mg of cobalt per 100g. Of the total 61 g of free sugar present in raisins, 23 g is fructose, 16 g is glucose, 22 g is sucrose along with traces of starch (Longvah *et. al.* 2017).

The traditional sweetening agents have different antioxidant capacities as their composition is also different. It is therefore necessary to compare the different sweetening agents with respect to their antioxidant capacity so that one can replace sweeteners with low antioxidant capacity by sweeteners with high antioxidant capacity in daily life. By this antioxidant intake can be increased without compromising on the sweetness. An attempt has been made in this direction.

2. MATERIALS AND METHODS

A suitable sugar product for substitution of refined sugars by other sweetening agents was done based on review of literature. Jam was selected for this as it is consumed by many people especially children. The sweetening agents used for replacing the refined sugar was jaggery, dates, raisins and honey. Beetroot was chosen for making jam as it is rich in antioxidants, pectin content and has a favourable natural colour. According to study conducted by Jatinder Pal Singh *et. al*. (2016), among the vegetables beetroot has strong antioxidant activity because of presence of betalains. Cardamom was used for flavour and lemon juice for taste and for improving shelf life. No synthetic food additives were added for colour or flavour.

Jam was prepared by the following method. Beetroot was pressure cooked for a period of 15 minutes after peeling, washing and weighing the beetroot. After this it was cooled and made into a fine paste using a grinder. The excess water was kept aside for further use. Dates and raisins were grinded separately into a fine paste using a grinder. Jaggery for hand pounded and cardamom was finely powdered. Sterilization of utensils, cutlery and containers to be used for preparing jam were sterilized by boiling for 15 minutes and air dried. The beetroot pulp was cooked in a thick bottom pan for 5 minutes. The excess water kept aside was added to the pulp with constant stirring to prevent charring. After beetroot was cooked, natural sweeteners were added in varying proportions along with lemon juice and cardamom powder and cooked till done. Viscosity of the jam was tested by putting a teaspoon of jam into a saucer plate and tilting it. If it flowed, jam was further heated till a thick paste like viscosity was obtained. End point temperature was recorded using a candy thermometer. The jams were stored in sterilized self sealing glass jars (Vaijayanthi Kanabur and Deborah Daisy, 2018). The composition of the jam is shown in Table 1.

Table: 1 Percent Composition Beetroot Jams (By weight)

SL. NO	INGREDIENTS	Beet root jam prepared using jaggery as sweetener	Beet root jam prepared using jaggery and honey as sweetener	Beetroot jam prepared using jaggery, raisins and honey as sweetener	Beetroot jam prepared using jaggery, dates, raisins and honey as sweetener
1.	Beetroot pulp	49	48	48	48
2.	jaggery	49	48	24	24
3	Honey	0	02	02	02
4	Raisins	0	0	24	12
5	Dates	0	0	0	12
6	Cardamom powder	1	1	1	1
7	Lemon juice	1	1	1	1

The jams were evaluated for organoleptic properties and found to be acceptable.

pH: pH of the samples was determined by method described by IS:3025(part11):1983(RA 2012).

Brix: It was determined by AOAC(2016) method.

Shelf life: The total plate count was estimated at three different time intervals of refrigerated storage. Glass bottles were used for storage of samples and were refrigerated at 4°C. Determination of total plate count was done by standard method (IS 5402:2012).

Antioxidant capacity: The antioxidant capacity was estimated by DPPH method (Tepe and Sokmen, 2007).

IC 50: IC (Inhibitory concentration 50%), which denotes, concentration needed to scavenge DPPH free radicals by 50% was determined from per cent inhibition vs concentration graph in Excel.

Statistical Interpretation: Descriptive and inferential statistical analysis has been done. SPSS version 18 (IBM corporation, SPSS Inc., Chicago, II USA) for used for analysing results. The tables and graphs have been generated using Microsoft word and Excel. Level of Significance has been expressed at 5 per cent. Continuous measurements have been presented as mean values. Difference between the groups has been assed using one-way ANOVA.

3. RESULTS AND DISCUSSION

pH value of the jam: The sweetness of the sugar is reduced by the acid and helps in maintaining pH required to set the pectin. A part of acid also comes from fruits or vegetables used in preparing jam. To bring the pH within the optimum range for gel formation and for flavour a fruit acid may also be added. pH ranging from 3.0 to 3.3 is needed for the setting of the gel depending on the pectin content. The pH of lime juice is lower than 3.3. So lime juice was added to bring the pH down. The pH of the prepared jam ranges from 5.12 to 5.66 (Fig 1). The beetroot jams although are acidic the pH is not within the optimum range.

Brix: The sugar content of a solution is expressed in terms of Degrees Brix (symbol Bx). It shows the dissolved solid content. The total soluble solids (TSS) of a jam or Degrees Brix also called end point of the jam is expected to be in the range of 65% to 68%. If TSS is lower than 65% then it results in runny jam which is conducive for growth of bacteria and molds. If TSS content is higher than the optimum range it results in a stiff jam and sugar crystals may form in the jam. The brix value of the prepared samples is given in Fig 2. It ranges from 44.3% to 62.2%.

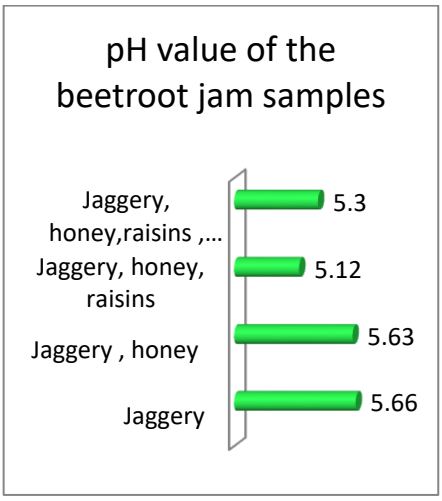

Fig 1: pH value of the beetroot jams

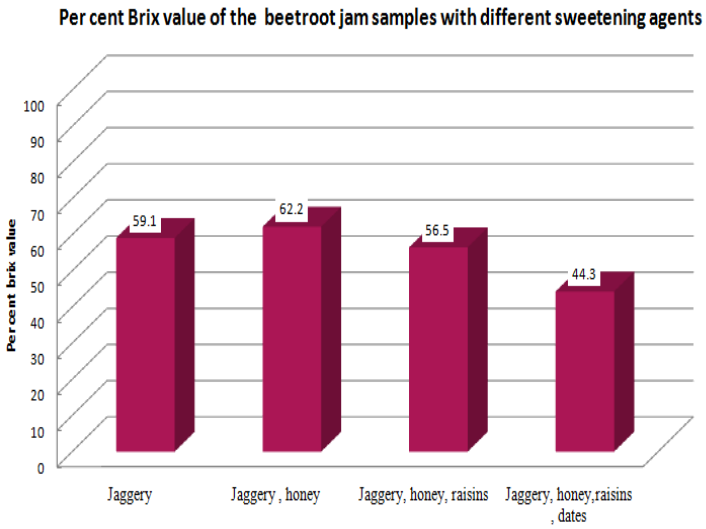

Fig 2: Per cent brix value of beetroot jam samples

Table 2: Microbial load of the samples

Storage time interval	Total Plate Count of different types of jams			
	Beet root jam prepared using jaggery as sweetener	Beet root jam prepared using jaggery and honey as sweetener	Beetroot jam prepared using jaggery, raisins and honey as sweetener	Beetroot jam prepared using jaggery, dates, raisins and honey as sweetener
Fresh	3.3X 10^3 cfu	1.9X10^4 cfu	3.6 X 10^3 cfu	3.4X10^7 cfu
After 1 month	4.1X10^2 cfu	<10 cfu (considered absent)	<10 cfu (considered absent)	3.2 X10^2 cfu
After 9 month	3.5X 10^2 cfu	<10 cfu (considered absent)	<10 cfu (considered absent)	<10 cfu (considered absent)

From the table 2 it can be inferred that under refrigerated storage the microbial load was within acceptable limits and was safe for 9 months.

Antioxidant capacity: Testing of free racial scavenging activity by DPPH method is one of the widely used tests for estimating antioxidant capacity. Figure 3 shows the results of DPPH method. It can be seen from the figure that antioxidant capacity of samples increases with increase in sample concentration. It was found that there was no significant difference between standard and jam samples. The antioxidant capacity of beetroot samples almost matched that of the standard ascorbic acid.

A study conducted by Raquel Guiné (2016) in which they developed an innovative jam using a basis of pear or apple, to which was added the water from boiling beetroot, without the addition of any conservatives observed that the antioxidant activity was on an average 28.7mg TE/g when analysed by ABTS method. According to them the antioxidant activity of their innovative jam may be partly attributed to the addition of beetroot juice. Compared to this study in the present study whole beetroot itself is used for preparing jam and so antioxidants can be expected to be higher than previous innovative jam (Raquel Guine 2016).

Inhibition Concentration 50 (IC 50) values of the samples: The inhibition concentration 50 values are shown in Table 3.

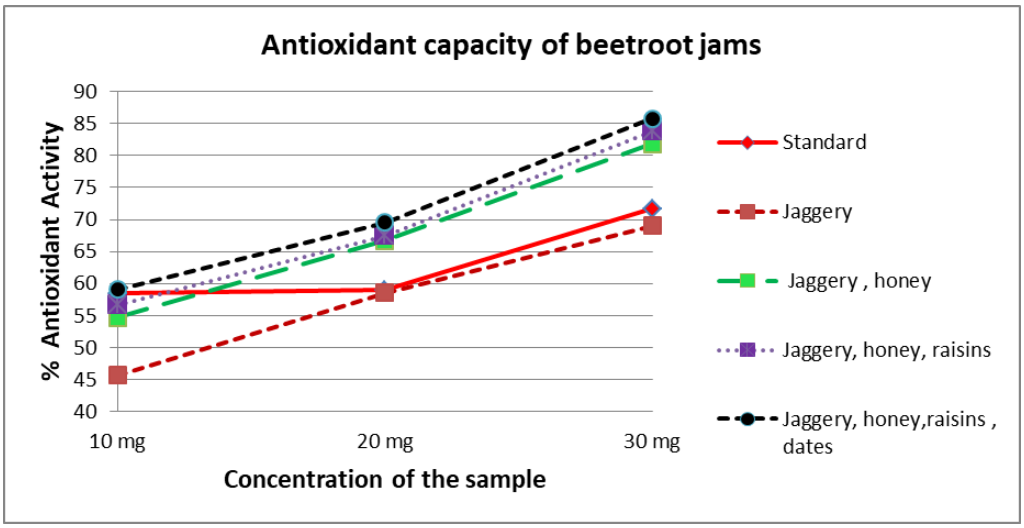

Fig 3: Antioxidant capacity of the beetroot jams

Table 3: IC 50 values of the samples

Sl No	Sample	IC 50 value (mg)
1	Standard (Ascorbic acid)	0.28
2	Sample 1 (Jaggery)	13.37
3	Sample 2 (Jaggery, honey)	6.90
4	Sample 3 (Jaggery, honey, raisins)	5.76
5	Sample 4 (Jaggery, honey, raisins, dates)	3.91

The antioxidant activity of sample 4 (Jaggery, honey, raisins and dates) is highest and sample 1 (Jaggery) is least. The antioxidant capacity of individual components present in the food, along with the synergistic relations between the antioxidant components is responsible for total antioxidant capacity of the jam. The antioxidant activities depend on structural factors like the number of phenolic hydroxyl or methyl groups (Patt and Hudson, 1990).

Levaj B et. al. (2012) have concluded that in case of strawberry, although there is some loss of bioactive components during processing jams still represent important source of bioactive compounds in the diet with noticeable antioxidant capacity. According to some authors the antioxidant capacity of jams may also be partly due to Millard Reaction products formed during jam processing. Marcia Da Silva et. al. (2007) in their study on strawberry jams have opined that jams do contain a significant amount of antioxidants although little less than their corresponding fruits. This is important because fruits like strawberry are seasonal. So the bioactive components of seasonal fruits can be made available throughout the year by processing them into jams. There is a significant difference in the antioxidant capacity of different sweetening agents. Research has shown that there is considerable reduction in antioxidant capacity of sugars due to process of refining. Sreeramulu and Raghunath (2011) have shown that there is a significant difference in the antioxidant capacity of different sweetening agents. The DPPH activity of honey, jaggery and refined sugar was 19.6 TE, 208 TE and 15 TE respectively. According to the authors their findings differ from that of previous studies. In their opinion, the difference might be due to variations in agronomic, genetic or post harvest processing methods. So there is a need for in depth study of antioxidant capacity of various sweetening

agents including the locally processed products. According to Murphy and Johnson (2003) there is no conclusive evidence from research which shows the negative health consequences of sugar consumption. The increase in the health risk might be due to higher energy intake and lack of micronutrients. Excess energy intake, not from sugars alone, can be detrimental to health. Therefore it is advisable to select nutrient dense foods irrespective of whether they contain sugar or not.

4. CONCLUSION

In this study antioxidant capacity of beetroot jams prepared using natural sweetening agents has been studied. Beetroot jams present a healthier option as compared to a regular jam as refined sugar in a regular jam is substituted by micronutrient dense natural sweetening agents. The results of the study indicate that beetroot jams are a good source of antioxidants.

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