The Pharma Innovation Journal 2023; 12(6): 2344-2348

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(6): 2344-2348

www.thepharmajournal.com
Received: 22-04-2023
Accepted: 26-05-2023

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Development of nutraceutical jelly gummies from amla (*Phyllanthus emblica* L.) using natural sugar sources

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Abstract
The present investigation focuses on the development of jelly gummy from amla fruit using different levels and sources of sugar. The objective was to develop a nutrient rich jelly gummy with low glycemic index that can be consumed as a diabetic supplement. Cane sugar were initially tried at different levels (20, 30, 40 and 50%) to a basic recipe containing key ingredients such as amla pulp, pectin, China grass and karaya gum. The sensory analysis conducted to study the consumer preference revealed that gummy jelly with 40 percentage sugar had maximum consumer acceptance. Fixing this as the sugar percentage (40%), another trial was conducted with different sources of sugar such as jaggery, sorbitol, honey, stevia and cane sugar as control following the basic recipe. Among the different sugar sources tried, the most acceptable one with respect to sensory analysis and nutrient content was honey, indicating that honey could be an alternative source of sweetness for development of a healthy gummy jelly.
Various nutritional parameters of gummies were also estimated in this study through proximate analysis and biochemical investigations. The results showed that amla jelly gummy developed is a good source of protein (1.6%), Ascorbic acid (66.5 mg/100 g), Total fat (0.07%), carbohydrate (70 mg/100 g) and TSS (72 mg/l) and is of low calorific value (148 K cal/100 g).

Keywords: Amla, jelly gummies, honey, vitamin C

1. Introduction

Increased health consciousness coupled with convenience as a matter of life has facilitated the global acceptance and demand for functional foods and nutraceuticals in recent years. This growth is driven by socioeconomic factors, increase in population, disposable income, life expectancy and health care costs. Consumer preference has shifted towards food products having natural based ingredients and colorants free of synthetic additives.

Amla or Indian gooseberry (*Phyllanthus emblica* L.) is an indigenous fruit considered as "wonder fruit for health" because of its unique medicinal and nutritional properties (Patil *et al*., 2012) [15]. Amla is one of the richest sources of vitamin C (ascorbic acid 500–1,500 mg/100 g), pectin (2.25%–11.19%) and polyphenols (24.61%–31.12%) and used as a strong rejuvenator in Indian pharmacopoeia (Devi *et al*., 2020) [1].

Amla is grown commercially throughout India because of high adaptability and good economic returns. The crop is hardy, does not require much care, and is suitable for marginal lands. There is also plenty of availability of this fruit during most part of the year at reasonable market prices.

Amla is not consumed much as a fresh fruit because of its sour and astringent taste (Nadheesha *et al*. 2007) [14]. However, the nutritive and remedial properties of the fruit offer great potential for value addition to products like dried powder, pickle, preserve, juice, ready-to-serve beverages, candy etc., (Meena *et al*., 2020) [12].

Confectionery products constitute one of the major categories of the Indian food-processing sector, of which jellies and gummies form a significant share. Jelly gummies are a sweet delicious dessert having a gel- like structure. It is popular among all age groups, particularly youngsters in the age group of 17-20 years due to their organic and chewy nature (Latif *et al*., 2022) [8]. However, most of the jelly gummy products sold with different brand names in Indian markets are mixed with a generous amount of sugar with less nutritional value and may contain synthetic ingredients and colors that are hazardous to human health. Amla contains a diverse range of bioactive compounds, including ascorbic acid, tannins, flavonoids, minerals, polyphenols and alkaloids, which contribute to its antioxidant and health-promoting effects. In this respect, amla provides opportunity to value add to gummy jelly as it is an ideal fruit that having excellent nutritive and therapeutic value (Pria and Islam, 2019) [16].

Incorporating amla into gummy jelly formulations presents an appealing way to deliver its health benefits while enhancing taste and texture.

The formulation of jelly gummies involves selection of a fruit base, suitable gelling agents, sweeteners, flavorings, and colors to achieve desirable texture, taste, and appearance. Different ingredients including gelling agents, such as China grass, gelatin, pectin, agar, or Karaya gum, have been used to create the gel matrix. Natural sweeteners like honey, jaggery, or stevia can be employed as alternatives to sugar. Flavorings and colors are added to enhance sensory appeal. The constituents of a gummy jelly product may include fruits (a minimum of 45 g/100 g), sugars (either sucrose syrup and/or glucose, @ 55%), combined with gelling agents, acids, aromas, and food colorants (Lohar *et al*., 2020., Lemos *et al*., 2021) [10, 9] and the final product will have a jelly-like structure.

Researchers have explored cane sugar reduction strategies to develop healthier alternatives without compromising taste and texture. Lowering refined sugar content has been achieved by using sugar substitutes, such as sorbitol or natural sweeteners, while maintaining desirable sensory attributes and shelf stability. Cane sugar substitutes with low calorific value are gaining considerable interest among researchers in view of the health risks involved (Kumar and Pathak. 2020) [7]. Reducing or even replacing sugars with other sweetening products such as honey might represent healthier alternatives for gummies and jellies (Rivero *et al*., 2020) [18]. A strawberry gummy could be developed after replacement of 50% sugar with sucralose having less calories, without compromising the sensory qualities. (Takeungwongtrakul *et al*., 2020) [21]. Honey and propolis were utilized to create jelly gummies with a sugar content of 525-704 g/kg. In contrast to other sugar sources, it has stronger antioxidant properties (Rivero *et al*., 2020) [18]. Amla Candy developed by using sorbitol syrup concentration treatments (45°Bx, 50°Bx and 70°Bx) along with 0.2% alum pretreatment was found to be suitable to improve the quality of candy. The candy product developed was nutrient rich with low calories and appreciable mineral content (Katke *et al*., 2018) [6]. The variation in sugar percentage and sources used in amla gummy jelly development has significant implications for the nutritional profile and sensory attributes of the final product.

The utilization of amla in the development of nutraceutical jelly gummies offers a promising avenue for incorporating its health benefits into convenient and enjoyable formats. Considering the demand for jelly gummies with improved nutritional characteristics, while also maintaining their traditional textural characteristics, an attempt was made to develop a palatable low calorie, diabetic friendly nutraceutical gummy jelly with a healthy recipe involving amla fruits along with other ingredients and evaluating its acceptability by consumers at Karunya Institute of Technology and sciences, Coimbatore during 2022-23. This study will provide valuable insights into the formulation, optimization, and consumer acceptance of amla jelly gummies and will add to the diversification of amla products.

2. Material and Methods

An experiment was conducted during 2022-23 in the Food Processing Technology laboratory of ‘School of Agricultural sciences’, Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu, India for the development of a nutraceutical jelly gummy from Amla as part of the PG programme.

2.1 Gummy preparation

Freshly harvested matured amla fruits were procured from local market in Coimbatore during 2022 -2023. The fruits were washed and cleaned thoroughly and were subjected to blanching at 60^0 C for 5 minutes. The pulp was extracted and seeds were removed from the pulp. The pulp was blended in an electric mixer until it is smooth and made it into the form of a paste by adding water in 1: 1 ratio. Sugar source is added to this pulp and then heated in a saucepan to around 80^0 C for 15 minutes and stirred until it is dissolved. China grass, pectin and Karaya gum is added to this mixture and cooked further for another 10 minutes with continuous stirring. After complete homogenization, the entire content is transferred to a glass pan. When partially cooled, the gummy jelly was poured into differently shaped gummy mold of approximately 5 g volume and allowed them to set at room temperature for 12 hrs. The jelly samples were removed from the mold and transferred to a refrigerator and stored at 4ºC in an airtight polypropylene plastic container. A flow chart on the preparation of gummy jelly is presented below:

Washing the fruits
↓
Boiling the fruit for 5 min at 60 °C
↓
Seed extraction, pulp separation
↓
Grinding the pulp with water to form a paste
↓
Add sugar source and heat for 15 minutes at around 80 °C
↓
Add China Grass, Pectin, Karaya gum into the sugar mixture
↓
Stir continuously and cook the mixture at 60 °C-80 °C
↓
Allow to cool, pour into shape molds and set them at room temperature for 12 hours
↓
Remove jelly gummies from mold
↓
Storing in refrigerator @ 40 °C for 24 hours

Experiment No 1: In this, gummy jelly was prepared with a standard recipe containing China grass (6%), Pectin (6%) Karaya gum (8%) and Amla pulp (40- 70%), along with cane sugar at 4 levels (20, 30 and 40 and 50%)

Experiment No 2: In this, various sugar sources (@40%) like sorbitol, jaggery, honey, stevia sugar and cane sugar were compared with cane sugar as control with a standard recipe of Amla pulp (40%,) pectin (6%), China grass (6%) and Karaya gum (8%).

2.2 Analysis of the product

The gummy jelly formulations were further subjected to sensory, proximate and microbiological analysis after finishing the product.

2.2.1 Sensory evaluation for organoleptic properties

The prepared gummy jelly samples were subjected to sensory evaluation. A semi-trained panel of 15 judges were selected at random consisting a heterogenous group of students, faculty and public for evaluating the product for appearance, color, taste, aroma, texture, flavor and overall acceptability on a 9-point hedonic scale (Girardot *et al*., 1952) [3]. Panelist fall on the age group of 18-60 years. The panelists were asked to rate the samples for a number of attributes on a Likert scale from 1 to 9, where 1 was the least preferred and 9 the most preferred of the attribute characteristics. (Meilgaard *et al*., 2006) [13]

2.2.2 Proximate analysis
2.2.2.1 Crude Protein
Protein was analyzed by Lowry's method of estimation with Folin-Ciocalteu reagent (FCR) to give blue color formation when reacted with alkaline copper solution and the absorbance recorded at 660 nm by spectrometer or Colorimeter (Lowry *et al*., 1951) [11].

$$\text{Protein content mg of 100 ml of sample} = \frac{\text{absorbance}}{0.2\ (\text{or})\ 0.4} \times 100$$

2.2.2.2 Total Fat
Total fat was estimated by the Soxhlet apparatus method by Sadasivam and Manickam (1992) [19]. A 5 g sample was taken and extracted using ethanol as solvent at 40-60 °C for 16 hrs. Excess of ethanol is evaporated at 105 °C for 30 mins and the particles left is weighed.

$$\text{Crude fat in sample (\%)} = (b - 1) \times \frac{100}{\text{wt.of.sample}}$$

Where, b=final weight of sample.

2.2.2.3 Total Carbohydrate
Carbohydrate was determined by phenol-sulphuric acid method. Phenol and sulphuric acid reagent when added to glucose result in a green colored product the absorbance of which is measured at 490 nm in a spectrophotometer (Dubois *et al*., 1956) [2].
Absorbance corresponding to 0.1 ml of the test sample =X mg of glucose.

$$10\ \text{ml contains} = X \times \frac{10\ \text{mg of glucose}}{0.1} = \%\ \text{of total carbohydrate present.}$$

2.2.2.4 Vitamin C
Ascorbic acid reduces 2,6-dichlorophenol-indophenol dye which is a blue-colored compound and titrated with oxalic acid to form a pink appearance (Harris *et al*.,1935) [4].

$$\text{Ascorbic acid (mg/100 g sample)} = \frac{0.5\ \text{mg}}{V1} \times \frac{V2}{15\ \text{ml}} \times \frac{100\ \text{ml}}{\text{wt.of.sample}} \times 100$$

2.2.2.5 Total sugars
The total sugars were determined by the Anthrone method using colorimetry. Samples were treated with HCl and Conc.H2So4 with anthrone reagent to form blue green coloured compound at 630 nm that is quoted (Hedge and Hofreiter, 1962) [5]

$$\text{Carbohydrate (\%)} = \frac{\text{sugar value from graph (mg)}}{\text{Aliquot sample used (0.5 or 1 ml)}} \times \frac{\text{Total vol.of.extract}}{\text{Wt.of.sample (mg)}} \times 100$$

2.3 Biochemical Analysis
2.3.1 Total Soluble Solids (TSS)
Total soluble solids were measured by digital refractometer (0-100º Brix) (Ranganna, 1986) [17].

2.3.2 pH
The pH of the samples was measured at room temperature with a digital glass electrode pH metre that had been adjusted using buffer solutions with pH values of 4.0 and 7.0. (Ranganna, 1986) [17].

2.3.3 Calorific value
It was calculated by addition of fat, protein and carbohydrates.
Calorific value = (F×9) + (P×4) + (C×4)
Where Fat = 9 Kcal, Protein= 4 Kcal, Carbohydrates= 4 Kcal.

2.4 Statistical analysis
Completely Randomized design (CRD) was adopted for analyzing the data by using WASP, OP stat and SPSS. Statistical significance was examined by analysis of variance (ANOVA) and LSDT for Sensory analysis for experiment 1 and 2 as well as proximate and biochemical analysis. All analyses were performed using the Statistical software.

3. Results and Discussion
An amla based gummy jelly could be developed as per the standard recipe and different concentrations of cane sugar, which was subjected to organoleptic evaluation. A panel of judges consisting 15 members were given the gummy samples for evaluation of organoleptic characteristics *viz*. appearance, color, taste, aroma, texture, flavor and overall acceptability. The average score recorded by the judges is presented in (Table 1) and discussed in fig 1.

Table 1: Mean sensory score for gummy jelly with different levels of sugar

Si. No	Parameter	20%	30%	40%	50%
1	Appearance	6.33	6.44	7.33	6.78
2	Colour	7.39	6.44	7.78	6.22
3	Taste	5.67	5.89	8.11	6.55
4	Aroma	6.78	6.33	8.11	6.78
5	Texture	6.78	6.22	7.22	6.67
6	Flavour	6.22	6.67	7.67	6.78
7	Overall Appreciation	6.29	6.89	7.78	6.44

Fig 1: Sensory analysis of gummy jelly with different level of sugars

Overall appreciation of the product varied from 6.29 to 7.78 for various levels of refined sugar tried. The mean scores of sensory evaluations showed that the formulation containing 40% sugar recoded the maximum values, while the samples containing 20% refined were least accepted by the sensory panel. The scores recorded for the overall acceptability of amla gummy jelly developed was the highest with 40% sugar.

So, the study revealed that this sugar percentage can be successfully tried to prepare a better acceptable product. These results were carried over to another trial involving different source of sugar such as sorbitol, jaggery, honey, stevia sugar fixing the sugar percentage as 40 following the same basic recipe as that of experiment 1. The gummy jelly developed were also subjected to sensory analysis and the results are presented in table 2 and fig 2.

Table 2: Mean sensory score for gummy jelly with different sources of sugar

Sl. No	Parameter	Sorbitol	Jaggery	Honey	Stevia sugar	Cane sugar
1	Appearance	7.67	7.44	7.33	7.04	7.56
2	Colour	7.00	7.04	7.84	6.22	7.15
3	Taste	6.74	6.78	7.70	6.63	7.04
4	Aroma	6.67	6.81	7.89	6.63	6.89
5	Texture	6.56	6.70	7.37	6.15	6.52
6	Flavour	6.70	6.44	7.30	6.56	6.67
7	Overall Appreciation	6.48	6.85	7.89	6.44	7.47

Fig 2: Sensory score for gummy jelly with different sources of sugar

The average scores recorded by various sources of sugar indicated that the formulation with honey was preferred mostly by the panelists. The aroma, texture, flavor and the overall acceptance was significantly higher for amla gummy jelly prepared with honey than other sugar sources. However, cane sugar was the second best preferred by the panelists indicating that the sugar percentages were not enough for other sources to make it acceptable to the consumers. Since honey is an ingredient with nutritional and therapeutic properties, it could satisfy the objective of developing a nutraceutical product being a component of the formulation. Similar results were published by Rivero *et al*., (2020) [18] in which the gummy jelly prepared with honey as a sugar source has better consumer acceptance. The use of honey as a sweetener has beneficial effects unlike added sugars such as cane sugar, since the bioactive compounds present in honey have antioxidant properties, either by themselves or by interacting with other substances (Samarghandian *et al*., 2019) [20]. The present study thus reveal that the development of amla gummy jelly sweetened with honey might be an alternative for healthy gummy products that meet consumer demands. This might be particularly important for the specific segments of the population those are affected by life style diseases like diabetes or obesity.

The gummy jellies developed from experiment 1 and 2 were also subjected to proximate and biochemical analysis. The results of the proximate analysis and biochemical analysis of Experiment 1 are presented in Table 3a and Table 3b.respectively.

Table 3a: Proximate analysis of gummy jelly subjected to different concentrations of sugar

Sl. No	Nutrient	Unit	20%	30%	40%	50%
1	Crude protein	mg/100 g	1.33	1.60	1.42	1.52
2	Total fat	%	0.07	0.08	0.11	0.10
3	Carbohydrate	%	35.7	47.5	70.0	60.7
4	Total sugars	%	35.9	47.5	70.2	60.7
5	Vitamin C	(mg/100 g)	66.5	65.7	66.3	63.8

Crude protein content of the samples ranged from 1.33 to 1.6 mg / 100 mg. Total fat content ranged from 0.07% to 0.11% in samples under various percentage of sugar. As expected, the carbohydrate content and total sugar was higher in samples with higher added sugar percentages of 40% and 50% which ranged from 35.7% to 70.0% for total carbohydrate and 35.9 to 70.2% for total sugars. However, Vitamin C content did not vary much under different sugar percentages which ranged from 63.8 mg/100 g to 66.5 mg/ 100 g.

Biochemical analysis done for the gummy jellies for various parameters are presented in Table 3b.

Table 3b: Biochemical analysis of gummy jelly subjected to different concentrations of sugar

Sl. No	Biochemical parameter	Unit	20%	30%	40%	50%
1	TSS	%	42.0	57.0	69.6	72.9
2	pH		3.65	3.48	3.24	3.14
3	Titratable acidity	%	0.37	0.32	0.27	0.20
4	Calorific value	Kcal/100 g	148.0	197.0	250.3	286.6

Biochemical analysis of amla gummy jelly with different levels of sugar varied for TSS from 42% to 72.9% and was correlated positively with sugar content. pH and titratable acidity values also decreased with higher content of sugar which ranged from 3.65 to 3.14. and 0.37 to 0.20 respectively. Calorific value showed an increasing trend with increase in sugar levels from 148 K cal/100 g to 286. 6 K cal/100 g which was on the expected lines.

Proximate and biochemical analysis were also carried out for gummy jellies developed from various sugar sources and are presented in Table 4a. and Table 4 b respectively.

Table 4a: Proximate analysis of gummy jelly subjected to different sources of sugar

Sl. No	Nutrient	Unit	Sorbitol	Jaggery	Honey	Stevia	Cane sugar
1	Crude protein	mg/100 g	2.66	2.30	1.75	1.87	1.84
2	Total fat	%	0.09	0.14	0.17	0.11	0.08
3	Carbohydrate	%	40.6	61.6	61.7	61.7	60.7
4	Vitamin C	(mg/100 g)	65.1	64.5	65.7	64.8	66.7
5	Total sugars	%	41.4	61.6	61.6	58.2	60.4

Proximate, analysis under various sugar sources did not indicate much variation in Ascorbic acid content which ranged from 64.5 to 66.7 mg/100 g of the samples. Crude protein content was highest in samples with sorbitol as sugar source while it was least in samples with honey. Carbohydrate and total sugars also followed similar trend where the gummies with jaggery and honey recorded highest carbohydrate and total sugars while they were lowest in gummies with sorbitol.

Biochemical analysis of different parameters like TSS, pH, titratable acidity and calorific value were also analyzed for gummies developed with different sources of sugar and the results are presented in table 4b.

Table 4b: Biochemical analysis of gummy jelly subjected to different sources of sugar

Sl. No	Biochemical parameter	Unit	Sorbitol	Jaggery	Honey	Stevia	Cane sugar
1	TSS	%	36.5	68.1	66.5	64.6	71.2
2	pH		2.83	2.80	2.23	2.73	2.94
3	Titratable acidity	%	0.36	0.32	0.38	0.37	0.22
4	Calorific value	K cal/100 g	169.6	254.5	235.7	239.9	258.1

TSS percentage was maximum in gummy jelly formulation with cane sugar (71.2%) while they were almost similar in jaggery (68.1%), honey (66.5%) and stevia (64.6%). However, it was the lowest in sorbitol (36.5%). Gummy preparations with sorbitol contain least calorific value (169.6 kcal/100 g) while it was the highest in gummies with cane sugar (258.1 K cal/100 g). pH and titratable acidity varied between different sources of sugar which ranged from 2.83 and 0.36% in Sorbitol and 2.94 and 0.22% in cane sugar respectively.

Traditional gummy jelly is considered as having minimal nutritional value, with higher calorific value due to their high refined sugar contents. In the present study, the gummy formulation developed with honey showed a lower calorific value with substantial nutrient content when compared to those with cane sugar.

Summary and Conclusion
The results of this study showed that the amla gummy jellies formulated with honey as a sweetener have been much appreciated by the panelists with acceptable sensory attributes. From the results, it is evident that nutrient rich, low calorie gummy jelly product could be developed with substantial amount of vitamin C, protein and carbohydrates. Even though it may not be as tasty as the traditional gummies with synthetic ingredients, it could be marketed for diabetic patients or for individuals who desire to reduce their obesity. However, further analysis is required to understand the gummies' stability over time so as to establish a longer shelf life, as well as to devise appropriate production and packaging solutions to market the product on commercial scale.

Acknowledgement
First and foremost, we would like to thanks to Karunya Institute of Technology and Sciences in Coimbatore for their guidance and mentorship. Their expertise and insightful suggestions greatly influenced the direction and quality of this work.

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