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FUNCTIONAL STRAWBERRY AND RED BEETROOT JELLY CANDIES RICH IN FIBERS AND PHENOLIC COMPOUNDS

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KEY WORDS:
antioxidant, fibers, sensory properties, physicochemical profiles, bioactive compounds, color values, texture analysis

ABSTRACT
Jelly candies have a poor nutritional value due to their primary ingredients, which include gelling agents and sugar. In comparison to commercial jelly candy, the aim of this study is developing a natural and healthy jelly candy using fresh fruit comparing with commercials. Three types of jelly candies were prepared (T1: 75% strawberry + 25% beetroot; T2: 50% strawberry + 50% beetroot; T3: 25% strawberry + 75% beetroot). Physico-chemical, phytochemical, microbial, and sensorial profiles of jelly candy were evaluated. The results showed the superior recipe was T1, which recorded the highest values of bioactive compound content. Therefore, it also had the highest antioxidant activity 52.55%. Otherwise, T2 was considered the most favorable recipe for sensory evaluation, which recorded the highest value of overall acceptability and other sensory properties. Decreasing moisture content in all treatments compared with control had a great effect of preventing microbial growth in all samples except control. Therefore, this study creates a new healthier alternative product with the same sensory parameters of commercial jelly candy for all consumer types, especially children.

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ФУНКЦИОНАЛЬНЫЕ МАРМЕЛАДНЫЕ КОНФЕТЫ ИЗ КЛУБНИКИ И КРАСНОЙ СВЕКЛЫ, ОБОГАЩЕНЫЕ КЛЕТЧАТКОЙ И ФЕНОЛЬНЫМИ СОЕДИНЕНИЯМИ

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КЛЮЧЕВЫЕ СЛОВА:
антиоксидант, клетчатка, сенсорные свойства, физико-химические профили, биоактивные соединения, цветовые характеристики, анализ консистенции

АННОТАЦИЯ
Целью данного исследования является создание натуральной и полезной для здоровья желейной конфеты из свежих фруктов по сравнению с обычными промышленными образцами подобной продукции. В рамках исследования были приготовлены три вида мармеладных конфет (T1: 75% клубники + 25% свеклы; T2: 50% клубники + 50% свеклы; T3: 25% клубники + 75% свеклы). Произведена оценка физико-химических, фитохимических, микробных и органолептических профилей мармеладных конфет. Определено что рецепт T1 показал самые высокие значения содержания биологически активных соединений и самую высокую антиоксидантную активность — 52,55%. Экспериментально подтверждено что, образец T2 стал наиболее благоприятным рецептом в плане органолептических свойств, данный образец наиболее соответствовал требуемым параметрам и благоприятные органолептические свойства. Доказано, что уменьшение содержания влаги во всех вариантах экспериментальных образцов по сравнению с контрольным оказало сильное влияние на предотвращение роста микробов во всех образцах, кроме контрольного. Таким образом, данное исследование позволяет создать новый, более здоровый, альтернативный продукт питания с теми же органолептическими параметрами, что и у промышленно производимых мармеладных конфет для всех категорий потребителей, и в частности для детей.

ВЫРАЖЕНИЕ ПРИЗНАТЕЛЬНОСТИ: Авторы благодарны отделу пищевых наук и программе технологий пищевой промышленности сельскохозяйственного факультета Каирского университета, Египет, за помощь в проведении практических экспериментов в лабораториях.

1. Introduction

Recently, not only nutrition experts but also consumers have no doubt that there is a close relationship between health and daily used food [1]. The market of confectionery products such as hard, soft, jelly candy and nougat is growing daily due to low price and high organoleptic indicators and that increases the amount daily consumption of candy all over the world [2]. Jelly candy was consumed at a high rate, which can negatively affect health, especially in children. The negative effect of this type of sweets may be due to the formation of contaminants during processing using heat treatment such as acrylamide and 5-hydroxymethyl-2-furaldehyde. Also, using artificial flavoring and coloring agents [3,4,5].

Moreover, gummy candies are low nutritional value products because the main components of them are gelling agents such as gelatin, pectin, guar gum, xanthan gum, carrageenan, starch and

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their derivatives. Gelatin is the main gelling agent for this type of candy [6]. sugar is the second main component of jelly candy (sucrose, dextrose and glucose or fructose syrups) and the mixture is boiling at high temperatures, then flavoring and coloring agents were added [7].

A few studies were focused on the production of functional jelly candies using fruit and vegetable, their wastes, or plant extracts. Mamatha and Prakash [8] prepared candies of tamarind (*Tamarindus indica*) fortified with iron for defeated the deficiency of anemia in young adults and children. Also, Muzzaffar et al. [9] processed pumpkin candy as an effective method for preservation and delaying loss of pumpkin bioactive compounds. Also, Kumar et al. [10] appeared the ability to utilization of beetroot pomace extract riches in phytochemicals to improve ginger candy. Recently, Krolevets et al. [11] explained the ability to use nanostructured motherwort extract as one of the fruit jelly candy ingredients which could be used as a therapeutic functional food.

Fresh or processed strawberries are economically and commercially relevant and widely consumed, such as jam, juice, and jelly. Recently strawberry is considered as one of the functional food that provides several health benefits outside basic nutrition as substantiated by growing proof of its antioxidant, anti-inflammatory, anti-hyperlipidemic, anti-hypertensive or anti-proliferative activity [12]. Strawberry's antioxidant qualities were mostly due to their amount of polyphenols and vitamins i. e. ascorbic acid, anthocyanins, and ellagitannins [13]. Strawberries have a unique combination of several nutrients, phytochemicals, and fiber that plays a synergistic function in characterizing them as functional foods [14,15].

Red beetroot is one of the healthy developing functional food [16]. Recently, beetroot has been driven primarily by the finding that dietary nitrate sources may have significant implications for cardiovascular health management [17]. Beetroot is rich in numerous phytochemical profiles that could have many health benefits, mainly for chronic inflammatory disorders. Consequently, in several clinical cases, the important function of beetroot as an alternative therapy [18].

Generally, food rich in fiber have a low glycemic index (GI). Low Glycemic index food with high fiber content has several benefits such as, lower postprandial glucose and insulin responses, improving lipid profile, and possibly reducing insulin resistance. Also, epidemiologic studies reported that the daily diet of normal persons (nondiabetic), based on carbohydrate-rich food with high fiber content and low GI may protect them from several diseases like diabetes mellitus and cardiovascular disease.

Therefore, the study aimed to produce healthy nutritional jelly candy for the new generation. Fortification jelly candy with natural fruit (strawberry and red beetroot) as a source of vitamins, minerals, phytochemicals and fibers 3) Evaluation of physical, chemical, phytochemical, microbiological, and sensorial properties of the final product.

2. Materials and methods

2.1. Materials and chemicals

The full ripe strawberry fruit (Fragaria ananassa), red beetroot (Beta vulgaris L.) "The samples were authenticated by Pros. Mohamed El-mogy, Vegetable Crop Department, Faculty of Agriculture, Cairo University, Egypt", sugar and polypropylene packages were purchased from a local market, Giza, Egypt. Gelatin, Meta phosphoric acid, citric acid, Anthrone reagent, Folin-Ciocalteau, 2,2-diphenyl-2-picrylhydrazyl (DPPH) and Gallic acid standard were purchased from Sigma Aldrich Chemical Co. (St. Louis, Mo, USA). Total plate count agar and Potato dextrose agar media were obtained from Merck (Darmstadt, Germany).

2.2. Preparation of fruit jelly candy

The preparation steps of fruit jelly candy samples were conducted in the laboratory with different concentrations. The formulas were applied to process jelly candies are presented in Table 1. The fruit (strawberry and red beetroot) were washed and the beetroot was blanched at 100 °C/30 min for softening the pulp and to be easily peeled. The beetroot pulp and strawberry fruit were crushed in a homogenizer, and then seeds and fibers were removed by filtration. The gelatin was soaked in a sufficient amount of water for 5 min then dissolved at 70 °C for 5 min in a water bath. The control sample was processed by preparation a sugar solution then the citric acid, gelatin, coloring and flavoring agents were added. They were manually stirred for 20 min. The optimum cooking temperature was maintained to 110 °C. For the preparation of fortified jelly candies, three types of jelly candies were prepared using either strawberry or beetroot in different concentrations (T1: contains 75% strawberry + 25% beetroot; T2: contains 50% strawberry + 50% beetroot; T3: contains 25% strawberry + 75% beetroot). The previous steps were used for the preparation of fortified candies, the sugar was added to the fruit and cooked for 5 min. The citric acid and gelatin were added and completely cooked at 110 °C for 20 min. The endpoint of cooking was identified using a hand refractometer for measuring the concentration of total soluble solids (TSS) which ranged from 61 to 66%. The final product was molded into a silicone mold (2 × 1.5 × 1 cm) and kept in a refrigerator at 4 °C for 6 h. The jelly candy was then un-molded and was packed in polypropylene pouches and stored at 4 °C until further analysis.

Table 1

The formula of commercial jelly candy (control) and fortified jelly candy with strawberry and red beetroot

Samples	Strawberry (g)	Beetroot (g)	Gelatine (g)	Sugar (g)	Water (ml)
Control	—	—	35	80	40
T1	75	25	35	75	10
T2	50	50	35	75	10
T3	25	75	35	75	10

T1:75% strawberry + 25% beetroot; T2: 50% strawberry + 50% beetroot; T3: 25% strawberry + 75% beetroot. Citric acid was added in 2% per kg of sugar. One ml of coloring and flavoring agents were added to control sample only (Kumar et al., [8]).

2.3. Physico-chemical analysis

Total soluble solids (TSS) and pH values of fruit pulp and jelly candy samples were measured according to the standard methods [19]. Five grams of candy samples were weighted and homogenized in distilled water (50 ml), then the pH was measured using a pH meter at room temperature (Orion Research Incorporated, Boston, USA).

Proximate composition (moisture, ash, and fiber contents) of fruit jelly candies were determined according to AOAC (2016) [19]. The total sugar of jelly candy was determined by the Anthrone method. The reaction was carried out as follow: 2.5 g of samples were homogenized in 50 ml methanol and was filtrated (using filter paper NO.1), one ml of the extract with 2 ml of Anthrone reagent was mixed and was left at room temperature for 15 min, and then the absorbance was measured using a spectrophotometer (model UV-2401 PC, Shimadzu, Milano, Italia) at 630 nm. Glucose was used as a standard [20].

The fruit jelly candy's color parameters (L^*, a^*, b^*, and ΔE) were measured by the Minolta colorimeter (Model CR-400, Konica Minolta, INC, Tokyo, Japan). The L^* value represents the lightness. The a^* value represents redness (with + values) and greenness (with — values). The b^* value represents yellowness (with + values) and blueness (with — values), and ΔE (total color differences) were measured using methods described by Abedelmaksoud et al. [21]. ΔE was calculated using the next equation:

$$\Delta E = \sqrt{(L_o - L^*)^2 + (b_o - b^*)^2 + (a_o - b^*)^2}$$

ΔE, where subscript "o" refers to the color reading of the control sample used as the reference and a high ΔE value indicates a large change in the color from the reference sample

The fruit jelly candy texture analysis was conducted using a Universal testing machine (Cometech, type B, Taiwan) fitted with an SMS5 cylinder probe (35 mm) to evaluate texture. Texture analysis conditions (at ambient temperature) were as follow: pretest speed was 2 mm/s, test speed was 1 mm/s, post-test speed was 1 mm/s, the distance between probe and sample was 10 mm, trigger force was 5 g and the delay between two compressions was 2s [22]. The hardness was recorded by Newton (N).

2.4. Determination of phytochemical profiles

The total phenolic content (TPC) of fruit pulp and fruit jelly candies was determined according to El-Mogy et al., [23] with some modifications using Folin- Ciocalteau reagent with Gallic acid as standard. For extraction, 2 g of candies were homogenized in 20 ml methanol (80%) and was stirred using a magnetic stirrer for 1 h. The extract was filtered through filter paper (Whatman No.1) to obtain a clear solution, 0.1 mL of extract was mixed with 0.5 mL of Folin-Ciocalteau reagent, stand for 5 min and then 1.5 mL sodium carbonate (7.5%w/v) was added. The mixture was diluted to 10 mL with distilled water and kept in the dark at room temperature for 1 h. The absorbance was measured at 765 nm with a spectrophotometer (model UV-2401 PC, Shimadzu, Milano, Italia). The results were expressed as Gallic acid equivalents in mg GAE/100 sample.

The ascorbic acid content of fruit pulp and fruit jelly candies was determined using a titrimetric method with 2, 6-dichlorophenol indophenol [24]. Five gram of candy samples were homogenized in 100 ml metaphosphoric acid (3%), and 10 ml of the extract was mixed with 25 ml acetone, then titrate with 2, 6-dichlorophenol indophenol (0.05 g/50 ml water and 42 mg of $NaCO_3$ was then the mixture with complete to 250 ml with distilled water) to pink color. The results of ascorbic acid content were expressed as mg/100 g of jelly fruit candy.

The antioxidant activity of jelly fruit candies was determined according to the method of Elsayed et al., [25]. Fruit candy samples (6 g) were homogenized in 75 mL of methanol and then filtered (Whatman No.1). After that, 0.2 ml of filtrate was mixed with 1 ml of 2,2-diphenyl-1-picrylhydrazyl (DPPH 2.4 mg/ 100 ml methanol) and 3 ml of methanol. The mixture was kept in the dark at room temperature for 30 min. The absorbance was measured at 517 nm. The antioxidant activity was expressed as% of inhibition according to the following equation:

$$\text{Inhibition (\%)} = (A_{control} - A_{sample} / A_{control}) \times 100$$

where

$A_{control}$: the absorbance of the control;

A_{sample}: the absorbance of the sample.

2.5. Microbiological analysis

Fruit candy samples (10 g) were taken from each jelly candy and homogenized with saline solution (0.85% w/v) sodium chloride to have a final dilution of 10^{-1} in a Lab-Blender for 5 min. Serial decimal dilutions were made using the same diluent and then plated in duplicate for bacterial counts. Total count was determined on nutrient agar after 48 h incubation at 30 °C. Mold and yeast counts were determined on acidified potato dextrose agar after incubation at 28 °C for 5 days [26].

2.6. Sensory analysis

Sensory properties such as color, taste, odor, sweetness, elasticity, biting, appearance, and overall acceptability were evaluated by 60 untrained panelists of the Food Science Department, Faculty of Agriculture, Cairo University (35 females and 25 males, aged 20 to 40 y). A 9-point Hedonic scale was utilized for such purpose; the rejection limit is less than 5 [27]. The candy samples were served at room temperature in polypropylene packages.

The statistical analysis program used was SPSS v.22 (SPSS Inc., Chicago, IL, USA). Duncan's multiple comparison test at ($p \leqslant 0.05$) was used to compare means between treatments.

3. Results and discussions

3.1. Physicochemical profiles of jelly candies

The effect of fortification with strawberry and red beetroot pulp on the physicochemical profiles of jelly candy samples are presented in Table 2. A significant increase ($P \leqslant 0.05$) in TSS of different jelly candy samples compared to the control sample. The control sample recorded the lowest concentration (61%), meanwhile, T1 recorded the highest concentration (66%). Due to the effect of using different percentages of fruit pulp (which has differences between them in total soluble solid content), which the TSS recorded 6.5% in ripe strawberry and 5.5% in blanched beetroot. The obtained TSS results in Table 2 agreed with Kumar et al. [10] who noticed that the ginger candy's TSS ranged from 63% to 69% due to the effect of using different concentrations of beetroot pomace extract in preparation.

The pH values of jelly candies were significantly decreased ($P \leqslant 0.05$) by the fruit fortification in different concentrations compared to the control sample. The control candy recorded the highest pH value (4.73) followed by T3, T2, and T1 which recorded the lowest pH value (3.52). This difference in pH values due to the acidity of the fruit, which comes mainly from citric acid. Therefore, the pH of the fruit was measured before candy preparation, which was 3.5 and 5.6 in ripe strawberry fruit and blanched red beetroot, respectively. In this respect,
[3] reported that the hot mixing technique at 115 °C improved the titrable acidity and reduced the pH value of the honey jelly candies. Modifications of acidity and pH in honey jelly candies may be related to sugar acids induced by hexose oxidation at high temperatures, as it is reported that sugars turn to low acids in weakly acidic media at high temperatures.

The proximate composition of control candy and fruit candies was significantly different ($P \leqslant 0.05$), and that due to the change in the chemical composition of different types of incorporated fruits. Strawberry and red beetroot are a good source for ash and fiber contents, which led to an increase in the ash and fiber contents in T1, T2, and T3 compared to the control sample. Meanwhile, moisture and total sugar contents were significantly decreased in all samples compared to the control sample, which makes the fruit jelly candy healthier than the control sample.

In this respect, Giampieri et al. [28] reported the chemical composition of 100 g of ripe strawberry fruit contains 90.95% moisture, 0.40% ash, dietary fiber 2%, and 4.89% total sugar. Besides, the chemical composition of 100 g of red beetroot contains 87% moisture, 4.3% ash, dietary fiber 17%, and 24.95% total sugar [29, 30]. Several studies noticed that the jelly fruit candy contains high moisture content, Muzzaffar et al., [9] reported that the moisture content of fresh pumpkin candy was 20.1%; Mutlu et al., [3] mentioned that the moisture content of honey jelly candy was 23.38%. This explained that high sugar concentration in jelly candy makes a colligative effect and gelatin water absorbance capacity Mutlu et al., [3]. The total sugar was decreased in fruit jelly candies comparing to control candy, because of using a large amount of sugar in the processing of control candy than fruit jelly candy to reach acceptable taste and a prorate TSS. Also, there was a significant difference ($P \leqslant 0.05$) between the other fruit jelly candy due to the difference in sugar content of strawberry and red beetroot as mentioned before.

Table 2

Effect of fortification with strawberry and red beetroot on nutritional value and physico-chemical properties of jelly candy

Samples	Nutrients (g/100g)				Physico-chemical properties	
	Moisture	Ash	Fiber	Total sugar	TSS%	pH
Control	39.13^{a} ± 0.08	0.11^{c} ± 0.02	0.04^{c} ± 0.15	17.13^{a} ± 0.18	61^{c} ± 0.03	4.73 a ± 0.04
T1	36.56^{b} ± 0.34	0.77^{b} ± 0.01	1.02^{a} ± 0.15	13.56^{d} ± 0.21	63^{b} ± 0.01	3.52 d ± 0.06
T2	36.20^{b} ± 0.02	0.73^{b} ± 0.03	0.92^{b} ± 0.02	14.20^{c} ± 0.31	64^{b} ± 0.01	3.99 c ± 0.01
T3	34.15^{c} ± 0.03	0.95^{a} ± 0.02	0.90^{b} ± 0.01	15.15^{b} ± 0.04	66^{a} ± 0.02	4.50 b ± 0.01

T1: jelly candy contains 75% strawberry and 25% beetroot juice; T2: jelly candy contains 50% strawberry and 50% beetroot juice; T3: jelly candy contains with 25% strawberry and 75% beetroot juice. TSS of fruit pulp ranged from 6.5% in ripe strawberry and 4.5% in blanched red beetroot. The pH of fruit pulp ranged from 4.6 in ripe strawberry and 5.6 in blanched red beetroot. The experimental values (means and SD for n = 3) with small letter are significantly different ($P \leq 0.05$).

3.2. Color values of jelly candies

A significant decrease in the color values (L^*, a^*, b^*) with decrease the strawberry content in all jelly candy samples (this is clear in T3, which has the lowest L^*, a^*, and b^* values). Also, a significant increase in the ΔE value compared to the control sample was observed (Table 3 and Figure 1). The ΔE values were 6.13, 9.41, and 12.57 for T1, T2, and T3 respectively, with the larger ΔE for the T3 sample indicating a larger color change (from the reference sample — control) compared to the T1 and T2. This decrease in color parameters or increase for the ΔE value compared to control may be due to the source of dye responsible for the red color in both strawberry and red beetroot. Also, the stability of pigments could affect the degradation rate of samples color. The betalains had low stability, which restricts their use. There are different factors affecting betalains' stability during processing such as temperature, oxygen pH, light, and food types. Regarding Jackman and Smith [30], the betalains are most stable at pH 5.5–5.8 in the presence of oxygen. Moreover, the betalains are degraded during processing at temperatures ranging from 50 °C to 120 °C [31]. The obtained results showed that the pH values of samples contain red beetroot was far from the stable pH range of betalains (3.99, 4.50 for T2 and T3, respectively), which make betalains easily degraded at processing temperature 120 °C. Meanwhile, Rababah et al., [32] reported that anthocyanin had more thermal stability at pH 3.0. This explanation agrees with the obtained results that indicated the pH of fruit after processing decreased from 4.90 to 3.52 in T1, which appeared a low change in color comparing with control, which contains synthetic color.

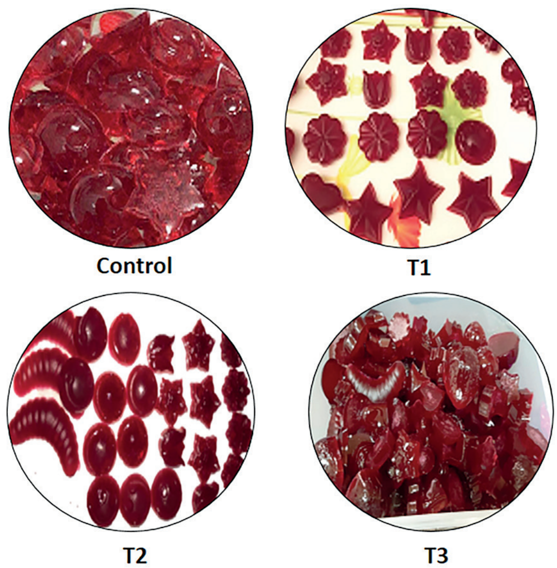

Figure 1. Effect of fortification jelly candy with strawberry and red beetroot on color.

T1: jelly candy contains 75% strawberry and 25% beetroot; T2: jelly candy contains 50% strawberry and 50% beetroot; T3: jelly candy contains 25% strawberry and 75% beetroot.

Table 3

Effect of fortification jelly candy with strawberry and red beetroot on color parameters

Samples	Color parameters			
	L*	a*	b*	ΔE
Control	39.13^{a} ± 0.18	18.72^{a} ± 0.56	4.40^{a} ± 0.16	-
T1	36.56^{b} ± 0.21	13.58^{b} ± 0.41	2.26^{b} ± 0.12	6.13^{c} ±0.24
T2	36.20^{b} ± 0.31	10.48^{c} ± 0.05	0.92^{c} ± 0.01	9.41^{b} ±0.12
T3	34.15^{c} ± 0.04	7.91^{d} ± 0.21	0.35^{d} ± 0.01	12.57^{a} ±0.08

T1: jelly candy contains 75% strawberry and 25% beetroot juice; T2: jelly candy contains 50% strawberry and 50% beetroot juice; T3: jelly candy contains with 25% strawberry and 75% beetroot juice. The experimental values (means and SD for n = 3) with small letter are significantly different ($P \leq 0.05$).

3.3. Texture analysis of all jelly candies

The presented data in Figure 2 showed an increase in hardness value for all samples compared to the control sample. Hardness is the required force to give deformation for the material to be deformed before it ruptures [33]. The order of hardness values of all samples were T3 (31.66 N), T2 (28.09 N), T1 (25.37N), and control sample (24.04 N). Jelly candy contained a high amount of beetroot (T3: 75% beetroot) was found to be harder than the control sample. This increase in hardness values may be related to an increase in the fiber and TSS with a reduction of moisture contents of T1, T2, and T3 compared to the control sample. The obtained results are in agreement with Figiel and Tajner-Czopek [34] who reported that any rise of candy's moisture content within the range of 1.3–2.0% has been found to decrease all of the tested parameters such as hardness, maximum cutting, cohesiveness, elasticity, and chewiness. Besides, fiber combination had a reinforcing effect on the gel's viscoelastic properties. An increase in fiber addition decreased the viscoelastic properties of the gels [35]. Therefore, sample T3 recorded the highest value of hardness (31.66 N) because it was the lowest moisture content sample (34.20%) and high fiber content too (0.90 g/100 g).

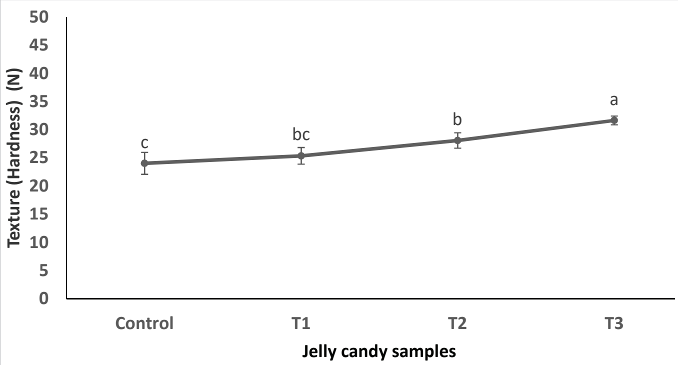

Figure 2. Effect of fortification jelly candy with strawberry and red beetroot on Hardness value.

T1: jelly candy contains 75% strawberry and 25% beetroot; T2: jelly candy contains 50% strawberry and 50% beetroot; T3: jelly candy contains 25% strawberry and 75% beetroot. The experimental values (means and SD for n = 3) with small letter are significantly different ($P \leq 0.05$).

3.4. Phytochemical profile of all jelly candies

The influence of fortification with strawberry and red beetroot on the phytochemical profile was illustrated in Figure 3. The results showed a significant decrease ($P \leqslant 0.05$) in TPC, ascorbic acid, and antioxidant activity in all samples compared with the control sample. The T1 recorded the highest concentration of TPC (299.02 mg Gallic acid /100 g jelly fruit candy) and ascorbic acid (18.10 mg/100 g jelly fruit candy), therefore, it was also recorded the highest value of antioxidant activity (52.66%). Moreover, the order of the rest samples was T2, T3, which was explained due to the difference in bioactive compounds of used fruit concentration. Full ripe strawberry contains 850.13 mg Gallic acid /100 g fresh fruit TPC and 58.8 mg/100g ascorbic acid. Meanwhile, the blanched red beetroot contains 238 mg Gallic acid /100 g fruit TPC and 33.9 mg/ 100 g ascorbic acid. In this regard, Muzzaffar et al., [9] reported that pumpkin fresh candy contains 40 mg GAE/300μL candy extract, 9.15 mg/100g of ascorbic acid and the antioxidant activity was 34.10%. Comparing with control jelly candy, which had not any bioactive compounds results indicated that fortified jelly candy with fruit achieved the aim of this study, producing healthier jelly candy for all consumer types.

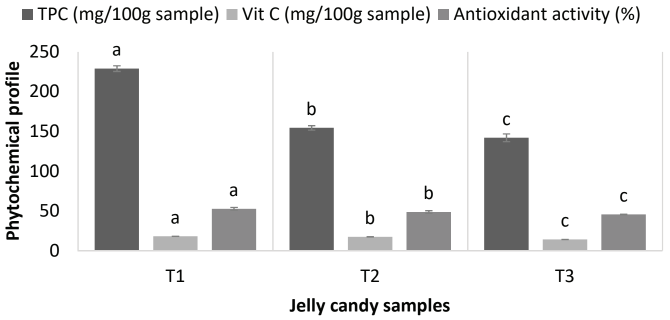

Figure 3. Effect of fortification jelly candy with strawberry and red beetroot on phytochemical profile.

T1: jelly candy contains 75% strawberry and 25% beetroot; T2: jelly candy contains 50% strawberry and 50% beetroot; T3: jelly candy contains 25% strawberry and 75% beetroot. Full ripe strawberry contains 850.13 mg Gallic acid /100 g fresh fruit TPC and 58.8 mg100g-1 ascorbic acid. The blanched red beetroot contains 238 mg Gallic acid /100 g fruit TPC and 33.9 mg 100 g-1 ascorbic acid. The experimental values (means and SD for n = 3) with small letter are significantly different ($P \leqslant 0.05$). All values of phytochemical compounds recorded zero for control jelly candy sample.

3.5. Microbiological analysis of all jelly candies

Total plate count and fungal growth (mold & yeast) results of fresh jelly candies showed a great significant difference between control candy and other candy samples. The only sample, which appeared bacterial or fungi growth after processing was the control sample, which reached 2.94 and 2.77 log cfu/gm, for total plate count and fungal growth, respectively. Meanwhile, there is no growth in any other samples that may be due to the jelly candy's content of phenolic compound and ascorbic acid, which showed a good effect as antimicrobial. Also, jelly candies have a high sugar content that reduces microbial growth by limiting water available for the growth of microorganisms Muzzaffar et al., [9]. This study showed that strawberry or red beetroot jelly candies were safe for human consumption.

3.6. Sensory analysis of all jelly candy samples

All the formulated jelly candies were subjected to sensory evaluation and the results are summarized in Table 4. The quality sensory parameters of all the jelly candy samples were described as appealing. There is no significant difference ($P \leqslant 0.05$) between all samples in color, taste, sweetness, and appearance. Meanwhile, the color that was determined using the Minolta system showed the difference between all samples but that difference wasn't noticed by the nicked eye. The T3 recorded the lowest value of odor because of the existence of pyrazine and geosmin compounds of betalains from the red beetroot, which has an unpleasant aroma, which is typical of the smell of wet earth [36]. Textual quality (elasticity and biting) was described as soft and easy to bite by the majority of the panel. Since the candies had added gelatin, the texture was maintained as gelatin gets bound to sugar and helps in the gelation process forming a network of fibrils [37]. Meanwhile, the T3 recorded the lowest value for texture quality parameters and overall acceptability. The reduction in acceptability of texture (elasticity and biting) value may be due to its high content of fiber and low moisture content as mentioned before in Table 2 (1.02 g/ 100g, 34.20%). Concerning Figiel and Tajner-Czopek [34], knowledge of how moisture influences the texture of candy may help meet the expectations of the consumer about the quality of the consumed products. Also, the pH is considered one of the most important factors that affect on strength of the gel. The optimal pH ranged from 4 to 10 but, in the case of acidity foods, the dose of gelatin should be duplicate [37]. The highest pH value 4.73 for control and the lowest value 3.55 for T2. Therefore, the dose of gelatin that was used for processing jelly candy was increased and reached 35 g comparing with other studies [3]. The T3 treatment recorded the highest values in all sensory parameters especially in overall acceptability, which makes it the favorable jelly candies at all.

Such jelly candies are not only nutritionally healthy, but they are also economically viable to start a small-scale industry. From the commercial view, the prices of the materials used in the production process have an important impact on the price of the final products. Therefore, the comparison between the recent price of fresh fruit or vegetables and the price of sugar, synthetic flavors, and colors which using in commercial jelly candy that is led to increasing the price of natural jelly candy. The national market price of natural commercial jelly candy was 15–30 LE "100 g" it's equal 0.80–1.60 €. on the other hand, the price of a fruit and vegetable jelly candy "100 g" was calculated to be 3.32 LE its equal 0.18 € while for the world retail price of commercial fruit and vegetable jelly candy was 1 € per 100 g. Therefore, the strawberry and red beetroot jelly candy as one of the new proposed snack products is estimated to represent healthy sweets with less price than other natural commercial ones and near from the price of synthetic jelly candy which reached 2–3 LE "100 g" is equal 0.1–0.15 €.

Table 4

Effect of fortification with strawberry and red beetroot on sensory evaluation of jelly candy

Samples	Sensory parameters							
	Color	Taste	Odor	Sweetness	Elasticity	Biting	Appearance	Overall acceptability
Control	8.6a ± 1.12	7.6a ± 1.18	8.4a ± 1.44	7.6a ±1.66	7.0a ±1.93	7.0a ±2.21	8.6a ±0.65	7.8ab ± 1.34
T1	8.6a ± 0.89	7.2a ± 2.05	7.1bc ± 0.70	7.7a ±1.95	5.6b ±1.68	6.2ab ±2.73	7.8ab ±0.46	7.3ab ±0.98
T2	8.6a ± 0.65	7.5a ± 0.50	7.9ab ± 1.06	7.6a ±1.43	6.3ab ±1.91	6.1ab ±2.37	8.7a ±1.41	8.1a ±1.09
T3	8.3a ± 0.51	6.6a ± 2.17	7.0c ± 1.24	7.4a ±1.98	5.8b ±2.17	5.5b ±2.13	8.0ab ± 1.20	7.0b ±1.41

T1: jelly candy contains 75% strawberry and 25% beetroot juice; T2: jelly candy contains 50% strawberry and 50% beetroot juice; T3: jelly candy contains with 25% strawberry and 75% beetroot juice. The experimental values (means and SD for n=60) with small letter are significantly different ($P \leqslant 0.05$).

4. Conclusion

Strawberry and red beetroot riches in nutraceutical compounds source for instance phenolic compounds and ascorbic acid, which lead to high antioxidant effect to them. Ascorbic acid and phenolic of those fruits can be retained by processing them into candies. Jelly candies production not only prolongs the shelf life of fruit and vegetable but also maintains its antioxidant effect. Also, the nutritional value of fruit jelly candies was superior to control candy, which contains more minerals and fibers than control. Therefore, this study creates a new healthier alternative product that has the same sensory parameters of commercial jelly candy for consumers especially, children. Otherwise, the scientific method of jelly candy processing establishes a livelihood alternative in the modern era.

Therefore, this experiment was also applied using several types of fruit and vegetable such as, orange with carrot, cantaloupe with rocket, mango with carrot, and pomegranate with grape, which achieved excellent acceptability by the majority of the panel. Otherwise, to assess the shelf life of this product particularly its free from preservative materials, this work needs more study.

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