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# Evaluation of physico-chemical, nutritional quality and safety of imported raisin samples available in Indian market

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**Abstract**
Drying of grapes is a very old practice adopted in various parts of world. Raisins have low to moderate glycaemic index and high nutritive value. In India, raisins are mainly prepared in Sangli, Solapur and Nashik districts of Maharashtra and Bijapur district of Karnataka. Raisins are also imported from several countries in India. However, evaluation of the quality of imported raisins has not been conducted by any agency in India till date. Thus, this study was undertaken to ascertain the physical, biochemical, nutritional quality attributes, microbiological safety and pesticide residues of imported raisins available in Indian markets. In this study, few evaluated samples showed slight deviations from the prescribed international standards. This study ascertained that the quality of imported raisins available in Indian markets is comparable to the raisins prepared in India and quality of the majority of the samples complied with the Codex Alimentarius standards.

**Keywords:** Raisin, imported, nutritional quality, safety, pesticide residue

## Introduction
Raisin is the product prepared from the matured sound dried grapes of the varieties of *Vitis vinifera* L. The quality of the dried products implies that several desirable changes (physical, chemical and biochemical) must occur during the drying process. The physical characteristics of raisins from different countries are quite different, while chemical characteristics being fairly consistent. The physical characteristics found out are probably the result of cultivars, cultural, and processing differences (Bongers *et al*., 1990) [5]. Raisins are preferred due to their unique delicious taste, high nutritive value and ability to reduce the risk of many serious and chronic diseases like cancer, cardiovascular disease, hypertension, constipation, diabetes, etc. (Bin and Clifford, 2008; Fang *et al*., 2010; Witherspoon, 2000). Raisins besides being a concentrated source of carbohydrate, also provide high soluble and insoluble fibre along with fructans, boron, phenolics and antioxidants (Bin and Clifford, 2008; Fang *et al*., 2008; Gary and Arianna, 2010; Ghrairi *et al*., 2013; Yeonsoo *et al*., 2008) [4, 10, 11, 12, 24].
As per an estimate about 200 thousand tons of raisins are produced in India during 2015-16. About 22.527% of the total grape production is dried for raisin making. Major raisin making regions in India are Sangli, Solapur and Nashik districts of Maharashtra; and Bijapur and Bagalkot districts of Karnataka. Raisin export from India during 2015-16 was 26,824 tons and 15,123 tons of raisins were also imported during same year. The United States, China, Afghanistan, Iran and Turkey are major countries supplying raisins to Indian markets. Raisin import in India has been growing with growth rate of 2.74%.
The quality of the raisins is of greatest significance since it directly affects the health and well being of the consumers. Besides, raisins are considered to be a very healthy dry fruit and are eaten by the sick, old and children to regain good health. Thus, it becomes very important to assess their quality at frequent intervals. Today consumers are preferring quality food and different agencies are monitoring the quality at different levels. But, no published report is available on the quality parameters of imported raisins available in Indian market. Moreover, in the market imported raisins are costlier than their domestic counterparts. Considering the importance of quality parameters of raisins present study was conducted. The generated data from this study will be useful to Indian consumers and traders to give the preference and deciding market value of imported raisins.

## Materials and Methods
The present investigation was undertaken at ICAR-National Research Centre for Grapes, Pune, Maharashtra (India). For this study, twelve samples from imported lots of raisin were procured from the different type of markets.

The traders provided information related to imported raisins lots from which samples were collected. The raisins were imported in bulk and repacked as per convenience of market. Imported raisins lots of countries Afghanistan, China, Pakistan and Iran were included for sampling.

**Physical parameters**

**Determination of damaged (%) and sugared (%) raisins**

Raisins affected by sunburn, scars, mechanical injury which seriously affect the appearance, edibility, keeping quality, or shipping quality were considered damaged according to the codex standards. In 'Seeded' types, normal mechanical injury resulting from normal seeding operations was not considered damaged while in 'Seedless' types, normal mechanical injury resulting from removal of cap-stems was not considered damaged. Raisins with external or internal sugar crystals which were readily apparent and seriously affected the appearance were considered 'sugared'. Raisins that were sugar-coated or to which sugar was added intentionally were not considered 'sugared raisins'. Immature or underdeveloped (%) referred to raisins that: (i) were extremely light-weight, lacking in sugary tissue indicating incomplete development; (ii) were completely shriveled with practically no flesh, or which (iii) were hard.

Portion of the branch or main stem were counted in each sample in three replicates per 100 g. Small woody stem exceeding 3 mm length which attaches the grape to the branch of the bunch and whether or not attached to a raisin were counted in each sample in three replicates per 100 g. The size of the individual berries was ascertained by measuring the length and diameter using ruler and weighed using weighing balance for 10 berries of each sample type (Ghrairi *et al*., 2013) [12].

**Determination of moisture content, dry weight, ash content and pH**

Raisins (5 g) were weighed in triplicates and placed for drying in a hot air oven at 80°C until constant weight was reached. The moisture content was calculated from difference in weight and expressed as percentage of fresh weight basis. The per cent dry weight was calculated by subtracting the moisture content (%) from 100. Raisins were weighed (5 g) in triplicates for each sample and placed in porcelain containers which were incinerated in a muffle furnace at about 550-650 ºC for 5 hr. Ash content was expressed as per cent of dry weight (Mutalik *et al*., 2011) [17]. The pH value was obtained by placing about 3 g of raisins in a flask containing boiling water. The flask volume was made up to 200 ml with distilled water. The pH of this solution was determined by using pH-meter (Dowson and Aten, 1963) [8].

**Biochemical parameters**

The total phenolics content of the raisins was determined by the method of Singleton *et al*. (1999) [19] and expressed as mg of Gallic acid equivalents (GAE)/ 100 g of extract. The colour intensity was determined following method of Zoecklein *et al*. (1995) [26]. The antioxidant capacity was measured according to Mensor *et al*. (2001). To determine browning, 10 g of raisin sample was crushed in 25 ml of methanol. The homogenate was centrifuged at 5000 rpm for 5 min at room temperature. The supernatant was then collected and absorbance was recorded at 420 nm in a UV-VIS spectrophotometer. Samples were taken in triplicates and analyzed comparing the O.D. values.

**Nutritional parameters**

The nutritional qualities of imported raisins were evaluated from the raisin ash (from 5 g fresh weight). The ash obtained was dissolved in 5 ml solution containing $HNO_3/HCl/H_2O$ in the ratio of 1:2:3. It was then heated gently on a hot plate until brown fumes disappeared. A 5 ml of distilled water was added to the remaining residue in each crucible and heated till colourless solution was obtained. The mineral solutions in each crucible was transferred into 100 ml volumetric flasks by filtration through Whatman Filter paper No. 42 and the volume was made up to the mark with distilled water. It was further diluted as and when required. This solution was then used for the determination of potassium, sodium, calcium, magnesium and iron by using an atomic absorption spectrophotometer (AOAC, 2000; Mutalik *et al*., 2011) [3, 17].

**Microbial safety parameters**

The raisin samples were tested for the presence of *Salmonella typhi*, *E. coli*, *Pseudomonas*, *Staphylococcus aureus*, yeasts and moulds and total plate count. All these were tested following sterilization of all required glasswares, plastic ware, petri plates and then preparation of specific media (potato dextrose agar, bismuth sulphite agar, Mueller Hinton agar, mannitol salt agar, macconkey agar, *Pseudomonas* isolation agar). The specific media solution for each study was prepared aseptically. The test tubes containing saline were used for serial dilution ($10^{-2}$ to $10^{-6}$) and spreading the sample on the media in laminar flow. The raisin sample (1 g) was taken and placed in saline and washed several times with saline so that the microbial population on its surface comes into the saline after which a small aliquot was transferred to the serially numbered specific media petri plates. The sample was then distributed evenly over the media surface and spread with L shaped plastic rod. It was then kept for incubation and colonies in each plate were counted at the end of incubation period. The presence of the specific bacteria, yeast and mould on the surface of the raisins was adjudged by the serial dilution test and the presence or absence of their growth on the specific media. The end point of the microbial parameter was to count the number of colony forming units per ml or per g.

**Pesticide residues**

The raisin sample was crushed and homogenized with distilled water in equal quantity (1:1). Then, 10 g of homogenized sample was mixed with 5 ml of acidified water (0.1% acetic acid) and 10 ml of ethyl acetate. It was then vortexed and 10 g of anhydrous sodium sulphate was added. The mixture was then centrifuged at 5000 rpm for 5 min. The supernatant (5 ml) was cleaned by 25 mg PSA/ml. The cleaned extract was evaporated to dryness under the gentle stream of nitrogen gas in the presence of 200 µl diethylene glycol (10%). It was reconstituted in methanol (0.5 ml) and water with 0.1% acetic acid (0.5 ml). It was then sonicated for one minute followed by vortexing for 2 min. The cleaned extract was then centrifuged at 10000 rpm for 5 min. Then the supernatant was transferred to the vials after microfiltration with 0.2 µm filter assembly.

**Statistical analysis**

The results obtained under different treatments in respect to various parameters were subjected to analysis of variance. Mean comparison among the different treatments were performed using the Duncan's multiple range test at a significance level of $P \leq 0.05$. All analysis was carried out with SAS software package version 9.2 for windows (SAS Institute, Cary, NC, USA).

## Results and Discussion

### Physical characteristics of imported raisins

Dried grapes are consumed in different forms like snacks, in bakery products, in dairy foods etc. The nutrient and health benefits of dried grapes are well known. In this study, moisture content of imported raisins ranged between 16-19% in almost all the varieties while minimum moisture content (9.9%) was found in sample 5 closely followed by sample 3 (11.2%) (Table 1). As per Codex standards the limit of moisture content in raisins is defined 18 per cent. Our results are in accordance with the results of Ghrairi *et al*. (2013) [12] who also recorded moisture content ranging between 15% in Raseki raisins to 25% in Chriha. However, it is in contrast with the study of Anon. (1981) [2] who reported a narrow range of only 14-15% moisture content in raisins. It is an important parameter and gives good mouth feel and taste depending upon its value. If moisture is less than 14 per cent it becomes hard while moisture more than 18 per cent invites the attack of microbes. Hence, it plays an important role in ensuring food safety. All samples studied in present study were not within acceptable limit of moisture. The maximum moisture content in seedless raisins should be 18% and substantially free from stems, extraneous plant material and damage according to Codex standards. The ash content of raisin gives the total mineral content in it. In this study, ash content of the raisins ranged from about 1.7% in sample 2, 8 and 9 to 3.7% in sample 5 (Table 1). Ash content gives the total mineral content of the raisins. The ash content in these imported raisins are comparable with the ash content of Tunisian raisins as reported by Ghrairi *et al*. (2013) [12].

Table 1 gives important insight about other physical properties of twelve imported raisin samples. These parameters give a holistic view of the quality of raisins in terms of its appearance, mouth feel and cleanliness. Sample 3, 6, 7, 8, 9 and 10 did not have any damaged berries and all the berries were approximately uniform in colour and size (Table 1). Sugared (%) raisins were only found in sample 1 and rest of the samples did not show any such berries. Sample 12 showed the maximum number of damaged (83.3%) as well as immature berries (35%) which was much higher than in any other sample. No pieces of stem were found in any sample apart from sample 8 and 12 which implies that the raisin samples were cleaned nicely. Sample 12 showed 50 raisins with cap stems/100 g which was again significantly different and highest among all the samples. No cap stem raisins were observed in raisin sample 1, 6 and 7. As per codex standards, the prescribe limit of stem piece is not be more than 2 per kg, cap stems 50/500 g in seedless types and 25/500 g in seed bearing types. Likewise, immature berries, damaged and sugared berries can be 6%, 5% and 15% by weight, respectively in seedless types and 4%, 5% and 15% by weight, respectively in seeded types. The inappropriate cultural practices such as using more nitrogen and irrigation than required or improper handling results in cracks on the berry surface and crystallization of sugars on the surface and other defects on raisin berries. As mentioned by Adsule *et al*. (2012) [1], Indian raisin sample comply the codex standards except cap stem.

The pH of the raisin samples differed significantly and ranged between 4.06 in sample 5 to 5.84 in sample 4 (Table 1). The pH of sample 12 was recorded to be 5.33. The raisin samples varied significantly in their length, diameter and weight among themselves (Table 1). The smallest raisin length (0.8 cm) was noted in sample 12 while the longest (2.2 cm) was in sample 1. The weight of the individual berries ranged between 0.37 g in sample 2 to 1.24 g in sample 3. The diameter of the raisin samples also varied significantly among themselves with 0.5 cm in sample 2 to 1.1 cm in sample 3. The variations in different physical attributes observed among the samples might be due to different origins, cultivars, growing conditions, cultural practices, harvesting stage, climatic conditions as well as the adoption of different processing methods and prevailing conditions during grape drying, treatments, storage, grading, packaging and transportation, etc.

### Biochemical quality attributes of imported raisins

The antioxidant capacity of raisin is mainly due to the presence of phenolic compounds and anthocyanin pigments in black coloured raisins (Cevallos-Casals *et al*., 2006) [7]. Williamson and Carughi (2010) [21] reviewed the health benefitting properties of raisins and reported that flavonols, quercetin, kaempferol, caftaric and coutaric acid were the major phenolic compounds. Breksa *et al*. (2010) [6] reported that the antioxidant capacity and phenolics content across the 16 raisin samples ranged from 7.7-60.9 mol Trolox/g DW and 316.3-1141.3 mg gallic acid/100 g DW, respectively. In this study, maximum phenolics content was recorded in sample 5 (5.78 mg GAE/100 g FW) followed by sample 3 (5.39 mg GAE/100 g FW) which also displayed correspondingly higher antioxidant capacity (91.2% and 61.9%, respectively). The higher antioxidant capacity in these two samples might be attributed to higher phenolics content and presence of anthocyanin pigments. The phenolics content (Fig. 1) and antioxidant capacity (Fig. 2) in the raisins ranged from 1.7 mg GAE/100 g FW (sample 1) to 5.8 mg GAE/100 g FW (sample 5) and 33.6% (sample 7) to 91.2% (sample 5), respectively. The colour intensity was recorded maximum in sample 5 (1.62) and sample 3 (1.45) as these were black in colour (Table 2). The browning was observed in the range of 0.17 in the sample 6 and 11 to 0.82 in the sample 5 (Table 2). High browning in these samples might be attributed to black coloured samples. Adsule *et al*. (2012) [1] recorded the range of phenolics content in green Indian raisin samples within the range of 0.808-4.631 mg/g. Samples of present were fall in given limit of Indian samples except sample 3 and sample 5 which contained higher phenolics due to its black colour. The observed differences in the biochemical parameters of the various raisin samples may be due to the different varieties, climatic, cultural and postharvest processing conditions (Ghrairi *et al*., 2013; Gong and Zhang, 2003; Yakushiji *et al*., 1996) [12, 13, 23]. Zhao *et al*. (2008) [25] have documented earlier that the phenolic acids and low molecular weight flavonoids are responsible for the antioxidant activity of raisins.

### Nutritional qualities of imported raisins

The imported raisin samples were analysed for important mineral nutrients like potassium, sodium, calcium, magnesium and iron (Table 2). The imported raisin samples exhibited high potassium levels. The sample 12 showed highest potassium (0.861%) followed by sample 1 containing 0.823% and then samples 3, 6 and 10 and contained about 0.76% potassium. The imported raisin samples were lower in sodium content as compared to potassium content. The range of sodium content varied from 0.01% in sample 2 to 0.07% in sample 3 and 12. There was significant difference in the different samples in terms of sodium and potassium content.

Our results are in agreement with the findings of Emine *et al*. (2011) [9], Gary and Arianna (2010) [11] and Ghrairi *et al*. (2013) [12]. Potassium (K) has significant importance in human health since its higher levels reduces blood pressure and lowers chances of cardiovascular diseases (Whelton *et al*., 1997) [20]. He and MacGregor (2008) [15] reported that potassium intake lowers urinary calcium excretion and decreases the risk of osteoporosis. It even counters the negative effects of the sodium mineral nutrient by controlling the blood pressure. The calcium content was found to be in the narrow range of 0.02% to 0.03% in the different raisin cultivars. The results clearly showed that the raisin samples contained magnesium (Mg) concentrations in the range of 0.027-0.047%. Simsek *et al*. (2004) [18] reported that different levels of mineral in raisin samples may also be due to improper extraction procedures, insufficient crushing, etc. apart from the fruit composition, cultivar and the variations due to cultivation factors. The iron content of the raisin samples showed large variation from 14.74 ppm in sample 11 to 65.9 ppm in sample 1 with rest of the varieties having intermediate values. However, it varied significantly among the different raisin samples. The high iron content of raisins is beneficial for the health of females who generally suffer from the deficiency of iron and suffer from anaemia since iron is important in composition of haemoglobin which acts as a carrier for transfer of oxygen in blood.

**Microbial safety of imported raisins**

The raisin samples were tested by using specific media for microorganisms which are significant for human health. The codex standards require that the raisins must be free of microorganisms, their products, or any other parasites in amounts which may represent a hazard to health. The results showed that all the samples were free from any pathogenic microorganisms except Sample 12 which showed $0.02 \times 10^3$ CFU/ 0.1 g raisin (Table 3). However, yeasts and moulds were observed in raisin sample 9 ($0.02 \times 10^3$ CFU/ 0.1 g) and sample 12 ($5.2 \times 10^3$ CFU/ 0.1 g).

The results of total plate count were obtained as $0.02 \times 10^3$ CFU/ 0.1 g in raisin sample 8, $0.04 \times 10^3$ CFU/ 0.1 g in raisin samples 3 and 9, $0.06 \times 10^3$ CFU/ 0.1 g in raisin sample 4 while the highest was observed as $8.8 \times 10^3$ CFU/0.1 g in sample 12. It was found that sample 12 was not fit for consumption because of the presence of pathogenic microorganism *Staphylococcus* and other microorganisms. This may be due to improper cultural practices followed during cultivation and lack of proper sanitation during harvesting, and processing. No other raisin samples contained any pathogenic microorganisms and were safe for consumption. The codex standards require that the raisin samples should be free from all pathogenic microorganisms, and other microorganisms should be lower than amounts which can be hazardous to human health. Halouat *et al*. (1998) [14] have recommended storage of raisins in modified atmospheric condition (40% $CO_2$, 60% $N_2$ or 80% $CO_2$, 20% $N_2$) in addition with K-sorbate (343 ppm) and Na-benzoate (321 ppm) for complete growth inhibition of *Z. rouxii* and extending shelf-life up to 6 months at ambient temperature of 30 ºC.

**Pesticide residues in imported raisins**

Grape receives frequent applications of various agrochemicals during cultivation to prevent economic losses and harvest a good crop by managing the pest and diseases before economic threshold level. However, the improper handling practices of pesticides and other agrochemicals like application of higher doses at frequent intervals, non-observance of pre-harvest interval after the final application of agrochemicals result in unwanted pesticides and their metabolites or residues in food products. Thus, there is requirement to scan the food products available in the market at random for pesticide residues to ensure safety of human health. The consumers are also concerned about the excessive chemical exposure to food products and the resulting unwanted residues in food. Keeping these in mind, the twelve imported raisin samples were subjected to test for pesticide residues by using both GC-MS and LC-MS/MS. The results showed that samples 2, 3, 4, 6, 9 and 10 were very clean in terms of pesticide residues. All the analytes were below limit of detection in these six samples. Chlorpyriphos was the most frequently detected pesticide in as many as 5 imported raisin samples viz. sample 1, 5, 7, 8 and 12. Difenconazole residues were detected in sample 1, 11 and 12. Cypermethrin was detected in sample 1 and 12. Carbendazim and tebuconazole in sample 1, dicofol in sample 5, hexaconazole in sample 8, imidacloprid and metalaxyl in sample 12 were the other pesticides which were found. Sample 1 and 12 were found to contain maximum number of pesticide analytes.

The pesticide residues obtained after analysis were compared with the maximum residue levels (MRL) permitted by the European Union for currant fruits (white or red), which are considered similar to raisins for comparing the agrochemical residues. Only cypermethrin (0.062 mg/kg) in sample 1 was found to be crossing the EU MRL limits for currants which is 0.05 mg/kg. Apart from this, all the other detected pesticide residues were below MRL levels.

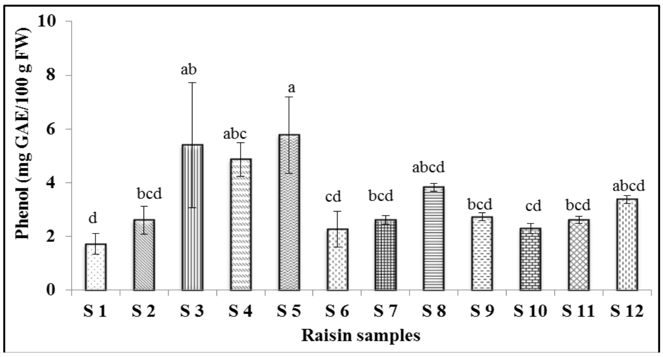


**Fig 1:** Phenolics content (mg GAE/100 g FW) of different imported raisin samples

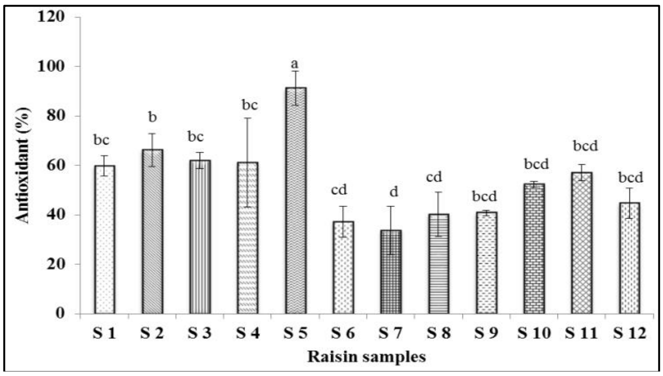


**Fig 2:** Antioxidant capacity (%) of different imported raisin samples

**Table 1:** Physical parameters of imported raisin samples

| Raisin samples | Damaged (%) | Sugared (%) | Immature (%) | Piece stem /100 g | Cap stem /100 g | pH | Individual raisin | | | Dry matter (%) | Moisture content (%) | Ash Content (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Weight (g) | Length (cm) | Diameter (cm) | | | |
| S 1 | $8.3^{cd}$ | $1.7^{a}$ | $3.3^{c}$ | $0^{b}$ | $0^{e}$ | $5.34^{b}$ | $1.15^{a}$ | $2.2^{a}$ | $1^{ab}$ | $82.1^{de}$ | $17.88^{bc}$ | $2.69^{d}$ |
| S 2 | $8.3^{cd}$ | $0^{b}$ | $11.7^{bc}$ | $0^{b}$ | $15^{bc}$ | $4.25^{i}$ | $0.37^{c}$ | $1.8^{abcd}$ | $0.5^{d}$ | $82.3^{d}$ | $17.60^{c}$ | 1.72h |
| S 3 | $0^{d}$ | $0^{b}$ | $10^{bc}$ | $0^{b}$ | $3.3^{de}$ | $5.02^{e}$ | $1.24^{a}$ | $2.0^{ab}$ | $1.1^{a}$ | $88.8^{b}$ | $11.16^{e}$ | $3.34^{b}$ |
| S 4 | $23.3^{b}$ | $0^{b}$ | $21.7^{b}$ | $0^{b}$ | $5^{cde}$ | $5.84^{a}$ | $0.52^{bc}$ | $1.6^{cd}$ | $0.7^{bc}$ | $83.6^{c}$ | $16.43^{d}$ | $2.53^{e}$ |
| S 5 | $13.3^{bcd}$ | $0^{b}$ | $18.3^{b}$ | $0^{b}$ | $13.3^{bcd}$ | $4.06^{j}$ | $0.66^{b}$ | $1.5^{cd}$ | $0.6^{cd}$ | $90.1^{a}$ | $9.91^{f}$ | $3.69^{a}$ |
| S 6 | $0^{d}$ | $0^{b}$ | $10^{bc}$ | $0^{b}$ | $0^{e}$ | $4.59^{g}$ | $0.41^{c}$ | $1.9^{abc}$ | $0.6^{cd}$ | $80.7^{f}$ | $19.28^{a}$ | $2.33^{f}$ |
| S 7 | $0^{d}$ | $0^{b}$ | $0^{c}$ | $0^{b}$ | $0^{e}$ | $5.09^{d}$ | $0.53^{bc}$ | $1.8^{abcd}$ | $0.6^{cd}$ | $81.7^{def}$ | $18.30^{abc}$ | $1.85^{gh}$ |
| S 8 | $0^{d}$ | $0^{b}$ | $18.3^{b}$ | $8.3^{b}$ | $8.3^{cde}$ | $4.83^{f}$ | $0.50^{bc}$ | $1.5^{d}$ | $0.7^{bc}$ | $81.4^{def}$ | $18.65^{abc}$ | $1.75^{h}$ |
| S 9 | $0^{d}$ | $0^{b}$ | $0^{c}$ | $0^{b}$ | $20^{b}$ | $4.87^{f}$ | $0.42^{c}$ | $1.6^{cd}$ | $0.63^{cd}$ | $80.5^{f}$ | $19.40^{a}$ | $1.80^{h}$ |
| S 10 | $0^{d}$ | $0^{b}$ | $0^{c}$ | $0^{b}$ | $11.7^{bcd}$ | $4.39^{h}$ | $0.50^{bc}$ | $1.8^{abcd}$ | $0.7^{cd}$ | $80.8^{f}$ | $19.11^{a}$ | $1.96^{g}$ |
| S 11 | $15^{bc}$ | $0^{b}$ | $10^{bc}$ | $10^{b}$ | $20^{b}$ | $5.20^{c}$ | $0.42^{c}$ | $1.6^{bcd}$ | $0.7^{cd}$ | $81.1^{ef}$ | $18.90^{ab}$ | $2.27^{f}$ |
| S 12 | $83.3^{a}$ | $0^{b}$ | $35^{a}$ | $36.7^{a}$ | $50^{a}$ | $5.33^{b}$ | $0.43^{c}$ | $0.8^{e}$ | $0.6^{cd}$ | $88.6^{b}$ | $11.35^{e}$ | $2.85^{c}$ |
| Codex standards | | | | | | | | | | | | |
| Seedless types | 5% by weight | 15% by weight | 6% | 2 per kg | 50/500 g | - | - | - | | - | - | - |
| Seed bearing types | 5% by weight | 15% by weight | 4% | 2 per kg | 25/500g | - | - | - | | - | - | - |

**Table 2:** Nutritional quality, colour intensity and browning of imported raisin samples

| Raisin samples | K content (%) | Na content (%) | Ca content (%) | Fe content (ppm) | Mg content (%) | Colour intensity | Browning |
|---|---|---|---|---|---|---|---|
| S 1 | $0.823^{ab}$ | $0.040^{de}$ | $0.028^{c}$ | $65.90^{a}$ | $0.042^{b}$ | $0.26^{c}$ | $0.18^{c}$ |
| S 2 | $0.537^{cd}$ | $0.013^{h}$ | $0.018^{h}$ | $17.32^{efg}$ | $0.027^{g}$ | $0.24^{c}$ | $0.19^{c}$ |
| S 3 | $0.769^{ab}$ | $0.074^{a}$ | $0.021^{fg}$ | $37.24^{c}$ | $0.040^{cd}$ | $1.45^{a}$ | $0.81^{a}$ |
| S 4 | $0.548^{cd}$ | $0.042^{de}$ | $0.031^{b}$ | $31.90^{d}$ | $0.036^{e}$ | $0.64^{b}$ | $0.29^{bc}$ |
| S 5 | $0.396^{d}$ | $0.024^{g}$ | $0.033^{a}$ | $42.82^{b}$ | $0.027^{g}$ | $1.62^{a}$ | $0.82^{a}$ |
| S 6 | $0.757^{ab}$ | $0.057^{b}$ | $0.025^{d}$ | $14.28^{g}$ | $0.046^{a}$ | $0.27^{c}$ | $0.17^{c}$ |
| S 7 | $0.739^{ab}$ | $0.034^{ef}$ | $0.022^{ef}$ | $18.22^{efg}$ | $0.038^{de}$ | $0.47^{bc}$ | $0.33^{bc}$ |
| S 8 | $0.658^{bc}$ | $0.037^{e}$ | $0.023^{e}$ | $19.40^{ef}$ | $0.036^{e}$ | $0.40^{bc}$ | $0.30^{bc}$ |
| S 9 | $0.534^{cd}$ | $0.028^{fg}$ | $0.021^{fg}$ | $21.80^{e}$ | $0.031^{f}$ | $0.43^{bc}$ | $0.35^{bc}$ |
| S 10 | $0.760^{ab}$ | $0.045^{cd}$ | $0.025^{d}$ | $21.32^{e}$ | $0.042^{bc}$ | $0.28^{c}$ | $0.23^{c}$ |
| S 11 | $0.796^{ab}$ | $0.052^{bc}$ | $0.020^{g}$ | $14.74^{fg}$ | $0.040^{cd}$ | $0.20^{c}$ | $0.17^{c}$ |
| S 12 | $0.861^{a}$ | $0.071^{a}$ | $0.030^{b}$ | $61.58^{a}$ | $0.047^{a}$ | $0.54^{bc}$ | $0.45^{b}$ |

**Table 3:** Microbiological analysis of imported raisin samples

| Raisin samples | *Salmonella typhi* | *Staphylococcus aureus* | *E. coli* | *Pseudomonas* | Yeasts and moulds | TPC |
|---|---|---|---|---|---|---|
| S 1 | Absent | Absent | Absent | Absent | Absent | Absent |
| S 2 | Absent | Absent | Absent | Absent | Absent | Absent |
| S 3 | Absent | Absent | Absent | Absent | Absent | $0.04 \times 10^3$ CFU/0.1 g |
| S 4 | Absent | Absent | Absent | Absent | Absent | $0.06 \times 10^3$ CFU/0.1 g |
| S 5 | Absent | Absent | Absent | Absent | Absent | Absent |
| S 6 | Absent | Absent | Absent | Absent | Absent | Absent |
| S 7 | Absent | Absent | Absent | Absent | Absent | Absent |
| S 8 | Absent | Absent | Absent | Absent | Absent | $0.02 \times 10^3$ CFU/0.1 g |
| S 9 | Absent | Absent | Absent | Absent | $0.02 \times 10^3$ CFU/0.1 g | $0.04 \times 10^3$ CFU/0.1 g |
| S 10 | Absent | Absent | Absent | Absent | Absent | Absent |
| S 11 | Absent | Absent | Absent | Absent | Absent | Absent |
| S 12 | Absent | $0.02 \times 10^3$ CFU/0.1 g | Absent | Absent | $5.2 \times 10^3$ CFU/0.1 g | $8.8 \times 10^3$ CFU/0.1 g |
| Codex standards | Absent | Absent | Absent | Absent | Absent in quantities possible to cause hazard | Absent in quantities possible to cause hazard |

**Table 4:** Pesticide residues obtained in different imported raisin samples

| Raisin samples | Pesticide residues (mg/kg) | EU MRL (mg/kg) | |
|---|---|---|---|
| S 1<br>S 2<br>S 3<br>S 4<br>S 5 | Carbendazim (0.012) | Carbendazim + Benomyl | 0.1 |
| | Difenconazole (0.023) | Chlorpyriphos | 1.0 |
| | Tebuconazole (0.041) | Cypermethrin | 0.05 |
| | Chlorpyriphos (0.822) | Dicofol | 0.02 |
| | Cypermethrin (0.062) | Hexaconazole | 0.01 |
| S 6<br>S 7 | Chlorpyriphos (0.016) | Metalaxyl | 0.4 |
| | Dicofol (0.024) | Difenconazole | 0.2 |
| S 8 | Chlorpyriphos (0.122) | Imidacloprid | 5.0 |
| S 9<br>S 10 | Chlorpyriphos (0.532) | Tebuconazole | 1.5 |
| | Hexaconzole (0.011) | | |
| S 11 | Difenconazole (0.244) | | |
| S 12 | Chlorpyriphos (0.042) | | |
| | Cypermethrin (0.040) | | |
| | Imidacloprid (0.208) | | |
| | Metalaxyl (0.012) | | |
| | Difenconazole (0.01) | | |
| All analytes are below limit of detection in Samples 2, 3, 4, 6, 9 and 10 | | | |

## Conclusions

The quality assessment of the twelve imported raisin samples encompassing all the parameters showed that the raisins varied significantly from each other which may be attributed to their different origins, cultivars, cultural practices during cultivation, processing methods, pretreatments if any, storage, packaging, and conditions prevailing during transportation and retail storage. Overall, it was found that samples 10 and 11 were free from residue of any pesticide and these samples also recorded microbiologically clean status, apart from being appealing by appearance and taste. Sample 12 was unhygienic at first sight and also showed high pesticide residues as well as tested positive for *Staphylococcus* presence. *Staphylococcus* is well-known human pathogen. This study will prove to be very helpful for comparing the qualities of imported raisins with domestic ones and to accordingly make policy decisions about import of raisins and to take required steps to market and export Indian raisins in other countries. It also shows that consumer should always be alert and check for raisin quality at least by viewing the cleaning defects which may act as an indicator for providing information about dirty samples, consumption of which can do more harm than good. Our study showed that the quality of imported raisins is at par with domestically produced Indian raisins and are in compliance with the standards prescribed by Codex Almentarius Commission.

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