Research Article

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The Quality Characteristics of Different Fruit Juice Brands Consumed in Oman.

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ABSTRACT

Evaluation of fruit juice quality is an important parameter in terms of consumer acceptability and international conformity standards. The objectives of this study were to evaluate the quality and sensory attributes of orange, mango, and apple juice brands consumed in Oman and to observe whether they meet the standard of compliance status and consumer satisfaction. Samples from five brands of different fruit juice products (15 samples in total) were collected to investigate the physicochemical characteristics, sensory attributes, consumer preferences, and compliance with label standards. The brands were labelled as (D, E, F, L, and J for orange juices; N, B, I, H, and O for mango juices; and M, C, K, A, and G for apple juices). Results revealed that non-compliance of Brix values in juices were as follows: mango juice brand B, 11.6 and brand O, 11.8; and apple juices brand M, 11.2 and brand K, 10.8. The overall acceptability scores for sensory assessment ranged from 2.3 to 3.7 for orange juices, 1.5 to 4.3 for mango juices, and 1.3 to 3.8 for apple juices, while average consumer preference scores ranged from 2.2 to 3.6 for orange juices, 2.5 to 3.7 for mango juices, and 2.4 to 3.4 for apple juices. All evaluated juice brands were found to be non-compliant (NC) with label requirements. This study may assist in improving and implementing legislation of fruit juice products, thereby contributing to the maintenance of a sustainable fruit juice industry through enhanced quality control.

Keywords : Fruit Juice, physicochemical, product's label, descriptive sensory analysis, consumer preference.

INTRODUCTION

Fruit juices are widely consumed beverages worldwide due to their refreshing taste, nutritional benefits, and convenience. They contain several important health-promoting bioactive that may reduce the risk of various non-communicable diseases. Fruit juices are rich in antioxidants, vitamins C and E, and possess pleasant taste and aroma (Caswell, 2009). The demand for fruit juices has increased rapidly in recent years, leading to the development of numerous commercialized fruit juice products with different formulations and flavour characteristics. The quality of fruit juices is defined by their physical properties, enzymatic, microbiological, and sensory characteristics as well as stability (Salehi, 2020). Evaluation of the physicochemical and sensory properties of these products is important in terms of quality, safety, and consumer acceptance (Ryan et al., 2020). The fruit juice industry has shown an increased interest in producing healthy, high-quality, minimally processed, and natural products (Salehi, 2020a), as consumers demand. Therefore, several non-thermal food processing technologies, such as sonication, pulsed electric field, and high-pressure homogenization, have gained considerable attention due to their capacities to keep original freshness and nutritional contents in foods, with minor energy utilization and high sensory acceptability, compared to the conventional heat treatments (Salehi, 2020; Salehi, 2020a; Salehi, 2020b). Heat treatments can degrade sensitive nutrients and enzymes in juices, leading to a loss of nutritional value and flavour. Non-thermal methods minimize nutrient loss by avoiding the high temperatures associated with traditional pasteurization. This retention of nutrients can result in juices with better taste, colour, and nutritional content (Salehi, 2020).

The physicochemical evaluation of fruit juice products involves analysing chemical and physical properties, such as acidity, pH, total soluble solids (TSS), colour, and viscosity. These parameters provide information about the composition,

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stability, and shelf-life of the products (Salehi, 2021). The acidity of fruit juice is a crucial parameter that determines its taste, microbial stability, and nutritional value (Mandha et al., 2023). The pH of fruit juice affects its stability and enzymatic reactions, while TSS represents the total amount of dissolved solids in the juice and influences its sweetness and texture (Pham et al., 2020). The colour and viscosity of fruit juice products are important sensory attributes that influence consumer acceptance (Shen et al., 2021).

In addition to the physicochemical properties, the sensory evaluation of fruit juice products involves assessing their taste, aroma, appearance, texture, and overall acceptability (Song et al., 2023). Sensory evaluation is crucial for determining the product's marketability, consumer preference, and final quality (Ruiz-Capillas and Herrero, 2021). The taste of fruit juice products is affected by their sweetness, sourness, bitterness, and astringency, while the aroma is influenced by their volatile compounds present in the juice (Berta et al., 2018). The appearance of fruit juice products, such as colour and clarity, also affects their sensory characteristics. The texture of fruit juice products, such as viscosity and mouthfeel, is important for their sensory characteristics and consumer acceptance (Gous et al., 2019).

Commercialized fruit juice products are produced using various processing techniques, such as pasteurization, sterilization, and concentration (Chiozzi et al., 2022). These techniques affect the physicochemical and sensory characteristics of the final product (Adams et al., 2020). Nowadays, consumers are increasingly demanding, giving preference to natural, healthier, innovative, and tastier products with sustainable characteristics and with a minimum amount of chemical preservatives and/or ultra-processing technologies (Vilela et al., 2019).

The quality and safety of fruit juice products are determined by their compliance with regulatory standards set by national and international regulatory authorities, such as the General Standard for Fruit Juices, Fruit Drink, and Nectars (GSO 1820, 2021) and Labelling of Fruit Juices, Nectars, and Fruit Drinks (GSO 2577, 2021). These standards specify the minimum and maximum levels of various physical, chemical, and microbiological parameters.

The objectives of this study were to evaluate the physicochemical and sensory characteristics of the different fruit juice brands (such as orange, mango, and apple) consumed in Oman and to investigate the consumer acceptability and international conformity standards of these brands.

2. MATERIALS & METHODS

2.1 Samples

Five commercial juice brands (Mazoon, A'Safwah, Marie, Nada, and Rawabi) including three fruit juices types (such as orange, mango, and apple) were purchased randomly from various shops and supermarkets in Muscat, Oman. To maintain anonymity, the samples were accurately coded, such as the brand name, location of purchase, collection time, and date were recorded. All collected samples (15 samples in total) were then stored at a cold temperature (5 °C) until the completion of analyses. The brands were labelled as (D, E, F, L, and J for orange juices; N, B, I, H, and O for mango juices; and M, C, K, A, and G for apple juices).

2.2 Physicochemical Analyses

The physicochemical analyses of fruit juices were conducted according to the official methods of AOAC (2007), moisture content (method 934.06), pH value (method 981.12), total acidity (method 942.15), Brix value, Brix/acidity ratio, and total solids (method 920.151).

2.3 Labelling Requirement

The mandatory labelling requirements of fruit juice products were evaluated according to the Labelling of Fruit Juices, Nectars, and Fruit Drinks Standard (GSO 2577, 2021). Five clauses from the standard were evaluated which are; 4.2 represents the type of product (Drink, Nectar or Juice), 4.2.1 represents whether juice is made from fresh or concentrated juice, 4.2.5 if sugar added, 4.3.1 availability of nutritional data and 4.4.2 when no added sugar it shall mention its natural.

2.4 Descriptive Sensory Analysis

Six panellists from the Natural and Medical Sciences Research Center, University of Nizwa (four males, and two females, aged between 30 and 50 years old), were recruited and trained according to the sensory practices and their reliability was assessed in three sessions (Kemp et al., 2009). The panellists conducted the sensory evaluation for colour, flavour, acidity, sweetness, and overall acceptability attributes for orange, mango, and apple juices. Each panellist received samples labelled with code numbers to evaluate using a 5-point test scales (Gacula, 1997). The average value of each sensory attributes was analysed using statistical analysis software.

2.5 Consumer Preference Analysis

The consumers were recruited (53 graduate and post-graduate students; 13 females and 41 males; and aged between 23 and 50 years old) from the Natural and Medical Sciences Research Center, University of Nizwa. The participation was based on voluntary and no monetary compensation was given. Each group consisting of 5 panellists was taken to the panel booths (where room temperature was 23 to 25 °C and relative humidity 67 to 75%) in the Food Science and Technology Laboratory. Each panellist evaluated 3 types of juices from five different brands. Each juice was served (20 mL) in a 50 mL clear plastic cup at room temperature (23 to 25 °C). Overall acceptability was rated on a 5-point category scale using the Consumer Preference Questionnaire (supplementary data) according to Wunwisa and Kamolnate, 2010.

2.6 Data Analysis

The physicochemical results were expressed as mean of triplicate determinations ± standard deviation on a wet weight basis. Microsoft Excel and Originlab Software were used to draw column and radar charts. The data from the physicochemical and sensory analyses were evaluated statistically using Microsoft Excel for the mean value. The analysis of variance (ANOVA) was used to determine the level of significance ($p < 0.05$).

3. RESULTS AND DISCUSSION

3.1 Physicochemical Characteristics of Orange Juice Products

In this study, we analysed the physicochemical characteristics, including moisture content, total solids, pH value, Brix value, total acidity, Brix/acidity ratio, and label compliance of various fruit juice brands consumed in Oman. Table 1 presents the average values resulting from triplicate analyses of orange juice products from different brands labelled as D, E, F, L, and J. The moisture content analysis revealed slight variability among the brands, with brand E having the highest moisture content of 90.9%, while brand J presented the lowest moisture content (88.9%). On average, the moisture content in various juice brands was reported as 90.1%. Previous literature suggests that high moisture content is inversely related to the shelf-life stability of juice products (Akhtar et al., 2013).

Similarly, in the total solid content of various orange juice types, brand J presented the highest total solid content of 11.1%, whereas brand E revealed the lowest total solid content of 9.1%. Statistical analysis observed significant differences among the total solid values of various fruit juice brands. The total solid contents of brands D, F, and L of orange juices were 9.9, 9.9, and 10.2%, respectively. The average total solid content in orange juice from various brands was 10.2%, which is consistent with recommended amounts (Ashurst, 2016). The total solids contents reported in this study are similar to those of orange juice samples studied by Ndife et al. (2013). Variations from other reported studies could be attributed to differences in drying methods used for studying solid contents. The Federal Institute of Industrial Research, Oshodi (FIIRO) reported that differences in production processes may explain most differences observed in juice composition and quality (Tiencheu et al., 2021).

The pH of fruit juice is primarily determined by the stage of ripeness and maturity of the fruits used for production (Falade et al., 2003). In the physicochemical analysis of orange juice conducted in the current study, a pH range of 3.42-4.12 was observed. These results fall within the typical range of 2-5 for fruit and vegetable juices (Tasnim et al., 2010), indicating the acidic nature of orange juice. The brand L exhibited the most acidic pH (3.42), while brand J had the least acidic pH (4.12). These findings are consistent with those reported by Tiencheu et al. (2021), who observed similar pH values for orange juices. Additionally, Ndife et al. (2013) reported pH values ranging from 3.23 to 4.08 for different brands of fruit juices, aligning with our results. The low pH of fruit juices is generally attributed to the presence of rich organic acids, with lemon and orange being particularly high in citric acid (Tasnim et al., 2010).

The Brix values for orange juice brands (D, E, and J) were reported as 11.3, whereas the values were 11.6 for brands F and L. According to the mandatory "General Standard for Fruit Juices, Fruit Drink, and Nectars" (GSO 1820, 2021), the Brix value of orange juice must fall within the range of 11.2-11.8, indicating that all investigated brands complied with the Brix requirement. The consistent Brix values suggest uniform sugar content in the products (Tiwari et al., 2008).

In terms of total acidity, the highest value (0.78%) was reported for brand F, followed by brands E, L, and D, with values of 0.73, 0.62, and 0.58%, respectively. Conversely, the lowest total acidity value (0.53%) was reported for Brand J, which could be considered more favourable than others (Talasila, 2012). An increase in total acidity corresponds to a decrease in pH; titratable acidity determines the acidic taste in the juice, while pH determines its susceptibility to microbial spoilage (Tasnim et al., 2010).

The Brix/acidity ratio varied significantly among the brands, indicating the balance between sweetness and acidity of the product. Brand J displayed the highest ratio (21.3), indicating a sweeter taste relative to acidity, while Brand F had the lowest ratio of 14.9. The Brix/acidity ratios of brands D, E, and L were recorded as 19.5, 15.5, and 18.7, respectively. These findings align with a previous study by Jayasena and Cameron (2008), indicating that taste preferences rely on this balance.

Product labelling is one of the most important aspects of food products, and it should adhere to national and international quality standards (Trienekens and Zuurbier, 2008). In the current study, we analysed the labelling information of different brands of orange juices, all of which were found to be non-compliant (NC) with the labelling requirements specified by GSO 2577 (2021). Non-compliance with orange juice labels includes failure to provide information about the type of juice (Drink, Nectar, or Juice), the source of juice (fresh or concentrated), and when a free sugar statement is used, it must specify that it is natural. This regards a clear violation of mandatory labelling standards, which requires the removal of the product from the market until the labelling requirements are corrected.

Table 1. Physicochemical characteristics of different orange juice brands

Brands	D	E	F	L	J
Moisture (%)	90.1 ± 0.1a	90.9 ± 0.6a	90.1 ± 0.4a	89.8 ± 0.5a	88.9 ± 0.1a
Total Solids (%)	9.9 ± 0.6a	9.1 ± 0.6b	9.9 ± 0.6a	10.2 ± 0.5a	11.1 ± 0.1c
pH	3.95 ± 0.02a	3.91 ± 0.03a	3.78 ± 0.01a	3.42 ± 0.04b	4.12 ± 0.03a
Brix (°Bx)	11.3 ± 0.1a	11.3 ± 0.2a	11.6 ± 0.1a	11.6 ± 0.2a	11.3 ± 0.1a
Total Acidity (%)	0.58 ± 0.01a	0.73 ± 0.01b	0.78 ± 0.03c	0.62 ± 0.02d	0.53 ± 0.01e
Brix/acidity ratio	19.5 ± 2.2a	15.5 ± 0.5b	14.9 ± 1.2b	18.7 ± 0.4c	21.3 ± 0.9d
Product Label	NC	NC	NC	NC	NC

Letters D, E, F, L, and J are the codes for orange juice brands. The values are average of triplicate analysis ± SD followed by the same letter, within a row, are not significantly different (P > 0.05). C and NC are compliant and non-compliant to the “Labelling of fruit juices nectars and fruit drinks Standard”, GSO 2577:2021.

3.2 Physicochemical Characteristics of Mango Juice products

Table 2 represents the values resulting from the triplicate analysis of all parameters and compliance status of the mango juice brands namely N, B, I, H, and O. Moisture content exhibited subtle variations among the brands, with brand O displaying the highest moisture content of 91.8%. Brands B and I have a value of 90.1%, followed by brand H (85.5%), and brand N with the lowest moisture content of 84.8%. It can be concluded from such high moisture content that the mango juice products from all brands have reduced shelf stability.

Brand N showed the highest total solid content of 15.2% followed by brand H. The total solid content value was 9.9% for brands B and I, while brand O had the lowest total solid content of 8.2%. These results agree with the previous study of Mahajan (1994), who reported high solid content in juice products stored for long periods.

In terms of pH, brand H exhibited the highest pH of 4.27, whereas brand N had the lowest pH of 3.9. The total acidity varied slightly among the brands, with brand I having the highest total acidity (0.27%) and brand H having the lowest total acidity (0.18%). Again, the results of pH and total acidity make perfect sense as brand I had the lowest pH and highest acidity and brand H had the highest pH value and lowest total acidity. The acidity of juice products indicates the storage period of the products. The acidity of the products increases with a longer storage period (Akubor, 1996).

The Brix values ranged from 11.6 for brand B to 15.1 for brand N. According to the General Standard for Fruit Juices, Fruit Drink, and Nectars, GSO 1820 (2021), the Brix value of mango juice must be not less than 13.5, which leaves brands B and O non-compliant with the Brix requirement.

The Brix/acidity ratio exhibited significant variation across the brands. The brand H exhibited the highest ratio of 81.7, followed by brands N, B, and I with ratios of 71.9, 52.7, and 49.6, and brand O with the lowest ratio of 49.2. Such significant variation in the Brix/acidity ratios highlights the critical value of sweetness and acidity equilibrium in flavour perception.

Similar to that of orange juice products, all the brands of mango juice products were categorized as “non-compliant” (NC) to the “Labelling of Fruit Juices Nectars and Fruit Drinks Standard”, GSO 2577 (2021). The non-compliance in mango juice labels include; provide information about type of juice (Drink, Nectar or Juice), source of juice (fresh or concentrated), mention when sugar added and when free sugar statement used it must mention its natural. Therefore, these non-compliant products should be removed from the market until they correct their Brix values and labels to the standard requirement.

Table 2. Physicochemical characteristics of different mango juice brands

Brands	N	B	I	H	O
Moisture (%)	84.8 ± 0.5a	90.1 ± 0.7b	90.1 ± 0.6b	85.5 ± 0.5a	91.8 ± 0.3b
Total Solids (%)	15.2 ± 0.5a	9.9 ± 0.6b	9.9 ± 0.7b	14.5 ± 0.5a	8.2 ± 0.7c
pH	3.90 ± 0.02a	4.03 ± 0.01a	3.64 ± 0.02b	4.27 ± 0.04c	3.95 ± 0.01a
Brix (°Bx)	15.1 ± 0.1a	11.6 ± 0.3b	13.4 ± 0.1c	14.7 ± 0.5a	11.8 ± 0.1b
Total Acidity (%)	0.21 ± 0.00a	0.22 ± 0.01a	0.27 ± 0.02b	0.18 ± 0.01c	0.24 ± 0.04d
Brix/acidity ratio	71.9 ± 2.5a	52.7 ± 3.3b	49.6 ± 0.4c	81.7 ± 3.0d	49.2 ± 3.9c
Product Label	NC	NC	NC	NC	NC

Letters N, B, I, H, and O are the codes for mango juice brands. The values are average of triplicate analysis ± SD followed by the same letter, within a row, are not significantly different (P > 0.05). C and NC are compliant and non-compliant to the "Labelling of fruit juices nectars and fruit drinks Standard", GSO 2577:2021.

3.3 Physicochemical Characteristics of Apple Juice Products

Table 3 outlines the average values obtained from the triplicate analysis describing the physicochemical parameters and compliance status of brands M, C, K, A, and G of the apple juice products. The moisture content ranged from 89.8% for brand G to 91.9% for brand C, with brands M, K, and A having moisture content of 90.5, 89.9, and 91.3% respectively. Again, the high moisture content indicates reduced shelf stability.

In terms of total solid content, brand K showed the highest total solid content of 10.0%, followed by brand G (10.3%), M (9.5%), and A (8.7%), while brand C exhibited the lowest total solid content of 8.1%. Such high solid contents indicate the longer storage period of the products (Akhtar et al., 2013).

The pH varied slightly among the brands, with brands M and A being the most acidic (3.73) and brand C the least acidic (3.96). Brands K and G had a pH of 3.79. Brand A had the highest total acidity of 0.45%, followed by K (0.42%), G (0.39%), and C (0.37%). Conversely, brand M showed the lowest total acidity of 0.28%. These pH and acidity values fall within the accepted range of pH 3-5 for fruit and vegetable juice products (Tasnim et al., 2010).

The Brix value of brand G (13.4) was the highest among the brands, suggesting its elevating sugar content. Brands M, C, and A had the Brix values of 11.2, 11.7, and 11. 5 respectively. Brand K exhibited the lowest Brix value of 10.8, indicating that brand K juice product had the lowest sugar content. According to the General Standard for Fruit Juices, Fruit Drink, and Nectars, GSO 1820 (2021), the Brix value of apple juice must be not less than 11.5, which leaves brands M and K non-compliant with the Brix requirement. All apple juice product brands were categorized as "non-compliant" (NC) indicating that none of the brands meet the GSO 2577 (2021) labelling standards. The non-compliance in apple juice labels includes; providing information about the type of juice (Drink, Nectar, or Juice), source of juice (fresh or concentrated), and when the free sugar statement is used it must mention its natural. All apple juice samples were non-compliant with the standard either from Brix and label requirements, therefore, they should be removed from the market until they correct their Brix values and label requirements.

Table 3. Physicochemical characteristics of different apple juice brands

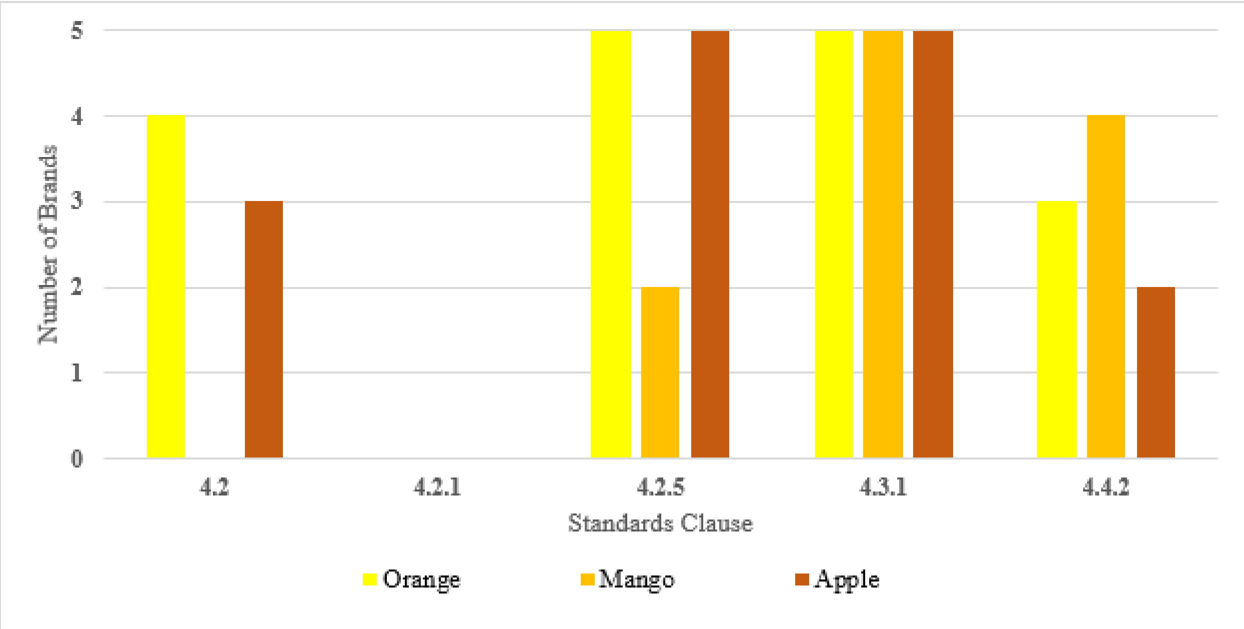
Brands	M	C	K	A	G
Moisture (%)	90.5 ± 0.4a	91.9 ± 0.6a	89.9 ± 0.2a	91.3 ± 0.5a	89.8 ± 0.7a
Total Solids (%)	9.5 ± 0.4a	8.1 ± 0.6b	10.0 ± 0.1c	8.7 ± 0.5d	10.3 ± 0.7e
pH	3.73 ± 0.01a	3.96 ± 0.03b	3.79 ± 0.02a	3.73 ± 0.01a	3.79 ± 0.03a
Brix (°Bx)	11.2 ± 0.3a	11.7 ± 0.2a	10.8 ± 0.1a	11.5 ± 0.2a	13.4 ± 0.1b
Total Acidity (%)	0.28 ± 0.00a	0.37 ± 0.00b	0.42 ± 0.01c	0.45 ± 0.02d	0.39 ± 0.00b
Brix/acidity ratio	40.0 ± 0.8a	31.6 ± 0.3b	25.7 ± 0.4c	25.6 ± 0.4c	34.4 ± 0.3d
Product Label	NC	NC	NC	NC	NC

Letters M, C, K, A, and G are the codes for apple juice brands. The values are average of triplicate analysis ± SD followed by the same letter, within a row, are not significantly different (P > 0.05). C and NC are compliant and non-compliant to the "Labelling of fruit juices nectars and fruit drinks Standard", GSO 2577:2021.

3.4 The Compliance to Label Standards

This study investigated the compliance of fruit juice products to the mandatory label requirements imposed by the standard "Labelling of Fruit Juices Nectars and Fruit Drinks Standard", GSO 2577 (2021). The standard defines the food product label as "Any label, mark, brand, image, or other descriptive data written, printed, stamped, placed, engraved, or prominent on the food packaging in a way that is not removable". Five clauses from the standard were evaluated which are 4.2, 4.2.1, 4.2.5, 4.3.1, and 4.4.2. These clauses have been selected as they present: type of product (Drink, Nectar, or Juice), if it is made from fresh or concentrated juice, if sugar is added, availability of nutritional data, and when no added sugar it shall mention its natural. **Fig. 1** presents the compliance of the investigated fruit juice samples to the label standard. None of the products managed to fulfill the standard's requirements for labels, the only requirement achieved by all samples is the availability of nutrition data. Therefore, all these samples are regarded as non-compliance samples according to the label standard and they should be removed from the market. These requirements demand that consumers should be aware of the contents of the food through the label and most importantly, be warned about unsafe, unhealthy food, in a manner that is intelligible to everyone, so that they make an informed choice and stay away from unhealthy food.

Figure 1. The compliance of product labels to standards requirements.



Clause 4.2: Types of the product (Drink, Nectar or Juice), 4.2.1: Made from concentrated juice, 4.2.5: When sugar added, 4.3.1: Nutritional data, and 4.4.2: when free sugar, shall be mentioned it's natural.

3.5 Descriptive Sensory Characteristics of Orange Juice Products

Fig. 2 represents the descriptive sensory analysis data of orange juices from different brands namely D, E, F, L, and J for the attributes of colour, flavour, acidity, sweetness, and an overall acceptability. The colour scores varied among the brands with brand E having the highest colour score of 3.83 and brand D having the lowest colour score of 2.5. The high colour scores of brands E and F imply that the juice had a vibrant and appealing colour due to the presence of high levels of beta-carotenoids and terpenes which are responsible for the vivid colour of fruits (Nabi et al., 2023). While less intense colour is indicated by the low colour scores of brands D, L, and J.

Concerning flavour, brand J had the highest flavour score (3.83), followed by brand F (3.5), and E (2.83). Brands D and L exhibited the lowest flavour scores (2.5). The high flavour scores of brands J and F indicated that orange juice of both these brands had strong flavouring profiles due the presence of abundant citric acid. This correlation is supported by their acidity scores.

The acidity scores of brands D and L were 2.33 and 2.87, suggesting that fewer organic acids were present compared to brands F and J with acidity scores of 3.5 each. Also, brands D and L had the lowest sweetness scores of 2.5 each compared to brands F and J, having the highest sweetness scores of 3.8 each. The sweetness score of brand E was 3, indicating the moderate sweetness of brand E juice product. The sweetness did not appear to be influenced by colour. Results in this study are in agreement with those reported by Fernández-Vázquez et al. (2013) related to colour variation in orange juice does not effect on sweetness.

Brands F and J received the highest overall acceptability score of 3.7 due to their appealing colours, strong flavouring profiles, balanced acidities, and notable sweetness. Brands E and L had with overall acceptability score of 3.0 and 2.8, respectively. While brand D had the lowest acceptability score of 2.3 due to its subdued colour, weak flavouring profile, elevated acidity, and reduced sweetness. These descriptive sensory attributes can assist in formulating a juice product according to consumer liking.

3.6 Descriptive Sensory Characteristics of Mango Juice Products

Fig. 2 also represents the descriptive sensory analysis of mango juices from different brands namely N, B, I, H, and O based on colour, flavour, acidity, sweetness, and overall acceptability. Brand N exhibited the highest overall acceptability score of 4.3 due to its consistently high scores across all attributes. Brand N exhibited 4.3 scores for colour, flavour, and acidity and a slightly elevated score of 4.7 for sweetness. Brand N was followed by brand B with an overall acceptability score of 4.0. The colour and flavour scores of brand B were 3.8 each, while the score of 4 was consistent for the acidity and sweetness of brand B. The high sensory scores of brands N and B suggest that juices from brands N and B were most appealing in colour with strong flavour profiles indicating the presence of excess vitamin A, citric acid, and malic acids, appropriate acidity and sweetness compared to brands O and H with moderate overall acceptability scores of 3.2 and 2.2 respectively. This indicate that all the attributes of brands O and H juices were moderate. In contrast, brand I exhibited the lowest overall acceptability score of 1.5 indicating its weak colour intensity (1.7), indicating low levels of carotenes and organic acids. The flavour, acidity, and sweetness score of brand I were consistent at 1.5, making the mango juice product of brand I least favourable suggesting that not fully ripened mangoes were used with low levels of mango specific aromatic compounds such as hexanal and isobutyl acetate (Yi et al., 2017).

3.7 The Descriptive Sensory Characteristics of Apple Juice Products

The data obtained from the descriptive sensory analysis of apple juices from different brands namely M, C, K, A, and G is presented in Fig. 2. Brand G exhibited a 4.2 score for colour, 3.8 for flavour, 3.7 for acidity, and 3.5 scores for sweetness, which lead to the highest score in acceptability among brands (3.8). The high sensory scores of brand G colour may be attributed to browning, which can be categorized into enzymatic and non-enzymatic browning. Similarly, polyphenols, including flavonoids, are known to be responsible for the colour profiles of apple fruit (Ley, 2008). However, brand M scored lower than brand G in the rest of the attributes with an overall acceptability score of 3.5, followed by brand K (3.3). In contrast, brand C had the lowest scores in colour (1.3), flavour (1.3), acidity (1.3), and sweetness (1.7), and therefore exhibited the lowest overall acceptability score of 1.3. Such low scores of brand C indicated an unappealing colour due to the low levels of anthocyanins and carotenoids, undesirable taste profile due to insufficient flavour intensity suggesting the low levels of polyphenols including flavonoids, and imbalanced sweetness-to-acidity ratio due to the imbalance between organic acids and sugars. These results agree with the previous study of Rosa-Martínez et al (2021), who reported desired acidity and sweetness profiles due to a balanced organic acids-to-sugars ratio.

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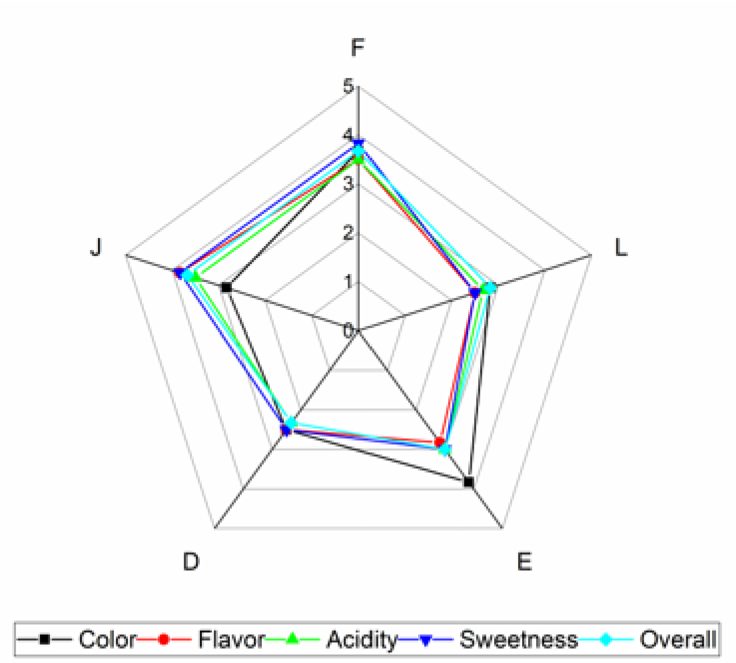
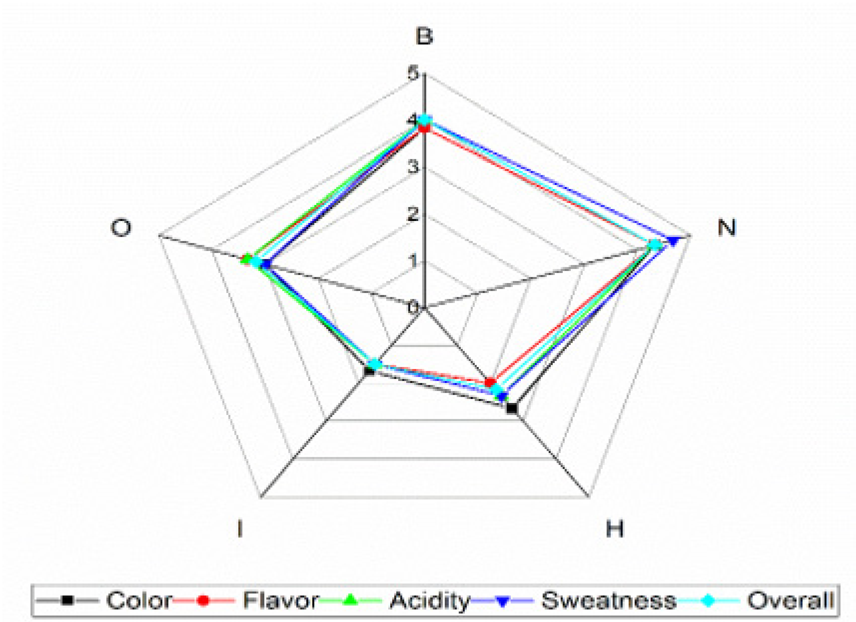
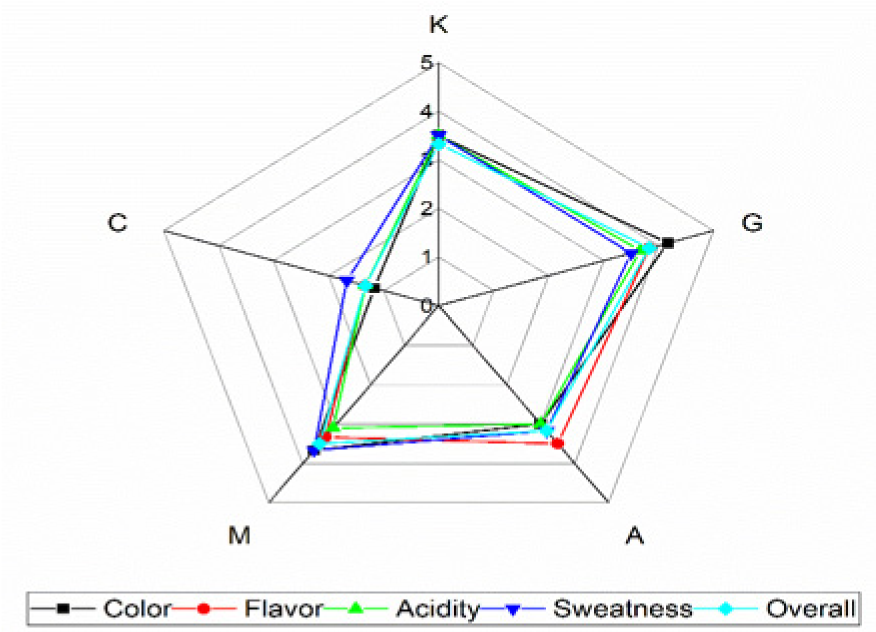
Figure 2. Descriptive sensory attribute scores of different fruit juice brands (n = 6).



Orange



Mango



Apple

3.8 Consumer Preferences of Orange, Mango, and Apple Juices

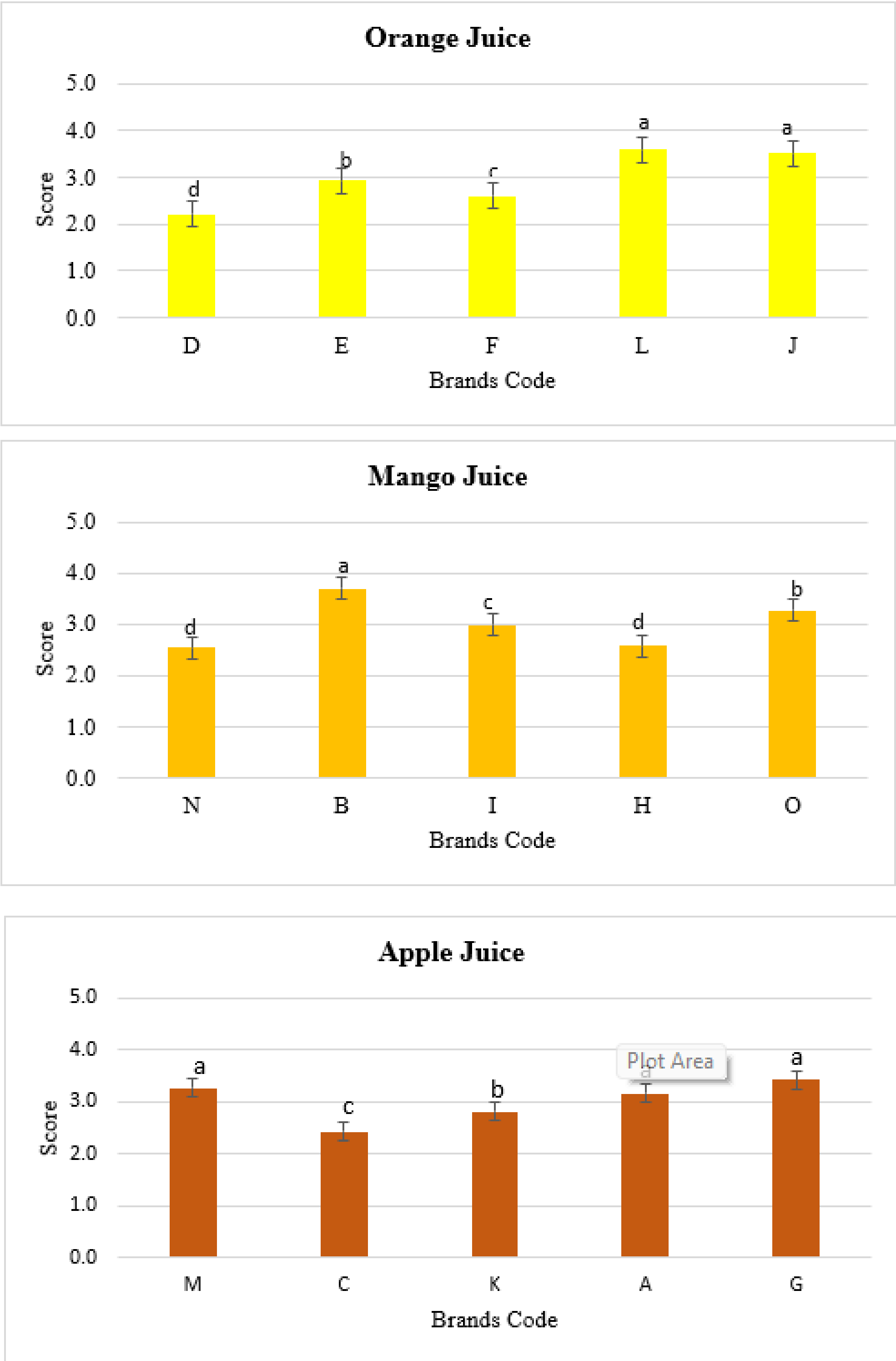
Consumer preference sometimes referred to as public or market preference is an important aspect of market and product development. The average preference scores provide a general overview of public perception and reflect the collective opinion of a group of consumers about a product. It is determined based on reviews and factors such as quality, price, brand reputations, and social and cultural influences. The average consumer preference scores for orange, mango, and apple juices of all brands are provided in Fig. 3. For orange juice, brand L received the highest average preference score of 3.6 among the fifty-three consumers surveyed, suggesting that consumers prefer this brand most for orange juices, followed by brand J with a preference score of 3.5. The preference scores of E and F were 2.9 and 2.6, respectively. Brand D showed the lowest preference score of 2.2, suggesting that brand D was the least preferred brand among the orange juices. The total average preference score for orange juice is 2.96.

The preference scores for mango juices varied among different brands. Brand B exhibited the highest preference score of 3.7, indicating that consumers preferred brand B for mango juice over other brands. The preference scores of brands O, I, and H were 3.3, 3.0, and 2.6, respectively. Brand N showed the lowest preference score of 2.5, suggesting that brand N was the least preferred brand among mango juices.

For apple juices, the highest preference score was exhibited by brand G (3.4). This indicates that brand G was the most preferred and brand C with a 2.4 preference score was the least preferred brand among apple juices. These perfectly align with the descriptive sensory results of apple juices. Brand G had the highest colour, flavour, acidity, and overall assessment scores, while brand C had the lowest scores in all sensory attributes. The preference scores of brands M, A, and K were 3.3, 3.2, and 2.8, respectively, making the average preference score of apple juice for all the brands 3.02, which is similar to other juices.

The correlation coefficient of each type of juice product varied considerably when compared between the overall preference values by descriptive and consumer analyses (the data not included). For orange and mango juices, the correlation was weakly positive (0.37 and 0.22, respectively), while it was strongly positive for apple juice (0.90). Also, the overall preference of the descriptive panel (45.7) was slightly higher than that of the consumer panel (44.9). This is similar to the result of Okayasu and Naito (2001), who reported that trained judges tended to find larger differences in liking among apple juice than an untrained panel.

Figure 3. The average of consumer preference score (n = 53).



The values followed by the same letter are not significantly different (P > 0.05).

4. CONCLUSION

This study focused on the physicochemical characteristics, sensory quality, and consumer perception of orange, mango, and apple juice brands consumed in Oman. The analysis of physicochemical characteristics revealed non-compliance with Brix requirements in mango and apple juices. Additionally, all evaluated juice brands were found to be non-compliant with label requirements, potentially misleading consumers and constituting a clear violation of mandatory juice and label standards. Therefore, such products need to be recalled or withdrawn from the market until they meet quality standards.

Descriptive sensory analysis and consumer preference scores showed significant differences in overall acceptability among different juice brands, highlighting consumer preferences. This study provides valuable insights into fruit juice quality, aiding consumers in making informed choices. Furthermore, it underscores the importance of improving legislation for fruit juice brands by incorporating quality parameters such as acidity and sensory preferences. Implementing such legislation will contribute to maintaining a sustainable fruit juice industry.

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Authorship contribution
Al-Farsi: Conceptualization, Investigation, Supervise Analysis and Writing original draft.
Sana Ullah: Methodology, Investigation.
Al-Omairi, Al-Amri, Al-Jassasi & Al-Yaqoobi: Methodology & Analysis.
Cesarettin Alasalvar: Review & Editing.

Conflict of interest
The authors declare no conflict of interest. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical approval
Ethic approval was not required for this study. Ethical approval for sensory evaluation of juice products is not required in Oman. However, the proper verbal consent of the taste panellists was obtained for sensory evaluation. All participants were aware of the juice formulation being evaluated, and the evaluation used the proper protocols for the juice product.

Data availability
The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCE

1. Adams, J., Hofman, K., Moubarac, J.C., and Thow, A.M. (2020). Public health response to ultra-processed food and drinks. BMJ, 369; 1-5. https://www.bmj.com/content/369/bmj.m2391

2. Akhtar, S., Khan, F.A., Ali, J., and Javid, B. (2013). Nutritional composition, sensory evaluation and quality assessment of different brands of commercial tetra pack apple juices available in local market of Peshawar Pakistan. Global Journal of Biotechnology and Biochemistry, 8(11); 69-73. https://idosi.org/gjbb/gjbb8(3)13/3.pdf

3. Akubor, P. (1996). The suitability of African bush mango juice for wine production. Plant Foods for Human Nutrition, 49; 213-219. doi: 10.1007/BF01093217.

4. AOAC (2007). Official Methods of Analysis. 18th Edition, Association of Official Analytical chemists.

5. Ashurst, R. (2016). Chemistry and technology of soft drinks and fruit juices, 3rd Edition. Wiley Online Library. ISBN: 978-1-444-33381-7

6. Berta, G., Ivo, O., Eunice, B., Maria Cristina, M., Alfredo, A., Fernanda, C., and Teresa, P. (2018). Aromas and Flavours of Fruits. In V. Alice (Ed.), Generation of Aromas and Flavours (Chpter 2).

7. Caswell, H. (2009). The role of fruit juice in the diet: an overview. Nutrition Bulletin, 34(3); 273-288. https://doi.org/10.1111/j.1467-3010.2009.01760.x

8. Chiozzi, V., Agriopoulou, S., and Varzakas, T. (2022). Advances, applications, and comparison of thermal (pasteurization, sterilization, and aseptic packaging) against non-thermal (ultrasounds, UV radiation, ozonation, high hydrostatic pressure) technologies in food processing. Applied Sciences, 12(4); 2202. https://doi.org/10.3390/app12042202

9. Falade, O.S., Sowunmi, O.R., Oladipo, A., Tunbosun, A., and Adewusi, SRA. (2003). The level of organic acids in some Nigerian fruits and their effect on mineral availability in composite diets. Pakistan Journal of Nutrition, 2(2); 82-88. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=3848647477aa3a1ab3b7d10240eb84edf7325f4b

10. Fernández-Vázquez Rocío, Louise Hewson, Ian Fisk, Dolores Hernanz Vila, Francisco Jose Heredia Mira, Isabel M. Vicario and Joanne Hort (2013). Colour influences sensory perception and liking of orange juice. Flavour, 3;1-8. https://flavourjournal.biomedcentral.com/articles/10.1186/2044-7248-3-1

11. Gacula MC (1997). Descriptive Sensory Analysis in Practice, Food & Nutrition Press, Inc., Trumbull, Connecticut, USA.

12. Gordon, A. (2017). Introduction: effective implementation of food safety and quality systems: prerequisites and other considerations Food Safety and Quality Systems in Developing Countries (pp. 1-19): Elsevier.

13. Gous, A.G.S., Almli, V.L., Coetzee, V., and de Kock, H.L. (2019). Effects of Varying the Color, Aroma, Bitter, and Sweet Levels of a Grapefruit-Like Model Beverage on the Sensory Properties and Liking of the Consumer. Nutrients, 11(2); 1-50. https://doi.org/10.3390/nu11020464

14. GSO 1820 (2021). The General Standard for Fruit Juices, Fruit Drink and Nectars, GCC Standardization Organization. https://www.gso.org.sa/store/standards/GSO:781045/GSO%201820:2021

15. GSO 2577 (2021). Labelling of fruit juices nectars and fruit drinks Standard, GCC Standardization Organization. https://www.gso.org.sa/store/standards/GSO:781600/GSO%202577:2021

16. Jayasena, V. and Cameron, L. (2008). ° Brix/acid ratio as a predictor of consumer acceptability of Crimson Seedless table grapes. Journal of food Quality, 31(6); 736-750. https://doi.org/10.1111/j.1745-4557.2008.00231.x

17. Kemp S., Hollowood T., and Hort J. (2009). Sensory Evaluation, A practical handbook, John Wiley & Sons Ltd, West Sussex, United Kingdom.

18. Ley, J.P. (2008). Masking bitter taste by molecules. Chemosensory Perception, 1(1); 58-77. https://doi.org/10.1007/s12078-008-9008-2

19. Mahajan, B., (1994). Biochemical and enzymatic changes in apple during cold-storage. Journal of Food Science and Technology-Mysore, 31(2); 142-144.

20. Mandha, J., Shumoy, H., Matemu, A.O., and Raes, K. (2023). Characterization of fruit juices and effect of pasteurization and storage conditions on their microbial, physicochemical, and nutritional quality. Food Bioscience, 51. Article 102335. https://doi.org/10.1016/j.fbio.2022.102335

21. Nabi, B.G., Mukhtar K., Ahmed W., and Manzoor M., (2023). Natural pigments: Anthocyanins, carotenoids, chlorophylls, and betalains as food colorants in food products. Food Bioscience, 102403. https://doi.org/10.1016/j.fbio.2023.102403

22. Ndife, J., Awogbenja, D. and Zakari, U. (2013). Comparative evaluation of the nutritional and sensory quality of different brands of orange-juice in Nigerian market. African Journal of Food Science, 7(12); 479-484. DOI:10.5897/AJFS2013.1060

23. Okayasu, H. and Naito, S. (2001). Sensory Characteristics of Apple Juice Evaluated by Consumer and Trained Panels. Journal of Food Science, 66, 7; 1025-1029. https://doi.org/10.1111/j.1365-2621.2001.tb08229.x

24. Pham, H.T.T., Kityo, P., Buvé, C., Hendrickx, M.E., and Van Loey, A.M. (2020). Influence of pH and Composition on Nonenzymatic Browning of Shelf-Stable Orange Juice during Storage. Journal of Agricultural and Food Chemistry, 68(19); 5402-5411. DOI: 10.1021/acs.jafc.9b07630

25. Rosa-Martínez, E., Adalid A., Alvarado L., and Burguet R. (2021). Variation for composition and quality in a collection of the resilient Mediterranean 'de penjar' Long Shelf-Life tomato under high and low N fertilization levels. Frontiers in Plant Science, 12; 633957. https://www.frontiersin.org/journals/plant-science/articles/10.3389/fpls.2021.633957/full

26. Ruiz-Capillas, C., and Herrero, A.M. (2021). Sensory Analysis and Consumer Research in New Product Development. Foods, 10(3); 582. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8001375/

27. Ryan, J., Hutchings, S.C., Fang, Z., Bandara, N., Gamlath, S., Ajlouni, S., and Ranadheera, C.S. (2020). Microbial, physico□chemical and sensory characteristics of mango juice□enriched probiotic dairy drinks. International Journal of Dairy Technology. 73(1); 182-190. https://doi.org/10.1111/1471-0307.12630

28. Salehi, F. (2020). Physico-chemical Properties of Fruit and Vegetable Juices as Affected by Pulsed Electric Field: A Review. International Journal of Food Properties, 23; 1036-1050. https://doi.org/10.1080/10942912.2020.1775250

29. Salehi, F. (2020a). Physico-chemical Characteristics and Rheological Behaviour of Some Fruit Juices and Their Concentrates. Journal of Food Measurement and Characterization, 14; 2472-2488. https://link.springer.com/article/10.1007/s11694-020-00495-0

30. Salehi, F. (2020b). Physico-chemical and rheological properties of fruit and vegetable juices as affected by

high pressure homogenization: A review. International Journal of Food Properties, 23, 1; 1136-1149. https://doi.org/10.1080/10942912.2020.1781167

31. Salehi, F. (2021). Quality, physicochemical, and textural properties of dairy products containing fruits and vegetables: A review. Food Science & Nutrition, 9(8); 4666-4686. https://doi.org/10.1002/fsn3.2430

32. Shen, Y., Zhu, D., Xi, P., Cai, T., Cao, X., Liu, H., and Li, J. (2021). Effects of temperature-controlled ultrasound treatment on sensory properties, physical characteristics and antioxidant activity of cloudy apple juice. LWT, 142; 111030. https://doi.org/10.1016/j.lwt.2021.111030

33. Song, Q., Rune, C., Thybo, A., Clausen, M., Orlien, V., and Giacalone, D. (2023). Sensory quality and consumer perception of high pressure processed orange juice and apple juice. LWT - Food Science and Technology. 173; 114303. https://doi.org/10.1016/j.lwt.2022.114303

34. Talasila, U., Vechalapu, R.R. and Shaik, K.B. (2012). Clarification, preservation, and shelf life evaluation of cashew apple juice. Food Science and Biotechnology, 21; 709-714. https://link.springer.com/article/10.1007/s10068-012-0092-3

35. Tasnim, F., Hossain, M.A., Hossain, M.K., Lopa, D., and Haque, KM. (2010). Quality assessment of industrially processed fruit juices available in Dhaka city, bangladesh. Malaysian journal of nutrition, 16(3); 431-438. http://maljnutr.org.my/2010.php

36. Tiencheu, B., Naji, D., Achidi A., Egbe, A., and Tenyang N. (2021). Nutritional, sensory, physico-chemical, phytochemical, microbiological and shelf-life studies of natural fruit juice formulated from orange (Citrus sinensis), lemon (Citrus limon), Honey and Ginger (Zingiber officinale). Heliyon, 7(6); e07177. https://doi.org/10.1016/j.heliyon.2021.e07177

37. Tiwari, B., Muthukumarappan, K., and O'Donnell C. (2008). Colour degradation and quality parameters of sonicated orange juice using response surface methodology. LWT-Food Science and Technology, 41(10); 1876-1883. https://doi.org/10.1016/j.lwt.2007.11.016

38. Trienekens, J. and Zuurbier, P. (2008). Quality and safety standards in the food industry, developments and challenges. International journal of production economics, 113(1); 107-122. https://doi.org/10.1016/j.ijpe.2007.02.050

39. Vilela, A., Bacelar, E., Pinto, T., Anjos, R., Correia, E., Gonçalves, B., and Cosme, F. (2019). Beverage and food fragrance biotechnology, novel applications, sensory and sensor techniques: An overview. Foods, 8(12); 643. https://doi.org/10.3390/foods8120643

40. Wunwisa, K. and Kamolnate, K. (2010). Sensory Characteristics and Consumer Acceptance of Fruit Juice Containing Probioitcs Beads in Thailand. AU Journal of Technology, 14(1): 33-38, 195-199. https://repository.au.edu/server/api/core/bitstreams/a6e39931-1b74-470c-b959-89f4f02259f4/content.