

SENSORY TEXTURE OF DATE FRUITS AS A FUNCTION OF PHYSICOCHEMICAL PROPERTIES AND ITS USE IN DATE CLASSIFICATION

V. SINGH^{a*}, N. GUIZANI^{a*}, I. AL-ZAKWANI^a, Q. AL-SHAMSI^b, A. AL-ALAWI^a and M.S. RAHMAN^a

^aDepartment of Food Science and Nutrition, College of Agricultural and Marine Sciences, Sultan Qaboos University, P. O. Box 34, Al-Khod 123, Muscat, Oman

^bDubai Municipality, P.O. Box 67, Dubai. UAE

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Eight descriptive sensory textural attributes of whole date fruit were evaluated by twenty trained panel members and correlated with sixteen physicochemical properties. All sensory parameters, except gumminess, significantly correlated ($P < 0.05$) with pectin, crude fibre, and moisture content. In addition, sensory hardness, cohesiveness, elasticity, and resilience correlated significantly with length of whole fruit ($P < 0.05$), sensory adhesiveness with glucose content ($P < 0.05$), sensory chewiness with mass of whole fruit ($P < 0.05$), and sensory gumminess with fructose, glucose, and total sugar content ($P < 0.10$). Sweetness, however, correlated only with moisture content ($P < 0.05$). CA and the biplot (i.e. including all products, their sensory texture and physicochemical attributes) generated through PCA recognized three groups of dates as hard-chewy, soft-(medium-chewy), and soft-(non-adhesive).

Keywords: date, moisture, sensory, PCA, classification

Date palm fruit is a berry consisting of a pericarp and a pit. The pericarp constitutes 85–90% of the total fruit mass and it is composed of exocarp, fleshy mesocarp, and papery endocarp (HUSSEIN et al., 1998). Dates can be consumed as fresh fruit at *khalal* and *rutab* stages (immature stages with short shelf life) or at *tamar* stage (mature stage with good storability). It is important to know the physicochemical, mechanical, structural, textural, and sensory properties of dates for their processing, storage stability, and consumer acceptability. The rank of the most preferred sensory quality attributes of dates at *tamar* stage of maturity were high for colour, appearance, sweetness, medium for fruit size, chewiness, solubility, flesh thickness, and low for elasticity, mouth feel, and shear force (ISMAIL et al., 2001).

Sensory properties of a food are the ultimate considerations used by the consumers for accepting a product. Sensory properties are mainly measured by expert-panels, trained panels, and consumer panels. Earlier sensory profile of 7 cultivars of date fruit from Tunisia showed a great morphological and physicochemical diversity among the tested cultivars (BEN ISMAIL et al., 2013). The sensory attributes of date syrup (ABBES et al., 2011) and date jams (BESBES et al., 2009) were also determined. Studying the effect of storage conditions on the sensory profile of two cultivars of date fruit, ISMAIL and co-workers (2008) observed behavioural variation in measured physicochemical and sensory attributes between the two cultivars under matching storage conditions. They concluded that most of the variation of the stored dates comes from “size”, followed by “texture” variables. In the literature, very

* To whom correspondence should be addressed.

Phone: +968 2414 1256; e-mail: vandita31@gmail.com; guizani@sqe.edu.om

limited studies have assessed the relationships between the sensory texture and physicochemical properties of date fruit. The overall objective of this study was to determine the sensory texture of nine batches of dates with different quality levels and to determine their relationship with 16 physicochemical properties.

1. Materials and methods

1.1. Descriptive sensory analysis

Fifteen physicochemical properties of nine batches of dates were measured previously (SINGH et al., 2013). Total polyphenols was measured by the method of SINGH and co-workers (2012). Sensory texture analysis was conducted with a panel consisting of a panel leader and twenty panel members.

1.2. Panel members

The panel consisted of twenty members (10 males and 10 females) within the age of 21–25 (students from the CAMS, Sultan Qaboos University). Most of the panel members consume dates regularly (i.e. every day) and none of them had teeth problems or diabetes, and all were non-smokers. The members agreed to participate in the training (three sessions, 2 h each) and to perform the sensory texture analysis, i.e. two sessions a day with at least 1 hour interval for one attribute. However, sweetness and hardness were measured at the same time.

1.3. Sample preparation

Different batches of dates were removed from the freezer and placed in the sensory preparation room for at least 2 h prior to analysis. Dates were then randomly selected from different polyethylene bags and placed on a disposable plate marked with 3 digit coding.

1.4. Training

The panel leader organized three training sessions before assessing the samples. In the first training session, panel members were trained on the concept of sensory properties including definition of different textural attributes. In the second session, they were trained on the scale and standard used for different attributes. In the third session, they were trained to assess the textural attributes considering its definition, following the procedure and standards as included in Table 1.

1.5. Sensory evaluation

The panel members received different date samples in the sensory evaluation booth. Panel members were instructed to remove the seed and place the date flesh in between the molar teeth and assess the sensory attributes based on the definitions and standards they received. They were then asked to include their rating on a scale considering the procedures provided in Table 1. Water was used to wash the mouth twice in between assessments. All sessions were conducted in a climate-controlled sensory analysis booth (i.e. 20 °C room temperature, positive air pressure) and under white fluorescent lighting. Detailed statistical analysis procedures were presented in an earlier paper by SINGH and co-workers (2013).

Table 1. Definition and scales of the attributes used for determining consumer preference level of date

Attributes	Definition	How to measure	Low	Medium	High
Chewiness	Number of chews required in preparing sample for swallowing	Place the date sample between the molar teeth, start chewing, and count the numbers of chews before swallowing	Soft gel candy	Fresh strawberry candy	Hard gel candy
Elasticity	Degree to which sample pushes back against the teeth during chewing (i.e. relationship between change in force and deformation)	Place the date sample between the molar teeth, start chewing and assess the force with initial chews (sample push back) (i.e. bite down evenly, evaluating the force required to compress at different degree).	Soft fruit candy	–	Almond
Gumminess	Degree to which sample sticks to itself in a dense, gummy mass at specific chews	Chew 15 times and assess the gummy mass of date sample sticking together	Almond	–	Soft fruit candy
Hardness	Force necessary to attain a given deformation during biting	Place the sample between the molar teeth, press it softly and assess the force (i.e. bite down evenly, and evaluate the force required to compress).	Banana	Apple	Carrot
Cohesiveness during biting	Degree of deformation undergone by a sample before it fractures, splits, cracks, or breaks on first bite with molars or incisors	Place a sample of date between the molar teeth, bite down evenly, and evaluate the deformation it undergoes before it separates into pieces or spread	Carrot	–	Dried apricot
Springiness	Degree or rate (i.e. time) at which a product physically springs back or returns to its original size or shape after partial compression	Place the sample between molar teeth, compress the sample mildly (i.e. around 20%), and assess the time under which the sample returns to its original size or shape	Cheese	Marshmallow	Hard gel candy
Adhesiveness	Degree to which sample sticks to mouth surfaces and teeth	Place a sample of date between the molar teeth, exert a bite, and evaluate the force required to pull the jaws apart	Milk chocolate	Hatwa	Honey coated dates
Resilience	Degree of product fight to regain its original position	Place dates between the molar teeth, compress 20% (mild) and hold, evaluating the sample pushing back before being chewed	Soft fruit leather	Apricot leather	Dried apricot
Sweetness	Sweetness of dates	Place a sample of date between the molar teeth, start chewing, and assess the intensity of sweet taste in the progress of chewing and swallowing	Water	Diluted sugar solution	Concentrated sugar solution

2. Results and discussion

2.1. Correlation between sensory textural attributes and physicochemical properties

Table 2 presents the sensory attributes of 9 batches of dates as a function of moisture content. Pearson's correlation showed that sensory hardness (HAS) was negatively correlated with moisture content (XW), crude fibre (CF); and positively correlated with length of whole date fruit (LT), pectin (PE) ($P < 0.05$), and sugar index (SI) ($P < 0.10$). Spearman's correlations did not improve the relation between the HAS and physicochemical properties ($P < 0.05$ or $P < 0.1$). Similarly, hardness of cheese decreased linearly with moisture and increased with increasing starch content (NORONHA et al., 2007), while it was positively correlated with pectin content in pear (YING et al., 2011) and apple (BILLY et al., 2008).

Table 2. Sensory analysis as a function of moisture content of date samples

CP ^a	XW	HAS	ADS	SPS	COS	RES	GUS	CHS	ES	SW
A	17.9 (0.1)	3.3 (1.3)	4.8 (2)	3.9 (1.7)	4.7 (1.7)	4.1 (2.0)	5.9 (1.7)	24 (13.4)	3.8 (1.4)	5.9 (1.5)
B	20.6 (0.3)	2.8 (1.7)	4.2 (1.5)	3.0 (1.4)	4.0 (2.2)	3.3 (2.0)	5.3 (2.1)	17 (10.6)	2.5 (1.6)	5.9 (1.3)
C	17.9 (0.2)	4.5 (2.1)	4.5 (2.1)	3.5 (1.4)	4.9 (1.5)	4.3 (1.7)	5.4 (1.7)	20 (13.5)	4.2 (1.4)	5.3 (1.9)
D	16.1 (0.3)	5.8 (2.5)	4.6 (2.2)	5.2 (2.3)	5.0 (2.2)	4.9 (2.2)	4.5 (2.2)	23 (10.8)	5.8 (1.7)	5.1 (2.0)
E	22.4 (0.6)	3.3 (1.4)	4.4 (1.6)	3.5 (2.0)	4.3 (2.0)	3.6 (1.9)	5.3 (2.1)	20 (12.3)	3.4 (1.2)	6.7 (1.8)
F	19.5 (0.2)	4.1 (1.8)	3.7 (1.4)	3.4 (2.0)	4.1 (1.0)	3.7 (1.9)	3.9 (1.7)	20 (10.5)	3.6 (2.0)	6.1 (1.5)
G	17.7 (0.3)	3.7 (1.5)	4.8 (2.0)	4.3 (1.7)	4.5 (1.6)	3.6 (1.5)	4.5 (1.9)	21 (11.7)	4.1 (1.1)	5.6 (1.7)
H	16.1 (0.1)	6.2 (1.4)	5.4 (2.4)	4.4 (1.7)	5.8 (1.5)	4.6 (1.7)	5.2 (2.0)	27 (16.3)	6.2 (1.7)	5.9 (1.8)
I	16.5 (0.2)	6.8 (1.7)	4.9 (2.1)	4.2 (1.7)	6.4 (1.6)	5.1 (2.1)	5.7 (2.2)	32 (18.3)	6.2 (1.9)	5.6 (1.1)
DT	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$

CP^a: commercial products; XW: moisture content; HAS: sensory hardness; ADS: sensory adhesiveness; SPS: sensory springiness; COS: sensory cohesiveness; RES: sensory resilience; GUS: sensory gumminess; CHS: sensory chewiness; ES: sensory elasticity; SW: sensory sweetness; DT: discrepancy test for each column

Pearson's correlation showed that sensory adhesiveness (ADS) was positively correlated with glucose (GL), SI ($P < 0.05$), total sugar (TS), and PE ($P < 0.1$); and negatively correlated with XW ($P < 0.1$). Spearman's correlations did not improve the relation for GL ($P < 0.05$ or $P < 0.1$), but improved negative correlations for CF and colour a value ($P < 0.05$). Sensory springiness (SPS) was correlated negatively with XW ($P < 0.05$) and CF ($P < 0.1$) and positively with SI ($P < 0.05$) and PE ($P < 0.10$). Spearman's correlation was improved for CF ($P < 0.05$), but not for other attributes.

Pearson's correlation was positive between sensory cohesiveness (COS) and LT, PE, and SI ($P < 0.05$), and mass of whole date fruit (MA) ($P < 0.1$) and negative with XW and CF ($P < 0.05$). Spearman's correlations did not improve the relation ($P > 0.1$). Sensory resilience (RES) was correlated positively with LT and PE ($P < 0.05$), and MA ($P < 0.1$) and negatively correlated with XW ($P < 0.05$) and CF ($P < 0.1$). In this case, Spearman's correlations did not improve for RES ($P > 0.1$). Sensory gumminess (GUS) was positively correlated (Pearson's) with fructose (FR), GL, and TS ($P < 0.1$).

Spearman's correlations showed poor correlations ($P > 0.1$) as compared to the Pearson's correlations. Sensory chewiness was correlated positively with MA, LT, and PE ($P < 0.05$) and negatively correlated with XW and CF ($P < 0.05$). Spearman's correlation improved positive correlation of SI ($P < 0.1$), and decreased correlation for MA ($P < 0.1$). Sensory elasticity (ES) was positively correlated with LT, PE, and SI and negatively with XW and CF ($P < 0.05$). Sensory sweetness (SW) was correlated with XW ($P < 0.05$) and SI ($P < 0.1$). Spearman's test improved the correlation for sucrose content (SU) in dates ($P < 0.1$). It is interesting that most of the sensory textural attributes correlated with XW, PE, and CF.

All sensory textural attributes of date fruit (except gumminess) negatively correlated with moisture and crude fibre; while it was positively correlated with the pectin content. Sugar content positively correlated with all sensory attributes except for cohesiveness and elasticity. Water is a well-known plasticizer that is able to rupture hydrogen bonds in the solid matrix, thus softer texture is formed with increasing water content. Higher sugar and pectin produced harder texture due to their thickening or gelling effect as also pointed out by BESBES and co-workers (2009) in the case of date jams. However, crude fibre influenced the gelling structure of sugar and pectin by damaging or weakening the firm gels.

2.2. Cluster Analysis (CA) and Principal Component Analysis (PCA)

A CA of dates based on Ward's method revealed 3 groups (Fig. 1). The PCA analysis of the same groups identified by CA showed six principal components (95.1% total variance) with Eigen values close to 1. These PCs explained 38.3, 23.7, 12.7, 12.6, 4.6, and 3.3% of the total variance, respectively. Figure 2 presents the bi-plot including all date fruit sensory texture and physicochemical properties. The first axis correlated well with MA, LT, HAS, RES, and CF, and corresponds to hardness (i.e. force required to compress or deform). The second axis was strongly correlated to colour-b value, PE, XW, SPS, CHS, COS, and RES, and corresponds to structure regain ability after deformation. The third axis was strongly correlated with colour-L value, SI, and SW, and corresponds to the sweetness. The fourth axis was strongly correlated with ADS, GUS, and SW, and corresponds to the surface sticking ability. The fifth axis was strongly correlated with SU and GL, and corresponds to low intensity sweeteners. The sixth axis was strongly correlated with SU, FR, TS, pH, TP, and width of whole fruits (WD) and corresponds to pH.

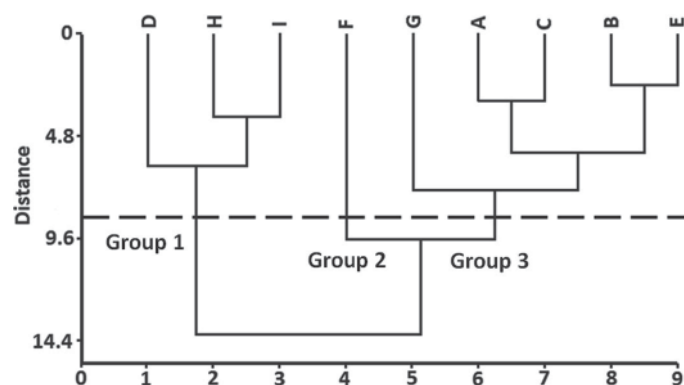


Fig. 1. Dendrogram of the cluster analysis for different date samples [Group 1 (D, H, I); Group 2 (F); Group 3 (G, A, C, B, E)]

This shows that complete sensory texture assessment can be explained by six major factors, among them three evolved from structure (force-deformation, structure regain ability, and surface sticking ability), and two from the composition (sugars and pH). Similar results were observed in the cases of sensory texture and physicochemical properties of 12 types of cheese (full-fat, low-fat, and reduced-fat) when analyzed by PCA (LTEIF et al., 2009). HAS and CHS belonged to the first axis, while SPS and COS belonged to the second axis. However, in the case of cheese, springiness was opposite to cohesiveness. ADS belonged to the fourth axis, while taste (i.e. saltiness) belonged to the third axis, which was similar to the sweetness of dates. In the case of cooked chicken breast, it was observed that the measured HAS, CHS, and SPS showed similarity to our results; however, other textural attributes were not considered in the study by LIU and co-workers, (2004).

The products' sensory textural attributes and physicochemical properties were plotted considering PC 2 and PC 1 (Fig. 2). The Group 1 (D, H, I) on the right hand side of the PCA plot includes hard and chewy (i.e. hard-chewy) dates. On the opposite side of Group 1, the dates in Group 3 (G, A, C, B, E) are high in water, soft, low-chewy, and medium-gummy [i.e. soft-(medium-gummy)]. Similarly, dates in Group 2 (F) are high in water, soft, and non-adhesive [i.e. soft-(non-adhesive)]. Group 2 is medium-chewy, while Group 3 is non-adhesive. In addition, Group 1 is low sweet, while Group 2 and Group 3 are sweeter. This indicated that different brands of date fruits with different degrees of chewiness and gumminess could be branded based on the desired consumer preferences.

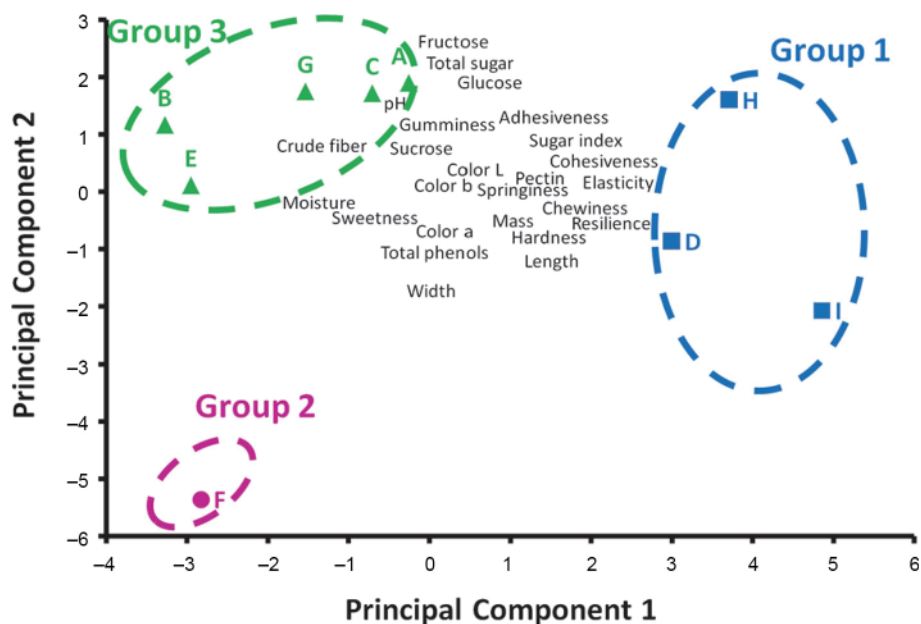


Fig. 2. Bi-plot of Principal Component 2 and Principal Component 1

3. Conclusions

With the exception of gumminess, all sensory texture of date fruit negatively correlated with moisture and crude fibre; while it was positively correlated with the pectin content. Sugar content negatively correlated with all sensory attributes with the exception of cohesiveness and elasticity. The results could be used to explore how physicochemical properties contributed to the sensory texture and could help to select and process the fruit with their desired sensory attributes. The CA and PCA suggest sorting dates into three groups as hard-chewy, soft-(medium-chewy), and soft-(non-adhesive). This classification could be useful for the pricing of dates in the local and international markets based on their desired attributes.

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