USE OF PREFERENCE MAPS TO EVALUATE THE EFFECT OF COLD STORAGE ON SENSORY QUALITY OF AROMATIC HERBS

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Abstract

Nowadays consumers desire a diet rich in fresh food, but they are also in search for ready-to-eat products. These are not usually the healthy choice. In this context minimally processed fresh fruit, vegetables and aromatic herbs became popular. But, their shelf life is usually short even when applying packaging and cold storage. In this context, it is important to understand the evolution of acceptance and preference of minimally processed products during storage. So, the present paper aimed to evaluate the effect of refrigeration on some sensory characteristics of minimally processed herbs from a consumer's point of view. The herbs under study were parsley (*Petroselinum crispum*), dill (*Anethum graveolens*) and lovage (*Levisticum officinale*) minimally processed, packaged in polyethylene bags and stored at 4°C for 12 days. Color, texture and flavor were measured on a scale of 1 to 5 in the 1st, 5th, 8th and 12th day of storage. Principal component analysis (PCA) was performed on sensory analysis results and a consumer preference map was obtained. They showed the dynamic of consumer preference compared to sensory quality attributes during storage. At the beginning of the study none of the assessors was satisfied with the sensory quality of parsley, 60% were satisfied with dill and all preferred lovage. After 12 days of storage, satisfaction provided by dill decreased to 0%, by lovage to 40% and by parsley to 20%. Consumers preferred flavor in proportion of 80-100% compared to only 40-60% for other sensory attributes such as texture and color. The use of PCA and preference maps helped identifying the effect of cold storage on sensory parameters of minimally processed herbs and the existing correlations among quality parameters.

Key words: parsley, dill, lovage, principal component analysis, sensory analysis

Nowadays consumers dedicate less time to prepare their meals, so ready-to-eat products are becoming more popular. But, they are increasingly more aware of the health benefits of fresh foods because they are a rich source of nutrients, antioxidants and antimicrobials (Blasa, M. *et al.*, 2010; Cătunescu, G.M. *et al.*, 2015). In this context, minimally processed fresh fruit, vegetables and aromatic herbs have a growing market worldwide because of this new lifestyle (Landgraf, M. *et al.*, 2006).

Minimally processed products are foods with fresh-like characteristics that provide the convenience demanded by consumers because they need minimal or no further processing prior to consumption (Artes, F. *et al.*, 2014). The plants are treated mildly by washing, cutting, grating, shredding, pulling the leaves off and they are usually free of additives. Other traditional preservation methods such as freezing, dehydration or salting are not employed (Cătunescu, G.M. *et al.*, 2012a). But, these products have a short shelf life, usually 5-7 days at refrigeration temperature (Cătunescu, G.M. *et al.*, 2012a). So, some shelf life extension methods are used: washing with chlorinated water, modified atmosphere packaging and refrigeration (Wiley, R.C. *et al.*, 1995).

The products are prone to deterioration by physiological ageing, biochemical changes and microbial spoilage even when stored at refrigeration temperature (Artes, F. *et al.*, 2014).

Consumers observe only the sensory changes of herbs during storage, so from their point of view, these are the main changes in quality that affect liking and preference (Ayhan, Z. *et al.*, 2005; Rocha, I.F.D.O. *et al.*, 2015; Salinas-Hernández, R.M. *et al.*, 2015). Herbs suffer changes in color (discoloration, yellowing), texture (loss of crispness or juiciness), flavor (off-flavors) (Cătunescu, G.M. *et al.*, 2012a).

So, establishing how these parameters affect consumer acceptance and preference becomes a valid research direction. In food industry, sensory analysis measures the main characteristics of products as they are perceived by consumers. Usually, some or all five senses are employed: sight, smell, taste, touch and hearing (Calín-

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Sánchez, Á. *et al.*, 2015; Ghasemi-Varnamkhasti, M. *et al.*, 2012; Straumite, E. *et al.*, 2012).

Parsley (*Petroselinum crispum*), dill (*Anethum graveolens*) and lovage (*Levisticum officinale*) are the main herbs consumed in Romania (Cătunescu, G.M. *et al.*, 2012a). They are used to add flavor to traditional dishes mainly fresh. In this state they can be stored at 18-20°C and 85–90% humidity for about 3 days (Azeez, S. *et al.*, 2008).

Romanian legislation on leafy vegetables for fresh consumption states only sensory characteristics: whole, healthy, fresh leaves free of diseases, rots and pests, of characteristic color (STAS 12550-87). The herbs have to present no abnormal external humidity, no foreign taste or smell and no floral stem. So, sensory analysis is a must prior to large scale distribution (Cătunescu, G.M. *et al.*, 2012a).

But, sensory analysis usually generate vast amounts of data, so a new method to process and visualize them is needed (Jolliffe, I., 2014). Chemometric methods are currently employed on a large scale to describe and assess the quality of food products, and principal component analysis is preferred (Hossain, M.B. *et al.*, 2011; Patras, A. *et al.*, 2011). Principal component analysis (PCA) is a technique that reduces the dimensionality of large multivariate datasets. It decreases the number of variables by grouping them in linear combinations, the principal components. So, most of the variability in the original dataset is retained in a much smaller number of variables (Jolliffe, I., 2014).

Consequently, the aim of the present paper was to generate a consumer preference map by employing PCA to sensory analysis of minimal processed herbs (parsley, dill and lovage) packed in polyethylene and stored at 4°C for up to 12 days. The map would show the consumer's point of view on the evolution of quality parameters during the shelf-life of the three herbs.

MATERIALS AND METHODS

Sensory analysis. The sensory attributes: color, texture and flavor were previously determined during a 12-day storage for minimal processed parsley (*Petroselinum crispum*), dill (*Anethum graveolens*) and lovage (*Levisticum officinale*) (Cătunescu, G.M. *et al.*, 2012a). Texture and flavor were assessed using two parameters: firmness and succulence, and taste and odor, respectively. Each characteristic was scored on a scale of 1 to 5, 5 being the largest score having a list of attributes as reference. Quality numbers (Cătunescu, G.M. *et al.*, 2012a) and total scores were computed.

Statistical interpretation of data. Statistical analyses were performed using XLSTAT (Addinsoft, New York, USA, Version 2015.4.1) statistical software. Pearson coefficient was used to identify and quantify correlations among sensory attributes and storage, with a confidence level of 95%. Principal component (PCA) and cluster analysis of sensory scores generated a consumer preference map (Hossain, M.B. *et al.*, 2011; Patras, A. *et al.*, 2011).

RESULTS AND DISCUSSION

The sensory scores of minimally processed parsley, dill and lovage are presented in *Table 1* as reported by Cătunescu, G.M. *et al.* (2012a) and they were the basis for generating the consumer preference map.

Lovage had a strong taste and odor; dill had a particular dark green color, juicy stems and leaves; while parsley had a green to light green color and a subtle flavor.

Table 1

Sensory scores of minimally processed herbs during storage, means of 15 to 25 samples

Storage day	Herb	Color	Firmness	Succulence	Texture	Taste	Odor	Flavor	Quality numbers	Total scores
	parsley	3.55	3.45	3.50	3.48	3.25	3.25	3.25	3.43	17.00
1	**dill**	4.45	3.70	4.20	3.95	3.90	3.95	3.93	4.11	20.20
	lovage	3.80	3.70	3.80	3.75	4.40	4.55	4.48	4.01	20.25
	parsley	3.47	3.57	3.57	3.57	3.37	3.42	3.39	3.48	17.39
5	**dill**	4.22	3.67	3.97	3.82	3.87	4.02	3.94	3.99	19.74
	lovage	3.82	3.67	3.62	3.64	4.27	4.32	4.29	3.92	19.69
	parsley	3.50	3.40	3.40	3.40	3.10	2.90	3.00	3.30	16.28
8	**dill**	4.15	3.60	3.70	3.65	3.80	3.70	3.75	3.85	18.93
	lovage	3.85	3.60	3.55	3.57	4.05	4.35	4.20	3.87	19.38
	parsley	3.42	3.42	3.37	3.39	3.17	3.17	3.17	3.33	16.53
12	**dill**	3.82	3.52	3.62	3.57	3.67	3.57	3.62	3.67	18.18
	lovage	3.67	3.52	3.47	3.49	3.87	3.77	3.82	3.66	18.28

Source: Cătunescu, G.M. *et al.* (2012a)

The sensory profile established at the beginning of the study was consistent during the 12 days of storage: dill had high scores for color and juiciness; lovage for smell and taste; and parsley did not excel in any of the attributes, but it was the least affected by storage. This was shown by the statistically confirmed negative correlation between sensory attributes and storage in the case of dill and lovage ***(Error! Not a valid bookmark self-reference.)***. Parsley had smaller overall scores, but tolerated the storage better than the other two herbs, having no obvious signs of alteration.

Table 2

Pearson correlation coefficients (r) of sensory parameters with storage

Parameters	parsley	dill	lovage
color	-0.89	**-0.98**	-0.62
firmness	-0.41	**-0.98**	**-0.98**
succulence	-0.76	**-0.97**	**-0.98**
texture	-0.62	**-0.98**	**-1.00**
taste	-0.53	**-0.96**	**-0.99**
odor	-0.41	-0.87	-0.91
aroma	-0.46	-0.92	**-0.97**
QN	-0.65	**-0.99**	**-0.98**

Note: Values in bold are different from 0 with a significance level α=5%

The quality parameters showed significant positive correlation (*Table 3)*.

Succulence and texture were correlated with color (r_{sc}=0.90, r_{tc}=0.89, $p<0.05$) because the three attributes decrease with storage. The green pigment that confers the color of herbs decreases during storage because they are extremely photosensitive (Cătunescu, G.M. *et al.*, 2012b). This leads to discoloration of leaves as the centrally chelated magnesium atom is replacement by two atoms of hydrogen, producing metal-free pheophytin derivatives (Ferruzzi, M.G. *et al.*, 2001). Chlorophylls is important to the consumer acceptance because a deep green color is associated with freshness of minimal processed herbs (Cătunescu, G.M. *et al.*, 2012b).

The leaves and stems of the herbs lost their texture because of the physiological and microbial degradation of cellulose. The decrease of succulence is attributed to water loss through respiration (Catunescu, G. *et al.*, 2014).

Odor and taste were also significantly positively correlated (r_{ot}=0.97, $p<0.05$). Assessors usually find it difficult to score the two parameters individually because they express the content of aroma compounds. These are very volatile and overflow both mouth and nose (Grosch, W., 2001).

Firmness and texture were correlated with quality numbers (QN) (r_{fQN}=0.95, r_{tQN}=0.90, $p<0.05$). This indicated the consumer importance of an herb with crisp stem and leaves.

Total scores were significantly correlated with all parameters but color and succulence (*Table 3)*.

The use of chemometric methods to characterize and control food quality has become a common practice (Jolliffe, I., 2014). Mathematical approaches of multivariate research datasets allow a simple representation of similarities found among experimental results. PCA is a mathematical data analysis that reduces the spatial size of datasets and allows a simple visualization of the basic structure and correlations of experimental data (Jolliffe, I., 2014).

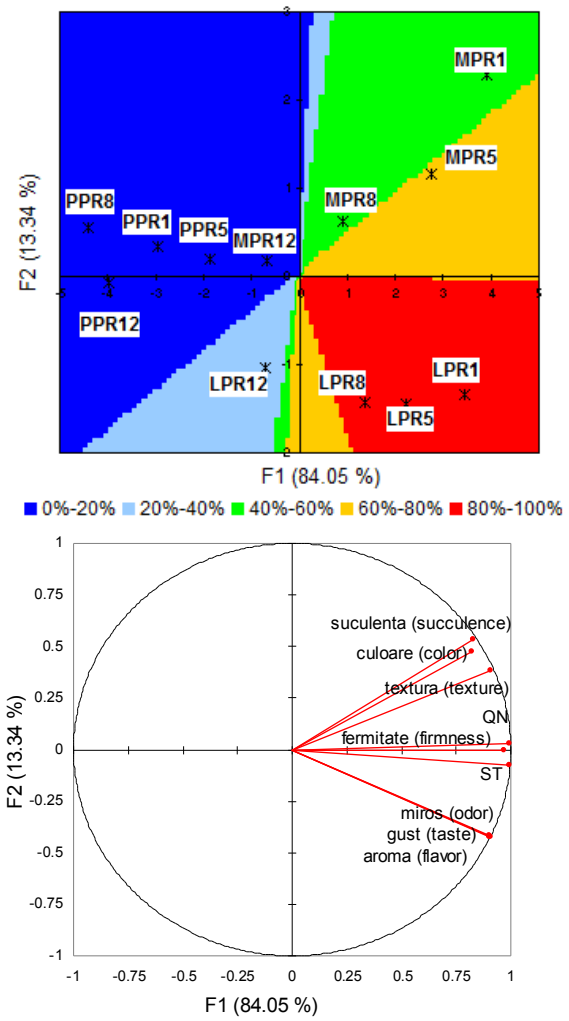
The PCA of sensory parameters of minimal processed parsley, dill and lovage was coupled with cluster analysis and a consumer preference map was generated (*Figure 1)*.

Table 3

Pearson coefficients (r) of sensory parameters

Parameter	Color	Firmness	Succulence	Texture	Taste	Odor	Flavor	QN	ST
Color	**1.00**	-	-	-	-	-	-	-	-
Firmness	0.75	**1.00**	-	-	-	-	-	-	-
Succulence	**0.90**	0.81	**1.00**	-	-	-	-	-	-
Texture	**0.89**	**0.91**	**0.98**	**1.00**	-	-	-	-	-
Taste	0.56	0.86	0.52	0.65	**1.00**	-	-	-	-
Odor	0.53	0.88	0.53	0.66	**0.97**	**1.00**	-	-	-
Flavor	0.55	0.88	0.53	0.66	**0.99**	**0.99**	**1.00**	-	-
QN	0.86	**0.95**	0.83	**0.90**	0.89	0.88	0.89	**1.00**	-
ST	0.80	**0.96**	0.78	0.87	**0.93**	**0.93**	**0.94**	**0.99**	**1.00**

Note: Values in bold are different from 0 with a significance level α=5%



Note: Numbers represent the storage day

Figure 1. **Consumer preference map and PCA of parsley, dill and lovage during storage (PPR = parsley, MPR = dill, LPR = lovage, QN = quality numbers, ST = total scores)**

The two factors explaining the variability of data summed 97.39%. The first factor (F1) was mainly composed of succulence, color, flavor, odor and taste, while the second factor represented quality numbers (QN), total scores (TS) and firmness *(Table 4)*.

All attributes were positively correlated with F1, thus describing the 1st and 2nd quadrant. Flavor, odor and taste were negatively correlated with F2 and positioned in the 2nd quadrant, with all the rest in the 1st.

Dill up to the 8th day of storage were placed in the 1st quadrant because of their high scores for the succulence, color, texture and QN.

Lovage samples up to the same storage day were grouped in the 2nd quadrant, with high scores for firmness, TS, odor, taste and flavor.

Parsley up to the 8th day were positioned in the 4th quadrant together with dill sample from day 12. These samples were characterized by low scores of succulence, color, texture and QN and very low scores for firmness, TS, odor, taste and flavor.

Lovage and parsley samples form the last day of study were located in the 3rd quadrant because they were characterized by very low scores for succulence, color, texture and QN.

The PCA established the sensory profile of the three herbs during cold storage. It was noted that none of the assessors was satisfied with the sensory quality of parsley, 60% were satisfied by dill and all of them preferred lovage samples.

On the 5th and 8th day of storage the results were similar, except that dill satisfied only 80%.

At the end of the 12 days the satisfaction rate decreased to 0% for dill, to 40 % for lovage and to 20% for parsley.

Consumer preferred the flavor among the seven sensory attributes in proportion of 80 to 100% and the texture and color in percentage of only 40-60%.

This distribution of consumer satisfaction can be explained related to the sensory profile of each herb: parsley has a light green color with a delicate aroma, dill is dark green with firm, crunchy stem and juicy leaves, while lovage has a specific pungent aroma.

Dill softened, weathered and yellowed when reaching the end of shelf life. Thus consumers were dissatisfied by its sensory characteristics. Similarly, lovage lost its texture and flavor. Although parsley obtained lower scores for texture, flavor improved, explaining increased satisfaction at the end of the study.

Table 4

Correlation and contribution of variables to sensory analysis PCA

Factor	Color	Firmness	Succulence	Texture	Taste	Odor	Flavor	QN	TS
Pearson correlation with factors, r									
F1	0.82	0.97	0.83	0.91	0.90	0.90	0.91	1.00	1.00
F2	0.48	0.00	0.54	0.39	-0.42	-0.42	-0.42	0.03	-0.08
Contribution to factors, [%]									
F1	8.98	12.47	9.10	10.94	10.72	10.72	10.86	13.10	13.12
F2	18.94	0.00	24.07	12.43	14.43	14.77	14.80	0.06	0.49

CONCLUSIONS

Consumer preferences maps can be successfully used to help in decision making process when dealing with similar products described by a wide range of parameters that influence consumer behavior. In general when buying herbs, the consumer prefers flavor to any other sensory characteristics.

PCA can be applied to determine a sensory profile: parsley has a light green color with a delicate aroma, dill is dark green, firm, crunchy and juicy, and lovage has a specific strong aroma.

PCA can be applied to herbs to evaluate the correlation among quality parameters, and their evolution along storage or during specific treatments.

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