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Integrated evaluation of cowpea (*Vigna unguiculata* (L.) Walp.) and maple pea (*Pisum sativum* var. *arvense* L.) spreads

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Abstract. The aim of this research was to develop pea spreads using local legumes and complete integrated evaluation of the spreads to find the most suitable pea spreads for shelf-life investigation. A total of twelve pea spreads were made of ground re-hydrated cooked seeds of cowpeas (*Vigna unguiculata* (L.) Walp.) or maple peas (*Pisum sativum* var. *arvense* L.), to which salt, citric acid, oil and different spices were added. Standard analytical methods were employed to determine overall preference and physicochemical composition (protein, fibre, ash, pH, etc.) of spread samples. Principles of integrated evaluation were used to select the most suitable spreads for pea spread shelf-life investigation. The overall preference of cowpea and maple pea spread samples ranged from 2.8 to 4.9 with significant differences among spreads ($P < 0.05$). Physicochemical evaluation was completed with only sensory satisfactory samples. There were no significant differences in protein, ash and dry matter content among pea spread samples ($P > 0.05$). Pea spreads were good sources of total dietary fibre (10.72 to 14.81 g 100 g^{-1}). Addition of spices had a significant impact on the lightness (L*) and firmness of pea spreads ($P < 0.05$). Cowpea spread with bruschetta spice (15.43) and maple pea spread with bruschetta spice (22.09) had the lowest integrated evaluation values among spreads from the same legume. It was concluded that shelf-life investigation should be completed with the most suitable spread (the lowest integrated evaluation value) and control sample, i.e., cowpea spread and maple spread with bruschetta spice and without spices.

Key words: cowpea, maple pea, physicochemical evaluation, sensory evaluation.

INTRODUCTION

Problem of sufficient protein supply is very acute for humans around the world as growing population requires more quantities and improved quality of protein. The need for dietary fibre is also rising due to the numerous health benefits, e.g. lower glycaemic index, increased satiation, cancer prevention, reduction in cholesterol levels, prevention or alleviation of constipation, and protection against cardiovascular diseases (Wang et al., 2010); dietary fibre consumption is typically low in the Western pattern diet which positively correlates with an elevated incidence of obesity, death from heart disease, cancer (especially colon cancer), and other Western pattern diet related diseases (McEvoy et al., 2012).

Local legumes growing in Europe – cowpeas (*Vigna unguiculata* (L.) Walp.) and maple peas (*Pisum sativum* var. *arvense* L.) – can be used for innovative product development to satisfy the daily needs for protein and fibre and increase legume

consumption. Hard-to-cook phenomenon, meteorism and time consuming preparation are the main reasons for low legume consumption in Latvia (Kirse & Karklina, 2014). Nutritionally, peas are characterised by high protein content (about 20–30%), a very high proportion of carbohydrate (about 50–65%) and a very low fat content (about 1%). They are a significant source of many nutrients, including fibre, protein and iron, as well as B group vitamins (Mudryj et. al., 2012).

Legumes constitute an important source of dietary protein for large segments of the world's population particularly in those countries in which the consumption of animal protein is limited by non-availability or is self-imposed because of religious or cultural habits (Boye et al., 2010). However, consumption of legumes, which are one of the most reliable sources of good quality protein and dietary fibre, in the Western world remains quite low at less than 3.5 kg per capita per year while in other parts of the world annual legume consumption can range up to 40 kg per capita (Mudryj et. al., 2012). Among European countries, higher legume consumption is observed around the Mediterranean, with per capita daily consumption between 8 and 23 g, while in Northern Europe, the daily consumption is less than 5 g per capita (Bouchenak & Lamri-Senhadji, 2013).

The concept of commercially available legume spreads as an innovative product and an alternative to traditional animal–derived spreads or pates is fairly new, however, as non-dairy and reduced fat/calorie spreads are becoming popular for health conscious people, animal product alternatives have the potential to contribute to overall public health, as well as increasing consumer choice.

Therefore, the aim of this research was to develop pea spreads using local legumes and complete integrated evaluation of the spreads to find the most suitable pea spreads for shelf-life investigation.

MATERIALS AND METHODS

Materials

For legume spread production the following materials were used: maple peas 'Bruno' (*Pisum sativum* var. *arvense* L.), cowpeas 'Fradel' (*Vigna unguiculata* (L.) Walp.), 'Extra virgin' canola oil (Ltd. Iecavnieks, Latvia), citric acid (Ltd. Spilva, Latvia), Himalayan salt (country of origin: Pakistan), onion spice 'Zwimax' (Ing. E. Graf KG, Germany), herb (sun-dried tomato, garlic and basil) spice 'Bruschetta' (P.P.H. fleisch mannschaft®-Polska Sp. z o.o., Poland), bell pepper spice 'Paprika spice mix' (Ing. E. Graf KG, Germany), sesame seeds (Ltd. Gemoss, Latvia), green herbs (fresh dill, dry parsley, dill, spring onions) which consists of 'Herba Fresh DILL' (Fuchs GmbH & Co. KG, Germany) and 'Mieszanka Wiosenna II' (P.P.H. fleisch mannschaft®-Polska Sp. z o.o., Poland).

Preparation of legume spreads

Legume spreads were prepared at the laboratory of Faculty of Food Technology (Latvia University of Agriculture) based on the vegetarian spread preparation technology (Latvian Republic Patent № 14705, 2014).

Maple peas (or cowpeas) were soaked in water (with added $NaHCO_3$, 21.5 g kg^{-1}) at 20 ± 2ºC for 15 h, then rinsed and boiled in a pressure cooker (KMZ, USSR) until tender (about 35 ± 5 min plus 15 min for natural pressure release). Warm cooked peas were then grinded in a food processor (Philips HR 7761/00, Philips, The Netherlands)

together with salt and citric acid, spices were added to the pea paste (if needed); oil was added at the end of mixing in the food processor. Vegetarian pea spreads were packed in 200 ± 5 g polypropylene cups and stored at 3 ± 1°C for 12 h prior to sensory and physicochemical evaluation. For physicochemical analyses where dry product samples were required, pea spreads were dried in a conventional dryer at 45 ± 1°C for 3 h to moisture content 15 ± 2%. Recipes of pea spreads are given in Table 1.

Table 1. Recipes of pea spreads without spices

Ingredients	Cowpea spread	Maple pea spread
Cowpeas, g	940.0	–
Maple peas, g	–	940.0
Oil, ml	60.0	60.0
Salt*, g	3.2	3.2
Citric acid, g	2.0	2.0
Total, g	1004.0 ± 2	1004.0 ± 2

* salt was not added to spreads with dry herbs and paprika spice because these spices already contained salt in respective amounts.

For maple pea and cowpea spread flavour diversification spices in the following amounts were used (g 1000 g^{-1}): onion spice – 21.0 g, bruschetta spice – 8.8 g, paprika spice mix – 33.0 g, roasted sesame seeds – 8.5 g, green herbs – 9.0 g (Herba Fresh DILL) and 4.0 g (Mieszanka Wiosenna II).

Methods

Sensory evaluation of pea spreads was performed during the Baltics food industry fair 'Riga Food 2014' (120 panellists; 62% women and 38% men, average age 35 years) using 5-point hedonic scale (5 – like very much and 1 – dislike very much) in order to determine the overall preference of the samples (ISO 4121:2003). After the sensory evaluation the samples which received higher points were subjected to physicochemical evaluation.

Physicochemical analyses

Physicochemical analyses including nutrients were determined according to standard methods: protein content (AACC 46-11.02), total dietary fibre content (AOAC 985.29), ash content (ISO 2171:2010). pH was determined using ISO 10523:2012, dry matter in pea spreads was calculated as 100% of product minus moisture content (ISO 24557:2009).

Polyphenol content

Total polyphenol content was determined spectrophotometrically using Folin-Ciocalteu reagent according to the method of Akond et al. (2011) using gallic acid as a standard phenolic compound. 0.5 ml extract sample (1 g product in 20 ml acidified (HCl) 70% ethanol and acetone blend) was placed in a test tube and mixed with 2.5 ml Folin-Ciocalteu reagent (Sigma-Aldrich Chemie GmbH, Germany) previously diluted 1:10 with deionized water. Between 1 min and 8 min, 2 ml sodium carbonate solution, prepared by dissolving 75 g in 1 L of deionized water (Sigma-Aldrich Chemie GmbH, Germany) was added to test tube and mixed thoroughly by hand. Then the test tubes with

the mixtures were allowed to stand for 1 h in the dark. Absorbance of the resulting solutions was read at 760 nm using a spectrophotometer (Jenway 6300, Bibby Scientific Limited, UK). Quantification of total phenolics was based on a gallic acid standard curve generated by preparing 0, 5, 10, 15, 20, 30 mg L^{-1} of gallic acid (Sigma-Aldrich Chemie GmbH, Germany) in deionized water. Total phenolics were expressed as mg gallic acid equivalent (GAE) per gram of pea spread using the following formula: gallic acid equivalent (mg g^{-1} GAE) = ('x' Coefficient from gallic acid standard curve x Absorbance at 760 nm + Slope of the gallic acid standard curve) x 40 (dilution factor).

Colour analysis

Colour analysis was performed using *Colour Tec PCM / PSM* with CIE L*a*b* colour system (Accuracy Microsensors Inc., USA). For integrated evaluation only L* value (lightness intensity value at the day of preparation) was taken into account. Measurements were completed in tenfold repetition.

Texture analysis

Texture analysis_– firmness of pea spreads – was performed with *TA.XT. Plus Texture Analyser* applying *Back extrusion* (Stable Micro Systems, UK). Data collection and analysis was carried out with program *Texture EXPONENT 32* using Back Extrusion Cell with a 35 mm disc. Disc movement speed during test mode was 1 mm s^{-1} (forwards) and 5 mm s^{-1} (backwards) with distance of 20 mm.

Pea spread assessment

Principles of integrated evaluation were used for pea spread assessment by a set of features (Martinov, 1987). Integrated evaluation method by a set of specific features is used when different features of samples (e.g., physicochemical composition, sensory features etc.), which are to be compared as a whole, have different measurement scales (e.g., proteins are measured in grams, firmness–in newton, dry matter content–in %). Then each feature is assigned with a contribution coefficient depending on how much of a contribution each feature is (e.g., for legume spreads higher protein and fibre content is important, therefore, these two features have higher contribution coefficients than pH or colour component L*). Integrated evaluation method can be used to assess and reduce the number of samples if the initial sample count is high, in order to limit the costs of time consuming analyses when these analyses will not produce the expected outcome.

As it can be seen in Table 2, the evaluation is completed by analysing the observations made with different measurement scales and assigning each feature group and each individual feature a contribution coefficient.

For example, high contribution coefficients can be given to protein and total dietary fibre content but valuable physicochemical composition is not compatible with low hedonic assessment values considering that no consumer is interested in a product which is sensory unsatisfactory but has a high nutritional value. Therefore it is important to assess each feature by its contribution in the final product, and integrated evaluation indicates the optimal ratio between feature contributions and the final product is both sensory satisfactory and nutritionally valuable.

Table 2. The characteristics of contribution coefficients for the integrated evaluation of pea spreads

No	Group and feature	Contribution coefficient, p_k	Features per group, n_k	Contribution coefficient, ω_i
Chemical composition		0.6	6	2.70
1.	Protein	0.3		4.86
2.	Total dietary fibre	0.25		4.05
3.	Ash	0.1		1.62
4.	Total polyphenols	0.15		2.43
5.	Dry matter	0.1		1.62
6.	pH	0.1		1.62
Physical features		0.15	2	2.03
7.	L* value	0.3		1.22
8.	Firmness	0.7		2.84
Sensory evaluation		0.25	1	6.75
9.	Hedonic evaluation	1		6.75

In this research integrated evaluation was used to find the spreads which would be most suitable for shelf-life investigation. Integrated evaluation was performed after the following formulas:

$$IN = \sum_{i=1}^{N} \omega_i (I_i - x_{vid,i}) / s_i \quad \text{or} \quad IN = \sum_{i=1}^{N} \omega_i \delta_i / s_i , \qquad (1)$$

where: IN – integrated evaluation value of pea spread; I – quantitative feature; I_i – desired value of the feature; $x_{vid,\,I}$ – actual value of the feature characterizing pea spread; ω_i – contribution coefficient of the feature; s_i – standard deviation; δ_i – deviation of the actual value of the feature characterizing pea spread from the desired value; N – number of features.

If $(I_i - x_{vid,\,i})$ or $\delta_i < 0$, then the actual deviation module was used (i.e., the corresponding positive value) (Formula 2):

$$\omega_i = p_k N / n_k \;; \qquad \sum p_k = 1 \quad \text{and} \quad \sum n_k = N , \qquad (2)$$

where: ω_i – contribution coefficient of the feature; p_k – contribution of feature groups; n_k – features per group.

Integrated evaluation value (*IN*) is characterized by the deviation of pea spread assessment values from the optimal values, which results in a lower integrated evaluation value corresponding to the spread, which is most suitable for a particular purpose, in this case, shelf-life investigation of pea spreads.

Initial shelf-life assessment

Shelf-life of freshly prepared spread was evaluated according to Guidelines for the Interpretation of Results of Microbiological Analysis of Some Ready-to-eat foods Sampled at Point of Sale (Gilbert et al., 2000). According to the guidelines, pea spread

is included in savoury group (paté (meat, seafood or vegetable)) which belongs to category 3, and satisfactory microbiological safety is obtained if total plate count for ready to eat pea spread is below 10^5 colony forming units per gram (CFU g^{-1}). Preparation of test samples, initial suspension and decimal dilutions for microbiological examination was carried out according to ISO 6887-1:1999. Total plate count (TPC) was determined according to the standard ISO 4833-1:2014. 90 ml 0.1% peptone water was added to 10 g sample of pea spread in a stomacher bag; then the sample was homogenized with a stomacher *BagMixer400* (Interscience, USA) for 10 seconds. After preparing serial decimal dilutions of the homogenate with 0.1% peptone water, triplicate plates were prepared using pour plate method for enumeration. Total viable counts were determined on Plate Count Agar with incubation at + 30 ± 1 °C for 72 ± 3 h. After the specified period of incubation, colony forming units were counted with automated colony counter *aCOLyte* (Topac Inc., USA).

Software and data processing

The obtained data processing was performed using mathematical and statistical methods with statistical software 'R 3.0.2' and 'Microsoft Office Excel 14.0'; differences among results were analysed using two way analysis of variance and Tukey's test. Each sample was analysed in triplicate (unless stated otherwise), and the results were expressed as mean ± standard deviation. For the interpretation of the results it was assumed that $\alpha = 0.05$ with 95% confidence and differences among results were considered significant if p-value < $\alpha_{0.05}$.

RESULTS AND DISCUSSION

Six pea spreads from each pulse were subjected to hedonic evaluation during the Baltics food industry fair 'Riga Food 2014' (Table 3). The overall preference of cowpea spread samples ranges from 2.8 ('not sure') to 4.6 ('like very much') and there were significant differences among cowpea spreads. Cowpea spreads with roasted sesame seeds (D), dry herbs (E), paprika (F) and cowpea spread without spices (A) were not significantly different among themselves however they were preferred significantly less ($P < 0.05$) than cowpea spread with onions (B) or bruschetta (C).

Table 3. Results of hedonic evaluation of pea spreads

Pea spread samples	Cowpea spread		Maple pea spread	
Control sample–without spices	A	2.9^{a*}	K	4.7^{a}
With onion spice	B	4.4^{b}	L	4.6^{a}
With bruschetta spice	C	4.6^{b}	M	4.9^{a}
With roasted sesame seeds	D	2.8^{a}	N	3.0^{b}
With green herbs	E	2.9^{a}	O	3.1^{b}
With paprika spice	F	3.0^{a}	P	4.8^{a}

* values within a column not sharing a superscript letter are significantly different ($P < 0.05$).

The overall preference of maple pea spread samples were within a similar range– from 3.0 ('not sure') to 4.9 ('like very much'). There were four spread samples that had a higher preference and did not differ significantly among themselves ($P = 0.221$): maple pea spread with onions (L), bruschetta (M), paprika (P) and without spices (K). The preference of samples N and O was significantly lower than of the previously mentioned maple pea samples ($P = 0.013$).

Preference of pea spread samples with bruschetta, onion and paprika spice (in the case of maple pea spread) was given due to more pronounced taste than in other spreads. Spreads with roasted sesame seeds and dry herbs had too mild taste for most panellists' liking. Both spread samples with bruschetta spice were characterised as 'very similar to traditional pate (made of meat)' but spreads with onion spice 'would taste excellent with a glass of kefir'. Spreads with higher hedonic value were said to have 'good consistency'.

The results of hedonic evaluation of pea spreads showed that not all samples should be subjected to physicochemical evaluation because some were sensory unsatisfactory. Further analyses were completed with control samples and highest rated samples: cowpea spreads A, B and C, and maple pea spreads K, L, M and P.

Physicochemical analyses showed significant differences among some pea spread samples (Table 4). Protein content in pea spreads ranged from 7.05 to 7.47 g 100 g^{-1} with no significant differences ($P = 0.071$) among all samples. A previous study on white bean (*Phaseolus vulgaris* L.) spreads showed that protein content was not dependent on spices used (Kirse & Karklina, 2013).

Table 4. Physicochemical composition of pea spreads (I): A, K – control sample (without spices), B, L – with onion spice, C, M – with bruschetta spice, P – with paprika spice

Pea spreads		Protein, g 100 g^{-1}	Total dietary fibre, g 100 g^{-1}	Ash, g 100 g^{-1}	Total phenolics, mg GAE g^{-1}
Cowpea	A	$7.23 \pm 0.06^{a*}$	14.80 ± 0.20^{a}	2.78 ± 0.02^{a}	7.94 ± 0.45^{a}
	B	7.14 ± 0.07^{a}	13.80 ± 0.02^{b}	2.53 ± 0.02^{a}	8.44 ± 0.49^{a}
	C	7.05 ± 0.02^{a}	12.00 ± 0.15^{c}	2.52 ± 0.02^{a}	9.23 ± 0.63^{b}
Maple pea	K	7.47 ± 0.01^{a}	14.81 ± 0.25^{a}	2.94 ± 0.02^{a}	11.67 ± 0.48^{c}
	L	7.42 ± 0.03^{a}	12.69 ± 0.02^{c}	2.90 ± 0.02^{a}	12.33 ± 0.60^{c}
	M	7.38 ± 0.04^{a}	11.98 ± 0.18^{c}	2.92 ± 0.05^{a}	11.64 ± 0.30^{c}
	P	7.16 ± 0.07^{a}	10.72 ± 0.01^{d}	2.91 ± 0.03^{a}	10.82 ± 0.22^{d}

* values within a column not sharing a superscript letter are significantly different ($P < 0.05$).

McCarty et al. (2009) have noted that legume proteins are relatively low in the essential amino acid methionine (as are seeds and nuts), nevertheless, most plant proteins are incomplete and by combining complementary foods from two or more incomplete protein sources, a complete protein can be created. Grains (which are deficient in lysine) are commonly consumed along with legumes to form a complete diet of protein. Legume spreads are supposed to be consumed together with bread or crackers hence avoiding incomplete protein. Legumes are among the best protein sources in the plant kingdom and unlike conventional animal food sources of protein such as beef or milk, legumes are packed with hormone-free, steroid-free and antibiotic-free plant

protein (Papanikolaou & Fulgoni, 2008). Amino acid content will be analysed during legume spread shelf-life investigation to identify imbalance of essential amino acids.

Ash content did not depend on spices used ($P = 0.061$), Filipiak-Florkiewicz et al. (2011) have shown simmilar findings on legume ash content.

Pea spreads were good sources of total dietary fibre (10.72 to 14.81 g 100 g^{-1}). Products can be labelled as a 'source of fibre' (Commission Directive 2008/100/EC; Regulation No 1169/2011) if the product contains ≥ 3.0 g fiber 100 g^{-1}, and 'high in fiber' if the product contains ≥ 6.0 g fiber 100 g^{-1}. According to previously mentioned documents, pea spreads are 'high in fibre' and a serving (100 g) of pea spreads covers over 43% of recommended daily fibre for adolescents (Regulation No 1169/2011) which is 25 g per day (per 2,000 kcal diet). Soluble and insoluble fiber ratio in cooked cowpeas and maple peas is about 1 : 3.2 (Khan et. al., 2007) that corresponds to European Guidelines on cardiovascular disease prevention in clinical practice (Perk et al., 2012); the ratio is maintained in the new pea spreads. Maple pea spread with paprika spice (sample P) has significantly lower total dietary fibre content ($P = 0.012$). To prepare maple pea spread with paprika spice, more of the spice was used (33.0 g per 1,000 g of the spread) compared to other spreads. Paprika spice is liquid (it contains oil) and therefore practically does no contribute to total dietary fibre content, but, in fact, slightly lowers it (as the amount of legume is reduced in 1,000 g of spread).

Khan et al. (2007) have shown that total dietary fibre content in cowpeas and maple peas is 18.2 and 13.4 g 100 g^{-1} (dry weight) which is less than in pea spreads. This can be due to changing climatic conditions, legume-growing region, harvesting time and legume storage conditions, as increased soil drought contributes to the increase in fiber content of legumes, and legume seed coat may account to over 10.2–19.6% of the legume seed mass (Gupta, 2011).

Siddhuraju & Becker (2007) have determined that total phenols in different varieties of cowpea (autoclaved after soaking) range from 6.45 to 9.53 mg GAE g^{-1} which correspond to total polyphenol content in cowpea spreads. However, our values for total phenolic content are significantly different to those reported by Zia-Ul-Haq et al. (2013), as total phenolic content in cowpea cultivars commonly consumed in Pakistan ranged from 11.90 to 19.32 mg GAE g^{-1}. Nithiyanantham et al. (2012) have shown that total phenolics in field pea seeds autoclaved after soaking ranged from 12.45 to 24.70 mg GAE g^{-1} which is simmilar but higher than total polyphenol content in maple pea spreads. The loss of phenolic compounds could be attributed to water-soluble phenolics leaching into soaking and cooking water. According to Amarowicz et al. (2004), the total phenolic content is directly associated with antioxidant activity; the binding between phenolics and the protein matrix might account for the enhancement of antioxidant capacity in peas because a phenolic–protein interaction is able to stabilize the protein and its antioxidant capacity is increased during heating (Tsai & She, 2006). During shelf-life investigation antioxidant activity will be determined.

The measurements with CIE L*a*b* colour system showed that cowpea spreads were lighter than maple pea spreads and addition of spices had a significant impact on the lightness (L*) of pea spreads ($P = 0.010$); samples without spices were lighter than pea spreads with spices (Table 5).

Table 5. Physicochemical composition of pea spreads (II): A, K – control sample (without spices), B, L – with onion spice, C, M – with bruschetta spice, P – with paprika spice

Pea spreads		L* value	pH	Dry matter, %	Firmness, N
Cowpea	A	60.72 ± 0.31^{a}*	5.90 ± 0.02^{a}	33.00 ± 0.05^{ab}	8.50 ± 0.02^{a}
	B	60.63 ± 0.81^{a}	5.80 ± 0.03^{a}	35.10 ± 0.05^{ab}	12.25 ± 0.03^{bd}
	C	58.89 ± 0.49^{b}	5.83 ± 0.03^{a}	33.00 ± 0.04^{ab}	11.76 ± 0.03^{b}
Maple pea	K	57.46 ± 1.01^{b}	5.91 ± 0.03^{a}	33.50 ± 0.05^{ab}	9.72 ± 0.03^{a}
	L	51.27 ± 1.42^{c}	5.81 ± 0.02^{a}	33.40 ± 0.03^{ab}	14.02 ± 0.05^{c}
	M	51.84 ± 1.51^{c}	5.83 ± 0.01^{a}	34.00 ± 0.03^{ab}	13.46 ± 0.04^{cd}
	P	50.38 ± 0.94^{d}	5.42 ± 0.02^{b}	32.30 ± 0.04^{a}	9.50 ± 0.03^{a}

* values within a column not sharing a superscript letter are significantly different ($P < 0.05$).

pH of maple pea spread with paprika spice was significantly lower than pH of other samples ($P = 0.023$) because lemon juice and vinegar are components of paprika spice mix. Dry matter content is similar in all pea spreads. Firmness of pea spreads ranged from 8.50 to 14.02 N and was influenced by the addition of spices ($P = 0.006$), more force was needed to compress samples with solid spices. Paprika spice mix is liquid; therefore less force was needed to compress the sample compared with maple pea spread without spices.

In order to determine the suitability of pea spreads for shelf-life investigation, many factors were assessed and high contrubution coefficients (ω_i) were given to protein content (g), total dietary fibre (g), total phenolics (mg), firmness (N) and hedonic evaluation, lower contrubution coefficients were given to ash content (mg), dry matter content (%), pH and L* value.

The integrated evaluation shows that both cowpea spread with bruschetta spice (Fig. 1) and maple pea spread with bruschetta spice (Fig. 2) have lower integrated value and are most suitable for pea spread shelf-life investigation.

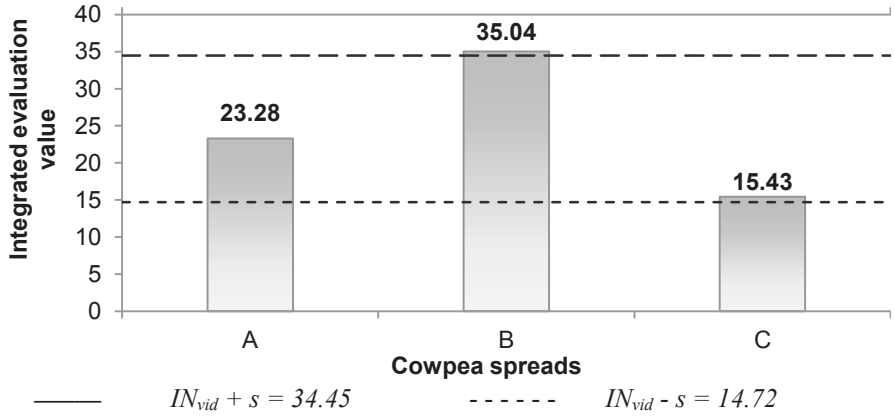

Figure 1. Cowpea spread suitability for shelf shelf-life investigation: A – control sample without spices, B – with onion spice, C – with bruschetta spice.

Shelf-life investigation should be completed with the most suitable spread and control sample, i.e., cowpea spread without spices (A) and with bruschetta spice (C). The integrated evaluation value of maple pea spread without spices (K) and with bruschetta spice (M) are not significantly different ($P > 0.05$). Both spreads should be subjected to shelf-life investigation as well. In pea spreads with lower integrated values there is a better balance between sensory and nutritional parameters thus suggesting these spreads have the potential to be produced for consumer consumption after shelf-life investigation.

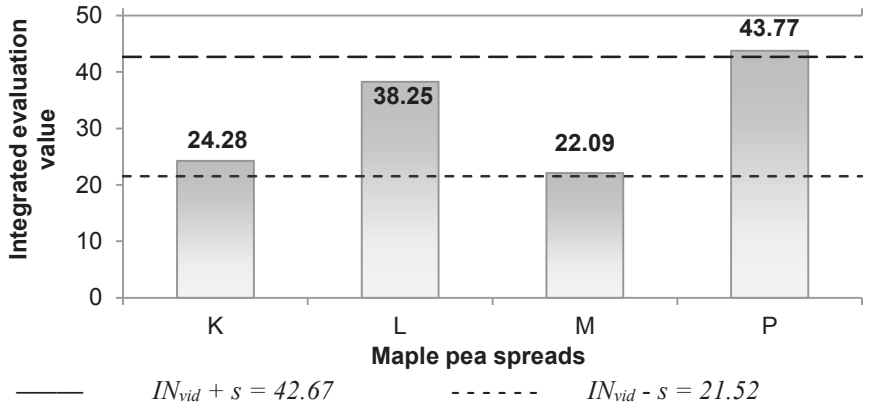

Figure 2. Maple pea spread suitability for shelf shelf-life investigation: K – control sample without spices, L – with onion spice, M – with bruschetta spice, P – with paprika spice.

Initial shelf-life testing was performed with maple pea spread with bruschetta spice as it was suggested for shelf-life investigation. Total plate count in freshly made maple pea spread with bruschetta spice was 4.11 log CFU g^{-1} and reached the critical 5.00 log CFU g^{-1} after less than six days of storage at refrigerator temperature (Fig. 3). This short term storage would not allow any manufacturer to expand the trade in further regions of Latvia or export this product.

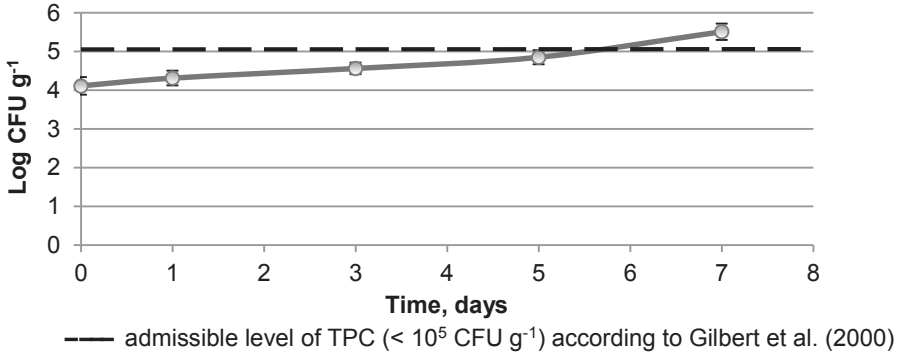

Figure 3. Total plate count (log CFU g^{-1}) dynamics in maple pea spread with bruschetta spice during storage at +4.0 ± 0.5 °C temperature.

Heat treatment and appropriate packaging solutions must be selected to extend pea spread shelf-life, thus reducing the total number of micro-organisms and avoiding accelerated deterioration of the product.

CONCLUSIONS

Total dietary fibre, total polyphenols, colour and firmness of pea spreads depend on spices used ($P < 0.05$), while protein, ash and dry matter content is not significantly different among pea spreads.

The integrated evaluation of new legume spreads shows that both cowpea spread with bruschetta spice and maple spread with bruschetta spice had the lowest integrated evaluation values and are most suitable spreads for shelf life investigation.

Shelf-life of maple pea spread with bruschetta spice is five days; heat treatment and appropriate packaging solutions must be considered.

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