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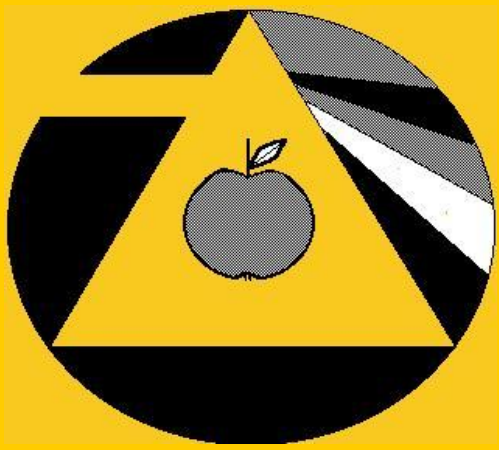

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EDITORIAL

This is the XXX Volume of the Journal of Food Physics, and as You know the first issue was published in 1988, almost 3 decades ago. Many thanks for your kind help, cooperation, support and understanding also the problems, during this period of not too easy existence.

We are sure, that also this issue gives the opportunity for the readers to get interesting and useful information about some special questions of our loved and respected subsidence, food physics. The topics of the scientific articles in this issue cover the following fields:

- enhancement of functional properties of noodles
- quality assessment of sausages using machine vision
- drying characteristic of black carrot pulp in microwave oven
- liquid food density
- thermal characteristics of cheeses
- teaching of physics with help of food measurements

Some of the papers were reported as lectures at the ISFP Debrecen Conference, 2016. As You probably know or remember the first conference we organized in Budapest, Hungary, 1994, followed by the second one in Bucharest, Romania, 1996. The place of the third meeting was Poland, Lublin, 1998, and in 2000 we met in Turkey, Istanbul. Later we decided to organize the conference in Brno, Czech Republic, 2002, and 2 years later, in 2004 we came back again to Hungary, but the place was Pecs. The 2006 meeting we had in Serbia, in a beautiful small town, Senta, and the next one in Plovdiv, Bulgaria, 2008. The place of the 2010 conference was Nitra, Slovakia, then in 2012 Budapest, and again in Plovdiv, 2014.

After Debrecen, we will be really happy to have the possibility to continue the organisation of the ISFP conferences, the next conference will be organized in Turkey, 2018, in Antalya at the sea-side. Please do not miss the opportunity and come to Turkey in 2018!

Dear Colleagues! Read and enjoy this issue! And please - if You can -support the Food Physics Public Utility Foundation! We need help and donations for existence.

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Andras S. Szabo
editor-in-chief

J. Food Physics, 2017, Vol.30, pp.1-3.

Enhancement of the Functional Properties of Home-Made Style Turkish Noodles (Erişte) with the Addition of Fresh Mints.

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Abstract. The primary focus of this study is the assessment of the benefits of fortified noodle products by the addition of mint to improve their functional properties. Therefore, the addition of mint in different amounts (2, 4, 6 and 8% weight:weight (w:w)) to the dough of the noodles was tried and the dough formulations were analyzed to maximise the effect of the mint without compromising appearance and consistency of the dough and to achieve a rich green colour for attractiveness of the finished product. Physical properties (moisture content, water activity and colour) and chemical composition (vitamin C, chlorophyll, total carotenoid and protein content analysis) of the plain and enriched dough and the noodles were determined. Cooking tests have also been implemented for a comparison between the samples for water absorption, swelling volume and cooking loss as well as a sensory analysis. The results showed that the addition of fresh mint beyond 4% caused a significant increase in the moisture content of the noodles compared to plain noodle ($P<0.05$). The water activity of plain dough and noodle were found to be as 0.99±0.03 and 0.59±0.09, respectively. The protein content of dough and "Enriched Turkish Noodle (ETN)" ranged between 15.00 - 16.77 and 16.45 - 19.43% (db), respectively. The water absorption and the total volume increase of all the samples for traditional and microwave cooking test ranged between 36.55 - 42.40g and 265.00 - 307.5%, and 33.23 - 39.06g and 235.00 - 257.50%, respectively. According to results of the sensorial analysis, the noodles containing 4% mint have the highest acceptability compared to both the plain and the other samples.

Keywords:

Turkish Noodles,
Mint,
Cooking Test,
Sensory Analysis

INTRODUCTION

Turkish Noodle (Erişte) is a staple traditional dish in the Turkish cuisine and generally made out of wheat flour, egg, salt and vegetable oil (Aktaş et al., 2014). The process of Turkish noodle production covers the dough preparation, the pre-drying, the cutting and drying as the final stage. Specific parameters of these steps may vary between the recipes throughout Turkey (Akillioglu and Yalcin, 2010). The matrix of wheat flour dough contains gluten as the continuous component and starch as the filler particles which make up

the main rheological properties of a wheat-based noodle product (Edwards et al., 2002). Egg can act to improve the handling of dough while preparing and also helps with the elasticity of the cooked product and guarantees a cohesive mass achieved by denaturation (Alamprese et al., 2005). Besides those two main ingredients, oil and salt can be added for further improvement of consistency and flavour. Although noodle products are rich in carbohydrates, they are lack of protein, fibre, vitamins or antioxidants. By the addition of vegetables or herbs to the noodle formulation the beneficial constituents such as fibres, minerals and vitamins of noodles can be increased. Health-enhancing characteristics may come from a wide variety of plant sources which provide important components when used in food systems (Lebesi & Tzia, 2011). Mint has high amount of vitamins (vitamin C and E), minerals, dietary fibre, and other nutrients such as phenolic components which contribute to antioxidant capacity (Pietta, 1997, Kähkönen et al., 1999). The production of pasta enriched with vegetables can increase the vegetable intake and vegetables can be a very good carrier of healthy compounds: dried pasta is a very good matrix to stabilize phytochemicals that otherwise, in fresh vegetables, are easily degraded during storage, transportation etc. (Jin et al., 2014).

The aims of this study were; to fortify noodles by the addition of minced mint (2, 4, 6 and 8% weight/weight) to dough formulation to improve their functional properties, to determine the effect of addition of mint on physical properties (moisture content, water activity and colour) and chemical composition (vitamin C, chlorophyll, total carotenoid and protein content analysis) of the plain and enriched dough and the noodles, to determine the cooking characteristics and to indicate consumer preferences of ETN with mint.

MATERIAL AND METHODS

Materials

Fresh mints, wheat flour (Sinangil Gıda San. ve Tic. A.Ş.), sunflower oil (Küçükbay Gıda San. ve Tic. A.Ş.,), eggs (Keskinoğlu Gıda San. ve Tic. A.Ş.,) and table salt (Billur tuz San. A.Ş.) were obtained from a local supermarket in Izmir, Turkey.

Methods

Preparation of Enriched Turkish Noodle

The plain dough was prepared with the formulation given in Table 1. In order to obtain ETN, the mints were cleaned, stalks were removed and leaves were grinded in a blender (Tefal Smart, MB450141, Turkey). All the dough formulations were prepared on the basis of plain dough with additional amount of mint in the percentages of 2, 4, 6 and 8%, respectively (w:w). All ingredients were mixed in a bowl and kneaded by hand in order to obtain homogenous dough. Then, the dough was flattened and brought into a regular shape at the same thickness with a pasta making machine (Fackelmann, Germany). The pieces of flattened dough were pre-dried in the oven (Siemens, Germany) for 10 minutes at 60°C (low temperature drying (Oliviero & Fogliano, 2016)). Then flattened dough was cut by the pasta making machine into long stripes with a width of 0.65cm. The shape of completed Turkish noodle was achieved by cutting the long stripes into 4cm pieces.

Final drying was performed in the oven for 90 minutes at 60°C. The obtained noodles were stored in small plastic bags at room temperature for further use.

Table 1: Standard dough formulation

Ingredient	Amount (g, dry basis)
Flour	63.9
Egg	35
Oil	1.0
Table Salt	0.1

Physical Analysis

The moisture content of the dough and the ETN were determined according to AOAC, 2000. The water activity of samples was measured by using Testo-AG 400, Germany water activity measurement device. The colour values (L*, a*, and b*) of samples were measured with a Minolta CR-400 Colorimeter, Japan and results were expressed in accordance with the CIE Lab system.

Chemical Analysis

The vitamin C content of dough and the Turkish noodles were determined according to Hısıl (2007). The method of Ferna´ndez-Leo´n et al. 2010 was applied to samples in order to determine the chlorophyll content of samples. The total carotenoid content of samples was determined according to the modified form of Lee and Castle, 2001 method. Protein content of samples was determined by using Leco FP-528, USA protein/ nitrogen determinator as percentage (%) of the total amount of sample.

Tests Cooking

Two different cooking tests were applied to samples. Traditional cooking was performed in a water bath at 100°C in a beaker (250ml). For this purpose, 25g noodle was added to boiling water in the beaker and boiled for 20min. A similar setup was used for microwave cooking at 720 Watt for 10 minutes. The total water absorption was determined by weighing of the sample before and after cooking (Yalçin & Basman, 2008). The total swelling volume is the percentage of increase in volume of a 25g sample after cooking. The swelling was determined by observing the increase of volume in 250ml water in the granulated cylinder after adding the samples (Yalçin & Basman, 2008). The total soluble solid content (TSSC) of the cooking water was analysed by using a refractometer (FG-103 - Chincan, China) measuring the index of refraction in degrees Brix (°Bx).

Sensory Analysis

Hedonic sensory tests were conducted by semi-trained 10 panellists among students of the Department of Food Engineering (Ege University, Izmir, Turkey). The sensory test included the attributes such as colour, texture, odour, flavour, and overall acceptability which were to rate on a five-points hedonic scales from 1 (poor) to 5 (excellent). The panellists were not informed by the amount of addition of mint to the dough formulation prior to sensory evaluation.

Statistical Analysis

The data were analyzed using statistical software SPSS 16.0 (SPSS Inc., USA). The data were also subjected to an analysis of variance (ANOVA) and

Duncan's multiple range test (α= 0.05) was used to determine the difference between means. The preparation steps were replicated twice and all the analyses were triplicated.

RESULTS AND DISCUSSION

Results of Physical Analysis

The ETN samples were prepared according to the formulation of the plain Turkish noodle and enriched with mint as can be seen in Figure 1**.** The moisture content and water activity values of the samples were given in the Table 2. The moisture content of mint, plain dough and plain Turkish Noodle were found to be as 86.45±1.02%, 31.43±1.02% and 9.69±0.92% (wb), respectively. The moisture content of plain Turkish noodles and fortified spaghetti with parsley leaves were reported as 8.66±0.50% (Aktaş et al., 2014) and 12% (Sęczyk et al., 2015) which are in the same range with this study. In addition, Fu, 2008 reported that the final moisture content of dried noodles is usually less than 14%. Due to the low moisture content, noodles have a long shelf life, up to 1–2 years (Fu, 2008). The addition of mint beyond 4% caused a significant increase in the moisture content of Turkish noodles compared to the plain sample ($P<0.05$). The water activity of the plain dough and plain Turkish Noodle were found to be as 0.99±0.03 and 0.53±0.09, respectively. According to results, it can be seen that the amount of addition of fresh mint did not cause a significant increase in the moisture content and water activity values of dough and ETN ($P>0.05$). The water activity values of all ETN were found to be significantly higher than the plain Turkish noodle ($P<0.05$). It can be due to high water activity values of mint (0.99±0.03).

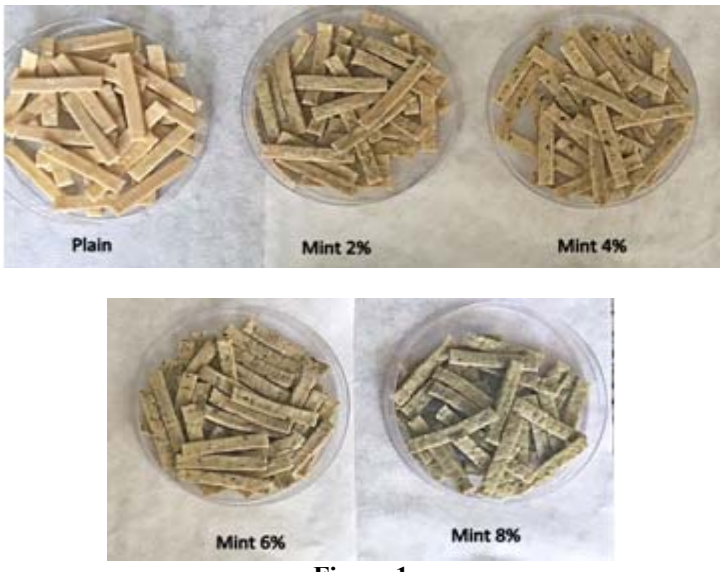

Figure 1
Enriched Turkish Noodles

Table 2: Moisture content (wet basis, wb) and water activity of the dough and ETN

Analysis	Concentration [%]	Dough	ETN
Moisture Content (wet basis, (wb)%)	2	31.73±1.44[a]	9.15±0.37[a]
	4	34.56±1.52[a]	10.51 ±0.12[a]
	6	34.21±2.56[a]	11.61±3.01[a]
	8	34.85±1.41[a]	10.43±0.33[a]
Water Activity	2	0.99±0.03[a]	0.55±0.05[a]
	4	0.99±0.03[a]	0.57±0.10[a]
	6	0.99±0.03[a]	0.66±0.24[a]
	8	0.99±0.03[a]	0.60±0.09[a]

Different letters in the column show significant difference in the column (P<0.05)

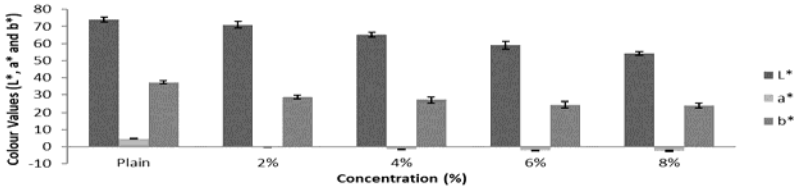

Figure 2
Colour Values (L*, a*, and b*) of dough

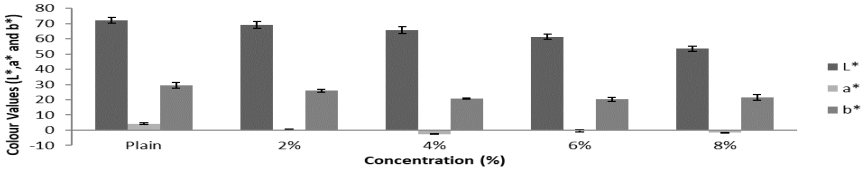

Figure 3
Colour Values (L*, a*, and b*) of Enriched Turkish Noodles

Colour is an important quality factor which affects visual attraction to consumers. It is expected by the Turkish consumers that the traditionally produced Turkish noodles should have golden colour. However, the noodles which have different colour due to different kind of fortification such as tomato, carrot etc. are also finding space in the markets. The colour values of the samples were given in the Figures 2 and 3. The colour values (L*, a*, and b*) decreased depending on the increase of mint concentration due to the colour values of mint (L*=21.44±0.46, a*=-7.04±0.71). The wheat flour (L*=94.51, a*=−0.77, and b*=9.59) which is the main ingredient of Turkish noodles have higher L* and a* values. For this reason, increasing the mint concentration resulted in a significant decrease in the brightness (L*) and greenness/redness (a*) values of dough (P<0.05). The amount of

fresh mint addition beyond 4% did not cause a significant decrease in the blueness/yellowness (b*) values of dough (P>0.05). Drying processes caused a significant decrease in the colour values of ETN (P<0.05). The degradation of chlorophyll or browning reactions may be related to pigment destruction and may caused the colour loss (L* and a*). Similarly, the brightness values of ETN significantly decreased according to increasing mint concentration (P<0.05).

The Results of the Chemical Analysis

The vitamin C (mg/ 100gram, dry basis (db)), total chlorophyll (ppm, db), total carotenoid (ppm, db) and protein contents (%, db) of the samples were given in Table 3**.** The Vitamin C content of fresh mint was found to be as 216.36±12.45 mg/ 100g (db). The results showed that increasing the mint concentration resulted in a significant increase in the vitamin C content of dough and ETN (P<0.05). Drying processes caused a significant decrease in the vitamin C content of ETN (P<0.05). Exposure to heat, light, oxygen, and metals may also lead to vitamin C losses, therefore the losses of vitamin C can not only be due to the drying processes, but also by the operations before and after drying such as kneading, cutting etc. Considering the plain dough and plain Turkish noodle where the vitamin C content was undetectable, vitamin C contents of the dough and ETN were improved with the addition of mint. Although the aim of this study was to improve the formulation of the Turkish noodles and to increase the attractiveness of them for the consumers, the increase in vitamin C content of noodles represents an important achievement. Van Boekel et al., 2010 reported that the drying and cooking temperatures can influence the losses of heat sensitive phytochemicals such as vitamin C which is well known to be degraded upon thermal treatments. Thus both drying and cooking can reduce the vitamin C concentration in the final product.

The total chlorophyll content of the plain dough and Turkish Noodle was found to be as 158.20±19.27 and 127.90±15.02 ppm (db), respectively. The results showed that an increase in the mint concentration caused a significant increase in chlorophyll content of both the dough and ETN (P<0.05). Drying processes caused a significant decrease in the chlorophyll content of Turkish noodle (P<0.05). The loss of chlorophyll content was found to be around 81%. It might be due to heat effect on the chlorophyll destruction. Since, chlorophyll is sensitive to heat and its retention is affected by temperature and duration of heat treatment (Naidu et al., 2012).

The carotenoid content of dough and ETN increased depending on increasing mint concentration (P<0.05). On the other hand, the drying processes during the preparation caused a significant decrease in the carotenoid content of ETN (P<0.05). Carotenoids are sensitive to heat, oxygen, light, and enzymes. Preparing the Turkish noodle process includes flattening, pre-drying, cutting and final drying stages. During these applications, the dough was exposed to heat, oxygen and light. It might be the reason of the loss of carotenoid. Van Boekel et al., 2010 reported that both drying and cooking can also have the opposite effect enhancing the bioaccessibility of some phytochemicals such as β-carotene. In a study conducted by Oliviero & Fogliano, 2016 who added the freeze dried carrot powder to the pasta formulation at different concentrations (10, 20 and 30%), it was observed that

drying (at 100 °C for 3 h) reduced β-carotene content of pasta around 24-35% due to isomerization of β- carotene during exposure to heat. However, boiling process did not affect β- carotene content. β- carotene content in the fresh-cooked pasta was found to be higher compared to dried-cooked pasta. This can be related to an initial higher content of fresh pasta, a shorter boiling time, and the wet conditions that prevent carotenoids isomerization.

The protein content of the plain dough and Turkish Noodle was found to be as 15.19±0.02% and 19.50±0.13% (db), respectively. The protein content of Turkish noodles was found to be as 15.84±0.13% (Aktas et al., 2014), 14.29±4.2 (Yalçin & Basman, 2008) and 13.2±0.28 (Bilgicli, 2009) which is consistent with this study. No significant differences were observed in the protein content of dough (P>0.05).

Table 3: Chemical Composition of Dough and Enriched Turkish Noodles

Analysis	Concentration [%]	Dough	ETN
Vitamin C Content (mg/ 100g, db)	2	45.81±2.15[a]	-
	4	47.62±3.43[a]	-
	6	77.11±3.21[b]	23.62±1.26[a]
	8	119.00±5.34[c]	25.94±2.13[a]
Total Chlorophyll Content (ppm, db)	2	352.70±23.23[a]	83.45±17.34[a]
	4	523.81±31.20[b]	98.84±25.45[b]
	6	811.29±37.65[c]	134.36±16.98[c]
	8	991.86±43.65[d]	173.84±34.76[d]
Total Carotenoid Content (ppm, db)	2	96.03±12.23[a]	50.29±7.56[a]
	4	184.89±17.54[c]	100.49±14.32[c]
	6	149.65±23.21[b]	70.42±20.12[b]
	8	285.73±21.34[c]	149.61±15.21[d]
Protein Content (%, db)	2	15.87±0.06[a]	16.45±0.09[a]
	4	16.04±0.12[a]	17.00±0.20[a]
	6	15.00±0.85[a]	19.43±0.18[b]
	8	16.77±0.35[a]	17.00±0.08[a]

[a -d] shows significant difference in the column (P<0.05)

Results of the Cooking Tests

Boiling is a simple process but being very critical in terms of noodle quality. The key factors for boiling are ratio of noodle to water (1:10-20 w:w), boiling time, and quality of boiling water (Fu, 2008). In this study, the ratio of noodles to water was chosen as 1:10 w:w. The results of traditional and microwave cooking tests of samples were given in Table 4. The determination of these characteristics gives an important overview in cooking behaviour of the noodles and describes the increase in weight and volume as well as the loss of solids while cooking. Cooking time of noodles was determined by sensory evaluation (taste and texture). Decrease in cooking time of the noodle samples cooked at 720W power was found to be as 50% compared to traditionally cooked samples. By using microwave cooking time, energy and cost might be reduced. Pilli et al. (2009) also reported that the microwave energy caused reduction in cooking time of pasta samples as compared to conventional cooking. Recently, with changes in our lifestyles, reduction of cooking time is desired because it takes a relatively long time for water outside the noodle to migrate into dried and ungelatinized center of the noodle. According to the results of the cooking tests, it can be said that traditionally cooked samples have significantly higher water absorption and swelling volume values than microwave cooked samples ($P<0.05$). Bilgicli, 2015 reported that the water uptake and volume increase values of noodles which includes different amount of buck wheat flour ranged between 237-248% and between 285-298%, respectively. The increase in the mint concentration caused a significant increase in the total soluble solid content of boiling water ($P<0.05$). Keeping cooking loss to a low level in the boiling process is extremely important. Formation of a sufficient and uniform gluten matrix in the sheeting process is necessary for low cooking losses. (Fu, 2008). The reason of higher total soluble solid loss in microwave boiling may be due to destruction of cells or starch damage under the microwave energy as Izydorczyk et al. (2005) reported that cooking losses are attributed to the weakening and/or disruption of the protein-starch matrix. In this study, the increase of cooking loss could be due to a disruption of the protein-starch matrix. In addition, total soluble solid content of cooking water during cooking is due to loss of soluble components in the noodle (Fu 2008, Sun-Waterhouse et al. 2013). TSSC of boiling water of ETN increased depending on the increase of mint concentration.

Results of Sensory Evaluation

Consumer research is one of the key applications for companies in order to take product decisions, such as the development and marketing of new products, the reformulation of existing products, the acceptance of suppliers and processes, and the establishment of quality control specifications. The results of the sensory analysis were given in Figure 4 where the scores of the samples of ETN with 4% mint addition were found to be favourable samples in terms of colour, flavour, and overall acceptability ratings.

Table 4: Results of the cooking test of Enriched Turkish Noodle

Type of Cooking	Concentration [%]	Water absorption [g]	Swelling volume [%]	TSSC [°Bx]
Traditional Cooking	Plain	38.90 ± 3.22^{ay}	267.50 ± 3.54^{ax}	0.00 ± 0.00^{ax}
	2	41.83 ± 6.56^{ax}	307.50 ± 3.54^{ay}	0.20 ± 0.00^{bx}
	4	42.40 ± 1.35^{ay}	265.00 ± 21.21^{ax}	0.20 ± 0.00^{bx}
	6	36.55 ± 7.26^{ax}	265.00 ± 21.21^{ax}	0.25 ± 0.07^{bx}
	8	36.77 ± 0.26^{ax}	275.00 ± 28.28^{ay}	0.40 ± 0.00^{cx}
Microwave Cooking	Plain	34.77 ± 10.38^{ax}	245.00 ± 42.43^{ax}	0.00 ± 0.00^{ax}
	2	39.06 ± 9.61^{ax}	257.50 ± 24.75^{ax}	0.20 ± 0.00^{bx}
	4	33.23 ± 0.67^{ax}	235.00 ± 21.32^{ax}	0.20 ± 0.00^{bx}
	6	36.17 ± 3.45^{ax}	245.00 ± 7.07^{ax}	0.40 ± 0.00^{cy}
	8	37.81 ± 5.96^{ax}	257.50 ± 10.61^{ax}	0.50 ± 0.14^{cy}

$^{a\text{-}d}$ shows significant difference in the samples according to concentration of mint ($P<0.05$).
$^{x\text{-}y}$ shows significant difference in the samples according to cooking tests ($P<0.05$).

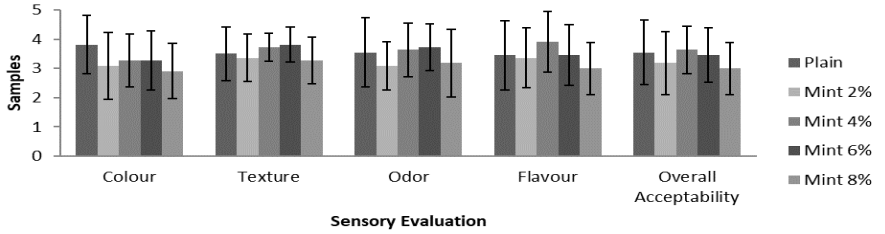

Figure 4
Sensory ratings for all samples.

CONCLUSION

The addition of the fresh mint to the Turkish Noodles did not significantly affect the moisture content, water activity values and protein content ($P>0.05$). On the other hand, colour values of the dough and ETN significantly decreased depending on the increase of mint concentration ($P<0.05$). Results of the chemical analysis showed that vitamin C, total chlorophyll and total carotene content increased depending on increasing of the mint concentration ($P<0.05$). The results for the cooking test showed that the traditionally cooked ETN have higher water absorption and swelling volume than microwave cooked ETN ($P<0.05$). Turkish noodles with 4% mint were found to be the favourable samples in terms of flavour, and overall acceptability ratings.

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Quality Assessment of Bologna Sausages Using Machine Vision

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Abstract. Non-destructive methods, such as digital image processing, play important role in the quality assessment since all members of the supply chain can check any product delivered. A simple, low cost and portable machine vision system was used in the presented study to estimate quantity of ingredients of Bologna sausages (also known as Lyoner). Five types of tested sliced sausages differ in ingredients: pork sausage with cheese, cucumber, pepper, mushroom and turkey sausage with cheese. Samples were collected from retail store. Ten slices were measured on both sides, therefore 20 images were acquired by sample groups. Pictures were preprocessed using linear or quadratic normalization depending on the contrast. Segmentation was performed using manually selected training samples and cluster analysis. Based on the surface area of segmented clusters and density data, ratio of ingredients were estimated in m/m % and results were compared to the label. The error of estimation was in the range of 0.22 – 5.49 m/m % where the smallest error was observed for ingredient of cheese and the largest for cucumber. Coefficient of variation was similar for all products. The proposed method needs further improvement but already obtained promising results.

Keywords:

digital image processing,
cluster analysis,
salami, cold cuts, Lyoner

INTRODUCTION

Meat is essential component of human nutrition. Depending on its source and quality, the typical protein and fat content vary in wide range, in 15-23% and 2-37%, respectively (Szabó, 2006). Meat protein is important due to its essential amino acids. Fat content contributes to the texture and sensory value of meat (Corbin et al., 2015; Ventanas et al., 2010). Especially in beef, the fat structure called marbling is investigated. Marbling affects significantly palatability, tenderness, juiciness and flavour of beef. The tissue of meat is also rich in minerals, such as Na, K, Ca, Mg, Fe and Zn. The vitamin content primarily means vitamin B, small amount of vitamin A and C can be found as well (Szabó, 2006). The meat consumption in Hungary is balanced between pork and poultry. The annual consumption per capita in 2015 was 27.5 kg of pork and 28.8 kg of poultry (KSH, 2017). Among meat products, Bologna type cooked sausages are very popular. Food industry continuously develops products for better nutritional value, longer consumption period, impressive appearance and better taste. Low fat Bologna sausage can be produced using pork skin and green banana flour gel as fat replacement. It was observed that

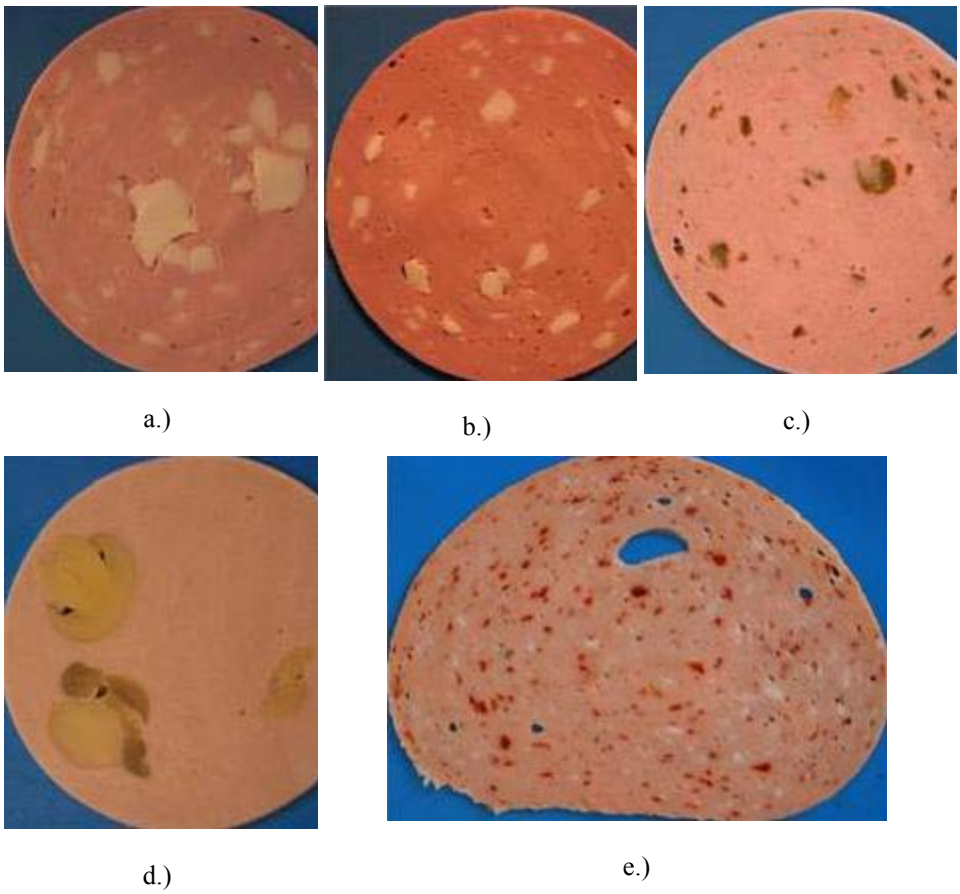
product color and texture did not change significantly with 60% portion of replacement gel (Agostinho dos Santos Alves et al., 2016). The gel also improved cooking loss and emulsion stability, while sensory quality was acceptable above 60% as well. Jongberg et al. (2013) found plant extracts helpful in prevention of oxidative protein modifications, except thiols. Green tea and rosemary extracts were added to raw materials of sausages. Additionally, lipid oxidation was inhibited by extracts and protein carbonyl formation changed positively. New additives used in sausages change their physical attributes, such as colour and density. This effect has to be considered in their optical recognition and quantity estimation.

Application of machine vision systems in food industry first focused on perishable produces using colour, surface pattern and shape features (Baranyai & Szepes, 2002). Quality assessment and monitoring of raw materials was found to be successful. Image processing technology is today part of the quality monitoring in several areas from fruits and vegetables such as strawberry, cereals and potato, to complex foods such as seafood, bakery products and pizza (Sun, 2008). These methods mainly rely on segmentation of macroscopic compounds or estimation using derived indices. The interaction of light and biological tissue was observed to change during ripening of horticultural produces and also depend on chemical compounds and physical state. The pattern of laser light migration in tissue was able to distinguish certain commercial grades of kiwifruit (Baranyai & Zude, 2008) and follow changes of products during postharvest and processing (Baranyai, 2011). The cutting-edge technology of hyperspectral imaging is able to estimate compounds according to their spectral response and provide information on spatial distribution. Moisture loss and drying pattern was observed on carrot slices using hyperspectral imaging system (Firtha, 2009; Kaszab et al., 2008). Regarding macroscopic components, fat and meat ratio and their structure, called marbling, was evaluated with this method (Felföldi et al., 2013). Provided that compounds are clearly visible and algorithms are able to recognize them by colour or pattern, there is no need for chemical information extracted from spectra. Colour imaging might be suitable for such food products.

The objective of the presented work was to estimate macroscopic ingredients of cold cuts using economic and portable vision system. The application of low cost vision system and colour image processing may help install quality check points rapidly.

MATERIALS AND METHODS

Five different types of Bologna sausages were acquired from retail store (Fig.1). One sausage was made of turkey meat, others were made of pork meat. Ten slices were used from each sample and both sides were captured by vision system. Cold cuts were placed on transparent plastic sheet over blue paper background. The blue background colour was selected to facilitate segmentation.



a.) b.) c.)

d.) e.)

Figure 1
Bologna sausage samples
a: Parizer with cheese, b: Turkey Parizer with cheese, c: Parizer with cucumber, d: Parizer with mushroom, e: Meat bread

A Samsung NX300 camera with 20.3 Mpx (megapixel) CMOS sensor was placed above samples. Auto exposure mode was selected in order to maximize colour contrast on the surface. The resolution was adjusted to 0.136 mm/px. Saved images were preprocessed with normalization according to the following equations:

$$C_{n,i} = \frac{C_i}{\sum_{j \in R,G,B} C_j} \quad (1)$$

$$C_{n,i} = \frac{C_i^2}{\sum_{j \in R,G,B} C_j^2} \quad (2)$$

where C_i and C_j mean intensity of colour channel i and j respectively, $C_{n,i}$ means

normalized intensity of colour channel *i*. Equation 1 presents calculation for linear normalization, while Eq.2 shows quadratic computation. Linear method highlights dominant colour but quadratic formula also increases colour contrast. The type of normalization was decided according to the observed contrast on the cold cut surface and the same computation method was used for the same sausage. Dynamic k-means clustering was applied in segmentation. The segmentation process resulted in grayscale image where compounds were identified by intensity level. Due to the uniform thickness of cold cuts, proportion of surface areas represents volume ratio as well. Density is required to transform volumetric information to mass ratio, what is comparable with official label (EU No. 1169/2011). Density of the meat pulp may vary a lot depending on recipe and quality of ingredients. Meat pulp density was estimated with the following simplified equation:

$$\rho_p = \frac{m_m + m_f}{\frac{m_m}{\rho_m} + \frac{m_f}{\rho_f}} \qquad (3)$$

where ρ_p, ρ_m and ρ_f means density of pulp, meat and fat, respectively; m_m and m_f are mass of meat and fat, respectively.
Self developed software was used for normalization and segmentation. The software was built using C++. Statistical analysis of obtained data was performed using IBM SPSS Statistics (IBM Corp., USA). Descriptive statistical attributes were calculated for samples and differences were evaluated according to their significance.

RESULTS AND DISCUSSION

Machine vision system was able to identify visible ingredients of sausages (Fig.1). Diffuse illumination and separating plastic sheet between slices and background paper removed disturbing shadows and decreased misclassification error.

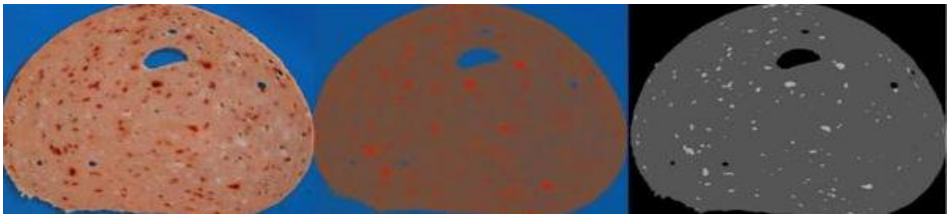


Figure 1
Recognition of sausage ingredients
(left to right: colour image, normalized image, segmentation result)

Correct density data is essential for reliable calculation. After investigation of related literature and consultation with experts of the Department of Refrigeration and Livestock Products' Technology of the Faculty of Food Science at Szent István University, density was estimated as 0.9 g/cm^3 for meat and 0.8 g/cm^3 for fat. Pulp density did vary in the range of 0.86 – 0.9 g/cm^3. Due to the high variability of cheese products, density of selected cheese block, the type is most likely to be used in

technology, was measured manually before experiments. It was found to be 1.1 g/cm^3.

Descriptive statistical parameters of samples (minimum, 25% quantile, meadian, mean, 75% quantile, maximum, standard deviation) are reported in the following table (Table 1). Multimodal distribution was observed in case of sample "Parizer with cheese". Slight deformation from normal distribution was observed for sample "Parizer with cucumber". Asymmetric distribution with more frequent low values was observed in case of samples "Parizer with mushroom" and "Turkey parizer with cheese". Due to the differences in frequency distribution compared to normal, the nonparametric one sample Kolmogorov-Smirnov test was also applied in order to confirm one sample t-test results.

Table 1: Descriptive statistical values of samples

Sample	Min.	25% Q	Median	Mean	75% Q	Max.	Std.dev.
Parizer with cheese	9.51	11.43	14.16	13.78	16.28	16.99	2.78
Turkey parizer with cheese	4.21	5.63	6.54	6.49	7.45	8.57	1.23
Parizer with cucumber	4.34	6.00	6.73	6.51	6.95	8.90	0.99
Parizer with mushroom	13.62	16.30	19.26	19.23	21.26	25.32	3.28
Meat bread (with paprika)	1.48	1.72	2.05	2.06	2.39	2.95	0.42

Calculated mean values were compared to the official information of the label. This reference value was provided by the manufacturer. The following table (Table 2) shows comparison results, where reported significance was calculated according to the one sample t-test ($p<0.05$). The best estimation was reached for pork parizer with cheese. Generally it was found that amount of cheese and mushroom was well predicted. Approximately 54% of reference value was calculated for cucumber. On the other hand, amount of paprika in pork meat bread was over estimated with additional 72%. All vegetables were calculated using the same density value accepted in the current practice of meat product processing. This density value fits well to mushroom, but resulted in large prediction error for others. Since recipe and processing technology are patented and protected by law, we cannot discuss them here in details. At this point it can be suggested to technology experts to revise simplified calculation and measure density of ingredients.

There seems to be contradiction in statistical results, since largest prediction error was reached for samples of lowest standard deviation. The coefficient of variation ranged 0.152 – 0.202, lowest for cucumber. These results together are likely to show that prediction works well for accurate initial information (density values, full list of ingredients with quantity). Best prediction was achieved with measured cheese density and worst with assumed cucumber density. Visual check of cucumber recognition confirmed segmentation accuracy, therefore its unexpectedly low value can be result of wrong density or too low amount of ingredients.

Table 2: Comparison of measured m/m% of ingredient with label information (reference)

Sample	Reference	Measured	Significance
Parizer with cheese	14	13.78	0.730
Turkey parizer with cheese	7	6.49	0.077
Parizer with cucumber	12	6.51	0.000*
Parizer with mushroom	20	19.23	0.331
Meat bread (with paprika)	1.2	2.06	0.000*

* $p<0.05$

CONCLUSIONS

Machine vision system built from low cost colour camera and simple diffuse illumination was used to capture images of Bologna sausages. Normalization of colour images was applied during preprocessing in order to enhance colour contrast of ingredients. This step allows vision system to work automatically and adapt itself to current conditions. Visible ingredients were successfully identified and mass ratio was computed (m/m %) similar to label information provided by manufacturer. Good prediction accuracy was achieved for three types (pork and turkey meat with cheese, pork meat with mushroom) and large error was observed for two (pork meat with cucumber and paprika). Results suggest to perform such estimation based on preliminary measurements of density. Prediction accuracy ranged 0.22 – 5.49 m/m% in the presented experiment. Although the pilot system can work well, further development is recommended to build a robust single box device. The introduced technique is promising and can be recommended for quality monitoring due to its rapid installation and easy management.

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Determination of the Drying Characteristics of Black Carrot Pulp During Drying in a Microwave Oven

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Keywords:

Black Carrot,
Microwave,
Drying Behavior,
Powder Properties

Abstract. In this study the drying behaviour of black carrot pulp was investigated in a microwave oven. The effect of different sample thicknesses (3, 5, and 7mm) and microwave powers (180, 540, and 900W) on the drying time of the samples were examined. The total drying times of the black carrot pulp samples ranged between 510 to 2430 seconds. Three thin-layer drying models, namely, Logarithmic, Two-Term, and Wang and Singh models were fitted to drying data and Two-Term model was found to satisfactorily describing the drying behaviour of black carrot pulp. The calculated effective moisture diffusivity values ranged between 2.822×10^{-7} and 8.532×10^{-6} $m^2 s^{-1}$.The colour values of the samples were measured and it was observed that the best preservation of the reddish colour and L* (the brightness level) were obtained at 7 mm thickness and 180W microwave power. The flow ability and cohesiveness values were found to be in the medium level.

INTRODUCTION

Black carrot (*Daucus carota L.*) which contains high amounts of anthocyanins and antioxidants have a high amount of consumption in Turkey as the raw material of turnip juice, salad, pickles, and fruit juice. Black carrots contain aproximately 1750mg/kg anthocyanin, where anthocyanins are pigments which give purple, blue, and red color for fruit, vegetables, and flowers (Gür et al., 2013). With the intense anthocyanin content black carrots may have an inhibitory effect on cancer, diabetes, heart, and vascular diseases. Also, black carrot extract can be used as an alternative to synthetic colorants since black carrot anthocyanins are stable against heat, light, and pH increase (Gür et al., 2013).

In order to prolong the shelf life of black carrots and create new consumption areas canning, freezing and drying might be suitable techniques. Among these techniques drying constitutes an alternative way to increase the shelf life and consumption of black carrots by reducing physiological, microbial, and enzymatic degradation. Agricultural products continue their respiratory activity after harvesting process. Therefore they tend to deteriorate quickly. Many methods have been found to increase the post-harvest durability. One of these methods is the drying (Alibas, 2006; Ertekin and Yaldız, 2004). Drying can be accomplished in many different methods such as spray, freeze, sun, and microwave drying. The most common drying methods

are sun and convective drying. These drying techniques have some disadvantages such as long drying time, microbial growth, loss of nutritional content and energy, etc. (Toğrul, 2006). For the given reasons above, the alternative drying methods must be used for decreasing the drying time and energy consumption and preventing the loss of nutritional compounds (Alibas- Özkan et al., 2007). Therefore in recent years microwave drying has become a widely used method due to low drying time and energy consumption and the protection of nutrients content (Alibas, 2006). The microwave drying method was used for several kind of foods such as nettle (Alibas, 2007; Alibas, 2010), Swiss chard leaves (Alibas, 2006), parsley (Soysal, 2004), spinach (Alibas- Özkan et al., 2007), mint (Özbek and Dadalı, 2007), yellow pea (Kadlec et all, 2001), celery leaves (Demirhan and Özbek, 2011), and pursuance (Demirhan and Özbek, 2010).The aims of this study are to observe the effects of different microwave powers and thicknesses on the drying characteristics of black carrot pulp, and to determine the powder properties of black carrot powders.

MATERIAL AND METHODS

Material

The black carrots were supplied from a local supermarket in Izmir, Turkey and were washed, peeled and the juice was removed after processing by a home type extractor (Premier PRJ-607, Turkey). The obtained black carrot pulp was placed in a layer of 3, 5, and 7mm in the petri dishes.

Methods

Microwave Drying

The experiments were performed in a domestic microwave oven (Arçelik MD 595, Turkey) at 2450 MHz with a maximum output power of 900 W. Drying experiments were performed at three different microwave powers (180, 540, and 900W). In order to determine the moisture losses, petri dishes were taken out at uniform intervals (30s) and weighed by using a digital balance with 0.01 precision (Ohaus AR2140, USA). The drying experiments were completed when the weight of the sequent samples reached the same weight. The powder was obtained by grinding the dried material for one minute in a home type blender (Tefal Smart, MB450141, Turkey). The powders were stored in the aluminium-laminated polyethylene packaging materials in the dark at room temperature until further tests were carried out.

Mathematical Modelling of the Drying Data

The moisture ratio (MR) of the black carrot pulp during the microwave drying was calculated by using Eq. (1).

$$MR = \frac{M_t - M_e}{M_O - M_e} \qquad (1)$$

Where the M_0, M_t and M_e are representing the initial, at any time and equilibrium moisture contents (kg water/ kg dry matter), respectively. The drying data were fitted to three well-known thin layer drying models (Logarithmic, Two-Term, and Wang and Singh) (Erbay and Içier, 2009).

The goodness of fit was determined by using the coefficient of determination (R^2) and the reduced chi-square ($\chi 2$) that can be described as Eqs. (2) and (3), respectively.

$$R^2 = \frac{N\sum_{i=1}^{N} MR_{pre,i} MR_{\exp,i} - \sum_{i=1}^{N} MR_{pre,i} \sum_{i=1}^{N} \mathrm{MR}_{\exp,i}}{\sqrt{(N\sum_{i=1}^{N} MR^2{}_{pre,i} - (\sum_{i=1}^{N} MR_{pre,i})^2)(N\sum_{i=1}^{N} MR^2{}_{\exp,i} - (\sum_{i=1}^{N} MR_{\exp,i})^2)}} \qquad (2)$$

$$\chi^2 = \frac{\sum_{i=1}^{N} (MR_{pre,i} - MR_{\exp,i})^2}{N - n} \qquad (3)$$

Where $MR_{exp,i}$ and $MR_{pre,i}$ are the experimental, and predicted moisture ratios at observation i; N is number of the experimental data points, and n is the number of constants in the model. The higher values of the coefficient of determination (R^2) and the lower values of reduced chi-square (x^2) were chosen for the goodness of fit (Celma et al., 2008).

For the determination of the effective moisture diffusivity (D_{eff}) values of the black carrot pulp Fick's diffusion model (Eq. 4) was used;

$$MR = \frac{8}{\pi} \sum_{i=1}^{\infty} \frac{1}{(2i-1)^2} \exp\left[-(2i-1)^2 \pi^2 \frac{D_{eff}}{4L^2} t \right] \qquad (4)$$

Where t is the time (s), D_{eff} is the effective moisture diffusivity (m^2/s) and L is the thickness of samples (m). For the long drying times, a limiting case of Eq. (5) is obtained, and expressed in a logarithmic form;

$$lnMR = \ln\left(\frac{8}{\pi^2}\right) - \left(\frac{\pi^2 D_{eff}}{4L^2}\right) t \qquad (5)$$

The effective diffusivity is typically calculated by plotting the experimental moisture ratio in versus the drying time. From Eq. (5), a plot of ln MR versus the drying time gives a straight line with the slope given in Eq. (6).

$$Slope = \frac{\pi^2 D_{eff}}{4L^2} \qquad (6)$$

Physical analyses

The moisture content of the fresh black carrot pulp and the dried black carrot pulp powder were determined according to AOAC (2000). The water activity values of the samples were measured by using Testo-AG 400, Germany, water activity measurement device. The colour values (L* (lightness), a*(greenness/redness), and b*(blueness/yellowness) of the samples

were measured with the Minolta CR-400 Colorimeter, Japan, and results were expressed in accordance with the CIE Lab system.

Analysis of the powder properties

In order to determine the tapped and bulk densities, the method explained by Jinapong et al. (2008) was used. The average wettability and solubility times (seconds) of the black carrot powders were determined by using the method explained by Gong et al., (2008), and Goula and Adamopoulos (2008), respectively. The flowability and cohesiveness of the black carrot powders were evaluated in terms of Carr index (CI) (Carr, 1965) and Hausner ratio (HR) (Hausner, 1967), respectively. Both CI and HR were calculated from the bulk (ρ_{bulk}) and tapped (ρ_{tapped}) densities of the powder as shown below Eq. (7) and (8).

$$CI = \frac{(\rho_{tapped} - \rho_{bulk})}{\rho_{tapped}} x\ 100 \qquad (7)$$

$$HR = \frac{\rho_{tapped}}{\rho_{bulk}} \qquad (8)$$

Statistical analysis

The data were analyzed using statistical software SPSS 16.0 (SPSS Inc., USA). The data were also subjected to analysis of variance (ANOVA) and Duncan's multiple range test (α=0.05) to determine the difference between means. The drying experiments were replicated twice and all the analyses were triplicated.

RESULTS AND DISCUSSION

Drying Curves

The experimental moisture ratio (MR) values of the black carrot pulp at the different microwave powers were given in Fig 1. According to Fig. 1, it can be seen that the drying time decreased depending on the increasing of microwave power and the drying time of the samples at 540W was less than the half of the drying time at 180W.

In order to describe the drying kinetics of the black carrot pulp during drying three different semi empirical models (Logarithmic, Two-Terms, and Wang and Singh) were fitted to the experimental data and the summary of model parameters of these thin layer drying models as well as the statistical results (R^2, and χ^2) were presented in the Table 1. Calculated R^2 and $\chi 2$ values ranged between 0.872-0.992, and 0.0506-0.6402. As a result of statistical analysis the Two-Term model was found to be the most appropriate model with the high values of the coefficient of determination (R^2).

The effective moisture diffusivity values (D_{eff}) of microwave dried black carrot pulp samples were calculated from the Fick's diffusion model and the results were given in Table 2. The black carrot pulp was placed in the oven as a thin layer, that can be assumed as an infinite slab and in Eq. (4) L is taken as the thickness of the black carrot pulp. As can be seen from Table 2, the effective moisture diffusivity values increased with increasing microwave powers, as expected. The effective moisture diffusivity (D_{eff}) of the black carrot pulp powder ranged between 1.370E-6 and 8.617E-7 m^2/s which is in the same range as (10E−12 to 10E−6 m^2/s) most foods (Erbay and Icier, 2009). The effective moisture diffusivity values of the microwave dried apple pomace (150–600 W), okra (180–900 W) and spinach (180–900 W) ranged between 1.05E-8 – 3.69E-8 m^2/s (Wang et al., 2007), 2.05E-9 – 11.91E-9 m^2/s (Dadali et al., 2007a), and 7.6E-11 – 52.4E-11 m^2/s (Dadali et al., 2007b).

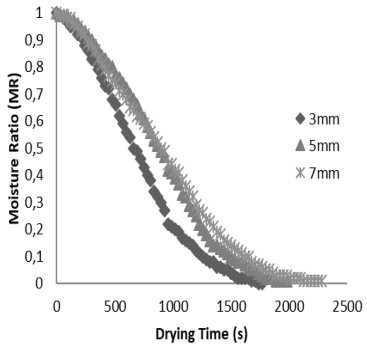

Figure (a)

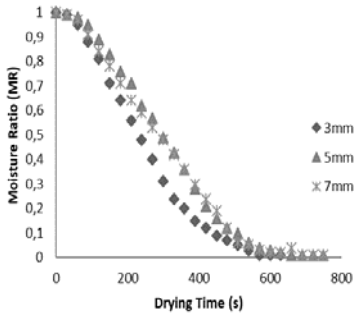

Figure (b)

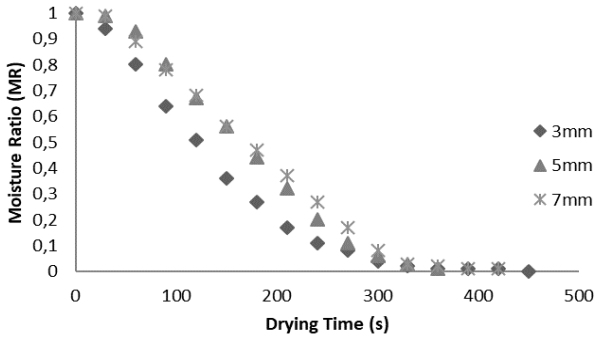

Figure (c)

Figure 1
The experimental moisture ratio values of black carrot pulp at different microwave powers (a); 180W, (b); 540W, and (c); 90im0W

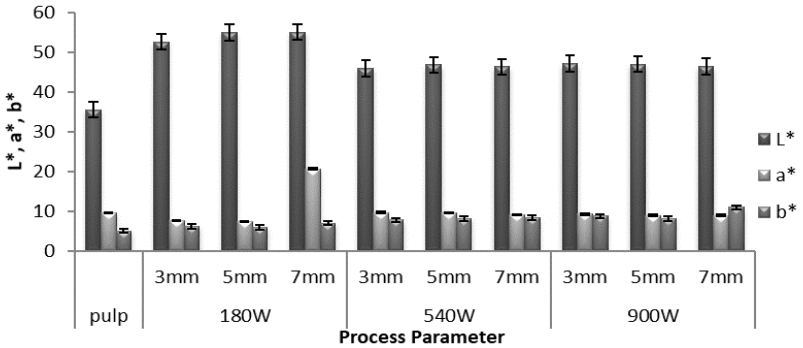

Figure 2
Color values of fresh black carrot pulp and black carrot pulp powder

Table 1: The coefficients of the model equations obtained from the statistical analysis of drying data.

Model	Microwave Power(W)/ Thickness(mm)	Model Constants	R^2	χ^2
Logarithmic ($MR=aexp(-kt)+b$)	180W/3mm	k=0.001 a=1.546 b=-0.435	0.984	0.1243
	180W/5mm	k=0.001 a=1.975 b=-0.860	0.979	0.4932
	180W/7mm	k=0.001 a=1.540 b=-0.435	0.987	0.2503
	540W/3mm	k=0.003 a=1.379 b=-0.257	0.980	0.0651
	540W/5mm	k=0.002 a=1.468 b=-0.316	0.968	0.0796
	540W/7mm	k=0.002 a=1.346 b=-0.593	0.973	0.3213
	900W/3mm	k=0.006 a=1.196 b=-0.095	0.981	0.0576
	900W/5mm	k=0.004 a=1.352 b=-0.208	0.962	0.0883
	900W/7mm	k=0.004 a=1.294 b=-0.426	0.968	0.2546
Two-Term ($MR=aexp(-k_0t)+bexp(-k_1t)$)	180W/3mm	k_0=0.003 k_1=0.003 a=93.946 b=-93.007	0.994	0.2853
	180W/5mm	k_0=0.003 k_1=0.003 a=121.097 b=-120.182	0.985	0.3598
	180W/7mm	k_0=0.002 k_1=0.002 a=104.132 b=-103.187	0.990	0.2469
	540W/3mm	k_0=0.009 k_1=0.009 a=96.733 b=-95.761	0.995	0.2771
	540W/5mm	k_0= 0.008 k_1=0.008 a=120.671 b=-119.723	0.989	0.3266
	540W/7mm	k_0=0.007 k_1=0.007 a=114.972 b=-114.006	0.989	0.2541
	900W/3mm	k_0=0.015 k_1=0.016 a=72.450 b=-71.457	0.999	0.2466
	900W/5mm	k_0=0.014 k_1=0.014 a=131.152 b=-130.180	0.990	0.2982
	900W/7mm	k_0=0.012 k_1=0.013 a=122.943 b=-121.967	0.990	0.2554
Wang and Singh ($MR=1+at+bt^2$)	180W/3mm	a=-0.001 b=1.575E-007	0.978	0.1361
	180W/5mm	a=-0.001 b=-5.053E-008	0.980	0.6402
	180W/7mm	a=-0.001 b=-1.080E-008	0.992	0.7118
	540W/3mm	a=-0.003 b=1.767E-006	0.976	0.1367
	540W/5mm	a=-0.002 b=9.320E-007	0.959	0.0862
	540W/7mm	a=-0.002 b=1.275E-006	0.973	0.1721
	900W/3mm	a=-0.005 b=6.464E-006	0.988	0.0506
	900W/5mm	a=-0.004 b=3.991E-006	0.962	0.0790
	900W/7mm	a=-0.004 b=3.690E-006	0.974	0.0692

Table 2: The estimated effective moisture diffusivity values (D_{eff}) for each microwave powers and thickness.

Microwave Power(W)/ Thickness(mm)	**D_{eff} ($m^2.s^{-1}$)**	**R^2**
180W/3mm	2.822E-7	0.910
180W/5mm	6.582E-7	0.889
180W/7mm	1.370E-6	0.892
540W/3mm	8.617E-7	0.914
540W/5mm	2.267E-6	0.924
540W/7mm	3.320E-6	0.864
900W/3mm	1.550E-6	0.956
900W/5mm	4.634E-6	0.928
900W/7mm	8.532E-6	0.939

Table 3: The moisture content and water activity values of black carrot pulp and the powders

Samples	**Thickness (mm)**	**Moisture Content (%, wb)**	**Water Activity (a_w)**
Fresh puree		19.50±0.02	0.986±0.02
Powder Dried at 180W	3	$4.35±0.12^{az}$	$0.242±0.01^{az}$
	5	$4.48±0.05^{az}$	$0.292±0.01^{bz}$
	7	$4.61±0.06^{bz}$	$0.371±0.01^{cy}$
Powder Dried at 540W	3	$2.70±0.08^{ay}$	$0.160±0.01^{ax}$
	5	$2.82±0.04^{ay}$	$0.171±0.01^{bx}$
	7	$2.99±0.05^{by}$	$0.242±0.01^{cx}$
Powder Dried at 900W	3	$2.16±0.01^{bx}$	$0.182±0.02^{ay}$
	5	$1.99±0.02^{ax}$	$0.209±0.01^{by}$
	7	$2.16±0.01^{bx}$	$0.245±0.01^{cx}$

Different letters (a–c) in the same column indicate significant difference between the microwave powers $P < 0.05$.
Different letters (x-z) in the same column indicate significant difference between the amounts of samples at $P < 0.05$

Results of the physical analyses

The moisture content and water activity values of the powders ranged between 1.99 and 4.61 % (wet basis, wb) and 0.160 and 0.371 (Table 3). Results showed that the moisture content and water activity values of the black carrot powders decreased with respect to increasing the microwave power and increased with the thickness. It may be due to a high transfer rate at high microwave powers. These values are in acceptable limits for the safe storage of the products. Although, the lowest moisture content values were obtained from the samples which dried at 900W microwave powder, the lowest water activity values were obtained at 540W microwave power.

The colour values of the fresh and microwave dried black carrot pulp powders were given in Figure 2. According to the Figure 2; significant differences were observed between the black carrot pulp and the black carrot pulp powders ($P<0.05$). The brightness value of the powders decreased according to increasing microwave powers and decreasing of the sample thickness. The degradation of the pigments or browning reactions may be related to the pigment destruction and may caused the colour loss (L*). The different microwave powers and the sample thicknesses did not cause any significant differences in the a* and b* values of the powders.

Results of the powder properties

On Dried products are usually grounded that have uniform size for further utilization. In this study, it was also aimed that to have powdered form of the black carrot pulp that will be suitable for different applications as food additive. The powder properties of the black carrot pulp powder were given in Table 4. The average wettability and solubility times of powders ranged between 2.5- 7s, and 3.5-8s, respectively indicating highly soluble powders. It was observed that the average wettability time of the samples at 180W was less than the wettability time of samples which were dried at 540, and 900W microwave powers. The tapped and bulk density values of the powders range between 224-277, 235-299, and 218-240 and 289-333, 297-404, and 281-301 kg/m^3 for 3, 5, and 7mm thickness, respectively. The flowability and cohesiveness properties of microwave dried black carrot pulp powders in terms of Carr Index and Hausner ratio were evaluated. The classification of powder flowability based on Carr index (CI) is very good (<15), good (15-20), fair (20-35), bad (35-45), and very bad (>45). The powder cohesiveness based on the Hausner ratio (HR) is classified as low (<1.2), intermediate (1.2-1.4), and high (>1.4) (Jinapong et al., 2008). According to powder properties flowability and cohesiveness values of the black carrot powders were generally found to be fair and intermediate, respectively.

CONCLUSION

Microwave drying technique has been effectively used in drying of the black carrot pulp. Drying behaviour of the black carrot pulp powder was investigated in the microwave oven at different microwave powers (180, 540, and 900W) and the different thicknesses (3, 5, and 7mm). Results showed that, the total drying time and moisture content of black carrot pulp decreased according to increasing microwave powers and decreasing sample thickness. Drying time decreased with increase the evaluation of three thin layer drying models with the comparison based on the coefficient of determination (R^2)

and the reduced chi-square (χ^2), Two term model was found to be satisfactorily describing the kinetics of microwave drying of black carrot pulp.

Table 4: The results of the analysis of powder properties for black carrot pulp powders

Microwave Power	Thickness (mm)	Wettability (s)	Solubility (s)
180W	3	3.75 ± 0.35^{bx}	4.50 ± 0.50^{ax}
	5	2.50 ± 0.70^{ax}	4.75 ± 0.35^{ax}
	7	2.25 ± 0.35^{ax}	3.50 ± 0.70^{ax}
540W	3	6.00 ± 0.00^{bz}	4.00 ± 0.00^{ax}
	5	5.00 ± 0.70^{ay}	6.00 ± 0.90^{by}
	7	5.00 ± 0.80^{ay}	5.50 ± 0.70^{by}
900W	3	5.00 ± 0.90^{ay}	4.00 ± 0.00^{ax}
	5	6.00 ± 0.89^{ay}	5.50 ± 0.70^{bx}
	7	7.00 ± 0.90^{bz}	8.00 ± 0.00^{cz}

Microwave Power	Bulk Density (kg/m^3)	Tapped Density (kg/m^3)	Flowability	Cohesiveness
180W	224.74 ± 3.57^{ax}	289.92 ± 5.94^{ax}	22.48 ± 0.36^{cy} (Fair)	1.29 ± 0.01^{cy} (Intermediate)
	256.60 ± 0.28^{by}	313.50 ± 2.12^{ay}	18.15 ± 0.46^{bx} (Good)	1.22 ± 0.02^{bx} (Intermediate)
	277.12 ± 8.79^{cz}	333.72 ± 1.58^{bz}	16.95 ± 0.56^{ax} (Good)	1.21 ± 0.05^{ax} (Intermediate)
540W	235.63 ± 1.05^{ay}	297.06 ± 0.00^{ax}	20.68 ± 0.35^{ax} (Fair)	1.26 ± 0.01^{ax} (Intermediate)
	298.61 ± 6.12^{bz}	404.08 ± 11.21^{bz}	29.05 ± 0.65^{bz} (Fair)	1.35 ± 0.06^{cz} (Intermediate)
	243.41 ± 4.15^{cy}	315.63 ± 0.00^{by}	22.88 ± 0.90^{cy} (Fair)	1.30 ± 0.02^{by} (Intermediate)
900W	221.74 ± 6.15^{ax}	289.92 ± 5.94^{bx}	23.52 ± 0.55^{bz} (Fair)	1.31 ± 0.01^{by} (Intermediate)
	240.48 ± 3.37^{bx}	301.52 ± 2.14^{bx}	20.24 ± 1.10^{ay} (Fair)	1.25 ± 0.03^{ay} (Intermediate)
	218.11 ± 2.05^{ax}	280.82 ± 0.37^{ax}	22.33 ± 0.83^{by} (Fair)	1.28 ± 0.01^{ay} (Intermediate)

Different letters (a–c) in the same column indicate significant difference between the microwave powers $P < 0.05$.
Different letters (x-z) in the same column indicate significant difference between the amounts of samples at $P < 0.05$.

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Liquid Food Density Affected by Selected Factors

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Abstract. Density of materials can be used in assessing of material's quality. Density of food materials depends on temperature. It is caused by thermal expansion during heating. Density of material is defined as a ratio between mass of material and its volume at the same temperature. One of the most exact methods for measurement of liquid density is pycnometric method, which is based on definition. Measurements of materials density could be also performed by hydrometers or densimeters, where exact value of density can be found on the hydrometer´s scale or on the display of measurement device. During our experiments we used two methods of density determination: pycnometric method and determination by densimeter Mettler Toledo DM 40. Our measurements were performed in approximate temperature range (0 – 30) °C. Effect of various parameters (such as temperature, fat content, alcohol content and short storing time) on material's density is analysed in this article. Linear decreasing character was applied for temperature dependencies of density for all samples in measured temperature range. The highest fat content of milk had caused the lowest density, but lower fat contents (less than 1.5 %) does not proved this proportion due to the different amount of proteins in measured samples of milk. Effect of alcohol content on density had to be investigated together with material composition (wine, whisky, pinacolada). Values of density were a bit higher after short storing due to the loosening of water during the storage.

Keywords:

density,
liquid food,
measurement,
influencing factors,
dependence

INTRODUCTION

Density of foods is an important physical property, which depends on structural properties of foods. (Kelkar et al., 2015). The quality of materials can be evaluated by material's density. Density of food materials is needed in many areas, for example in separation processes, pneumatic and hydraulic transports, determination of the power required for pumping etc. (Sahin and Sumnu, 2006). Density of material ρ is defined as a ratio between mass of material m and its volume V

$$\rho = \frac{m}{V} \qquad (1)$$

The definition is valid for solids, liquids, gases and disperses (Figura and Teixeira, 2007). The standard SI unit of density is $kg \cdot m^{-3}$. Density of most solids and liquids can be calculated using Eq. (1). The accuracy of this method depends on

precision of mass and volume determination. One of the most exact methods for measurement of liquid density is pycnometric method. Pycnometer is a closable glass jar with specified volume. Measured liquid material is filled into the pycnometer and after it the pycnometer is closed. All air bubbles must be removed before closing of the pycnometer. Pycnometer with the sample is weighted and the density of material can be calculated using equation (1). Wide – mouthed bottles can be used for very viscous materials such as tomato paste, butter, or honey (Sahin and Sumnu, 2006). Density of liquid materials can be also measured. For the density measurement of liquids could be used densimeters (hydrometers). Liquid density can be measured by placing a hydrometer in a beaker filled with the liquid material. The hydrometer has a stem that extends from tubular shaped bulb. The diameter of the stem is approximately equal to the diameter of thermometer. The bulb may be filled with a dense material to give it an appropriate weight so that the whole hydrometer sinks in the test liquid to such depth that the upper stem is partly above the liquid. The depth to which the hydrometer sinks depends on the density of the fluid displaced. The deeper the hydrometer sinks, the lower the density of the liquid. The constant weight hydrometer works on the principle that a floating body displaces its own weight of fluid. Density hydrometers are sometimes prepared for narrow range of measurement and therefore are sensitive to small changes in density. Specific names are given to these kinds of hydrometers such as lactometers for milk and oleometers for oil. The Twaddell hydrometer is used for liquids denser than water. The Baume scale has two scales, one of which is for fluids heavier than water and the other one is for lighter fluids. A variety of hydrometers are also available for specific purposes other than density such as brix saccharometers for percentage of sucrose by weight in solution, alcoholmeters for percentage of alcohol by volume, and others (Sahin and Sumnu, 2006).

Density is often used for determination of other physical properties (rheologic, thermal, etc.) There are several measurement techniques for density that involve separately determining mass and volume of the food sample (Kelkar et al., 2015). Barbosa (2003) and Barbosa et al. (2003) used ultrasonic measurements to measure densities of sucrose, glucose and citric acid solutions at temperature between 10 °C and 30 °C and pressures up to 600 MPa. Eder and Delgado (2007) used optical refractive index measurement to determine density of sodium chloride and sucrose solutions at pressures up to 500 MPa at 20 °C. Pycnometric method was used by Min et al. (2010) for determination of density for sucrose solutions, soy protein solutions, soybean oil, chicken fat, clarified butter, apple juice and honey. Authors find out that densities of analysed samples were increasing with increasing pressure. Densities of demineralised water and water-maltose-ethanol mixtures were investigated by Hoche et al. (2015) using reflection method in temperature range (10 – 30) °C. Densities of measured samples were decreasing with temperature increase. Densities of selected porous (breads and cookies) and non-porous food materials (tomato paste, mayonnaise and soybean oil) were determined by Kelkar et al. (2015) using X-ray imaging. Densities of porous materials were also determined by traditional technique (mass and volume measurement) and densities of non-porous

materials were also determined by pycnometric measurement. Authors had claimed that obtained results by both techniques were comparable (Kelkar et al., 2015). System of density measurement of liquid flowing in a pipeline based on quasi-hydrostatic measurement was presented by Remiorz and Ostrowski (2015). Densities of ternary aqueous solutions of piperidinium-based ionic liquids were measured by Chen et al. (2014) using automatic U-tube densimeter at atmospheric pressure. Effect of temperature and composition on bovine milk density was investigated by Alcantara (2012). Regression model of ultrafiltration milk concentrates were analysed by Dinkov et al. (2008). Comparison of cow´s milk and soymilk density were performed by Oguntunde and Akintoye (1991).
As density is influenced by many factors, effects of various parameters (such as temperature, fat and alcohol content and short storing) on material's density were analysed in this article.

MATERIALS AND METHODS

During our experiments we used two methods of density determination: pycnometric method and determination by densimeter Mettler Toledo DM 40, which contains internal Peltier thermostat for automatic temperature control and therefore does not require external thermostatic bath circulator. Values of density are shown on display of measuring device at each measured temperature. When pycnometric method was used, measurements were repeated three times and average values were calculated. Mass of pycnometer with samples was weighted at each temperature with precision ± 0.0001 g. Our measurements were performed in approximate temperature range (0 – 30) °C. Effect of various parameters (such as temperature, fat content, alcohol content and short storing time – one or two weeks) on selected material density was examined. Linear decreasing character (Eq. 2) was applied for temperature dependencies of density for all samples in measured temperature range.

$$\rho = A - B\left(\frac{t}{t_0}\right) \qquad (2)$$

where A and B are constants dependent on kind of material, and on ways of processing and storing, t is temperature and $t_0 = 1$ °C.

Measurements were performed on eight samples of liquid food materials purchased in local market: white wine (Rizling Vlašský), red wine (Frankovka Modrá), two types of whisky (Jim Beam and Grant´s), pinacolada and three types of milk with different fat content.

RESULTS AND DISCUSSION

Results are presented as temperature dependencies of material density (Fig. 1 – 6). Linear decreasing progress was applied for all samples in measured temperature range. All regression coefficients and coefficients of determination are presented in Table. 1.

On Figs. 1 – 2 are presented dependencies of wine density on temperature. Measurements were repeated after one week of storing for white wine. It can be seen (Fig. 1) that values of white wine density were a bit higher after short storing due to the water loosening during the storage. Measurements of red wine density were repeated after one week of storing and also after two weeks of storing (Fig. 2). Density values were also higher after storing so same proportion of curves were obtained after one week and after two weeks of storing as for white wine. Dependencies of whisky densities on

temperature are presented on Figs. 3 – 4. For both types of whisky were obtained similar results. Densities were a bit higher after one week of storing and little higher after two weeks of storing. Next analysed sample was alcohol drink pinacolada. Density measurements were performed at the beginning of storage and also after one week of storing (Fig. 5). It can be seen that density values were higher after storing.

Table 1: Coefficients A and B of regression equation (2) and coefficients of determination R^2

	Regression equation (2)					
Sample	**Coefficients**					
	A [kg·m^{-3}]	**B[kg·m^{-3}]**	**R^2**	**A[kg·m^{-3}]**	**B [kg·m^{-3}]**	**R^2**
Pinacolada	First measurement			Next measurement		
	1 106.86	0.469 087	0.983 177	1 108.21	0.460 286	0.990 478
White wine	First measurement			Next measurement		
	995.566	0.239 273	0.981 496	995.815	0.240 978	0.995 244
Red wine	First measurement			Second measurement		
	996.724	0.233 637	0.959 312	996.998	0.233 877	0.958 711
	Next measurement			997.248	0.236 864	0.969 206
Whisky Grant´s	First measurement			Second measurement		
	962.187	0.588 991	0.984 428	962.539	0.586 741	0.986 502
	Next measurement			962.897	0.579 167	0.987 977
Whisky Jim Beam	First measurement			Second measurement		
	962.305	0.578 705	0.981 369	962.960	0.569 368	0.981 292
	Next measurement			963.251	0.562 989	0.978 113

Milk/Fat content	**A [kg·m^{-3}]**	**B [kg·m^{-3}]**	**R^2**
0.5 %	1 036.55	0.276 969	0.991 812
1.5 %	1 037.09	0.248 183	0.983 792
3.5 %	1 036.00	0.286 364	0.988 326

It can be seen from Tab. 1 that coefficients of determination reached very high values in the approximate range (0.96 – 0.99).

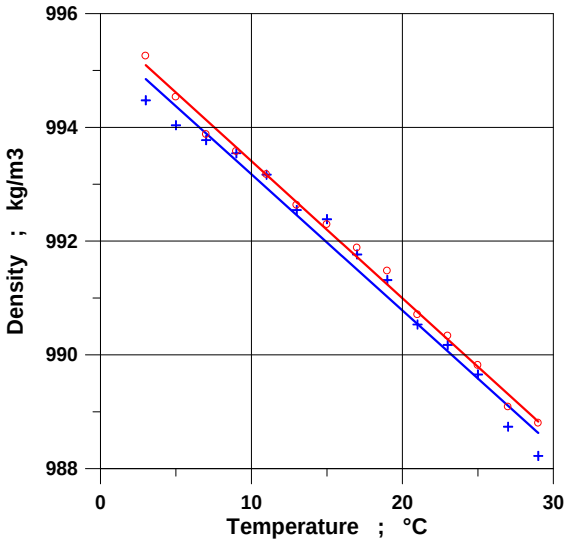

Figure 1
Temperature dependencies of white wine density
first measurement (+), next measurement (○)

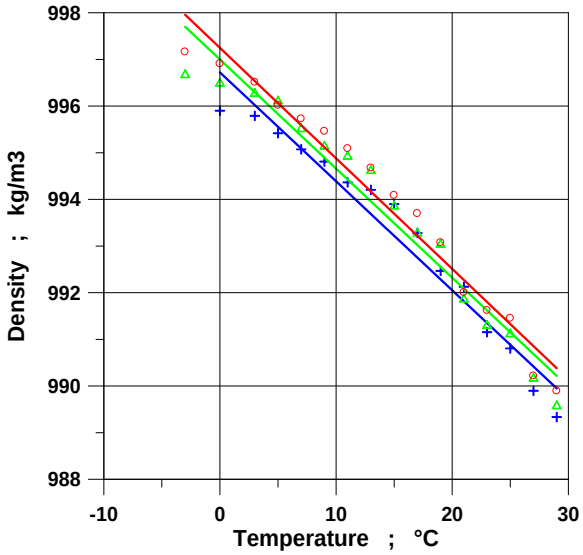

Figure 2
Temperature dependencies of red wine density
first measurement (+), second measurement (Δ), next measurement (○)

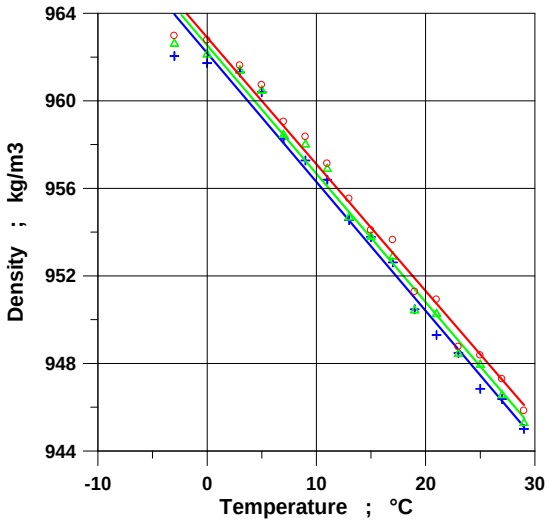

Figure 3
Temperature dependencies of whisky (Grant´s) density
first measurement (+), second measurement (Δ), next measurement (○)

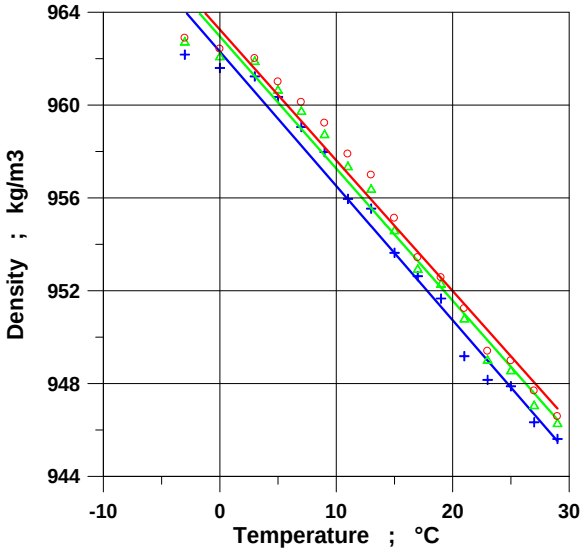

Figure 4
Temperature dependencies of whisky (Jim Beam) density
first measurement (+), second measurement (Δ), next measurement (○)

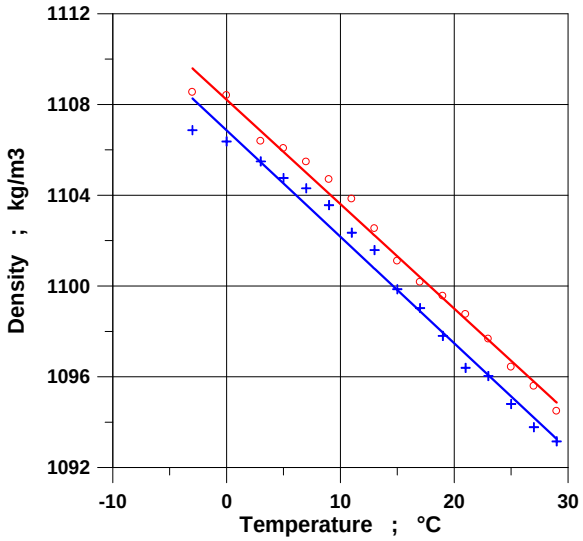

Figure 5
Temperature dependencies of pinacolada density
first measurement (+), next measurement (○)

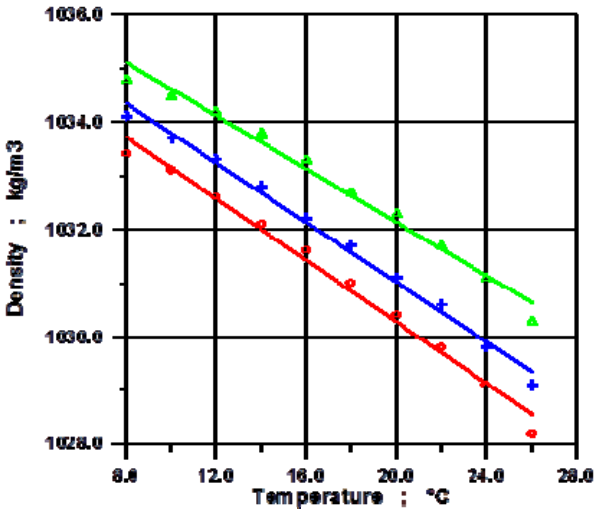

Figure 6
Temperature dependencies of milk density with fat contents
(+) 0.5 %; (Δ) 1.5 %; (○) 3.5 %

Effect of alcohol content on density had to be investigated together with material composition (wine, whisky, pinacolada). Wine with approximately 10 % of alcohol content had higher densities than whisky samples with 40 % of alcohol content. But on the contrary densities of pinacolada with 16 % of alcohol content were higher than other alcohol drinks, which is caused by its composition. Changes in density could be also caused by evaporation of alcohol during the heating and storing. On Fig. 6 are presented dependencies of density on temperature for milks with different fat content. The highest fat content of milk had caused the lowest density, but lower fat contents (less than 1.5 %) does not proved this proportion, this could be due to the different amount of proteins in measured samples of milk. Similar values and decreasing progresses of milk density with increasing temperature were observed by other authors (Kumbár and Nedomová, 2015; Alcantara, 2012; Dinkov et al., 2008; Oguntunde and Akintoye, 1991).

CONCLUSIONS

Effect of various factors on liquid food materials density was investigated in this article. Influence of temperature, fat content, alcohol content and short term storage on density was examined on eight liquid food materials, such as white and red wine, two types of whisky, pinacolada and three types of milk with different fat content. All measurements were performed in approximate temperature range (0 – 30) °C. Temperature dependencies of all measured samples densities are characterized by decreasing linear function in this temperature range, which is in accordance with other authors (Kumbár and Nedomová, 2015; Alcantara, 2012, Dinkov et al., 2008, Figura and Teixeira, 2007, Sahin and Sumnu, 2006, Oguntunde and Akintoye, 1991). The highest fat content of milk (3.5 %) had caused the lowest density, but lower fat contents (less than 1.5 %) does not proved this proportion, this could be due to the different amount of proteins in measured samples of milk. Effect of alcohol content on density had to be investigated together with material composition (wine, whisky, pinacolada). Lowest density of alcohol drinks had both types of whisky, and its alcohol content is highest (40 %). Wines with lower alcohol content (around 10 %) had higher densities. But on the contrary density of pinacolada with 16 % of alcohol content was higher than other alcohol drinks, which is caused by its composition. Alcohol content could be also changed due to evaporation during the heating and storage. Values of samples density were a bit higher after short storing due to the loosening of water during storage. Knowledge about physical properties and influencing factors of liquid food products can be used at determination of their quality.

ACKNOWLEDGEMENT

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Thermal Characteristics of Tekov and Lunex Cheeses

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Abstract. The article presents selected physical parameters of cheeses. Theoretical part contains description of different cheeses, their classifications and properties. Theory of plane source method which was used for the experiments is described. The main part of the article is the presentation of experimental results which were obtained for samples of selected cheeses. Presented results are relations of thermophysical parameters as: thermal conductivity, thermal diffusivity and volume specific heat to the temperature. All measured relations have mainly linear decreasing progress.

Keywords:

cheese,
temperature,
thermal conductivity,
thermal diffusivity,
specific heat

INTRODUCTION

Cheese is a diary product which belongs between milk-based food products. Styles, textures and flavours depend on the origin of the milk. Flavours, textures, and forms of cheeses are different throughout the world. Cheeses are made from milk, usually the milk of cows, buffalos, goats, or sheeps. According to origin of milk, cheeses have different content of proteins and different fat content. Many different types of cheeses are produced. In generally cheese during processing and storage goes through the thermal or mechanical manipulation. So it is convenient to know its physical properties, especially thermophysical and rheologic. Rheologic behaviour of dairy products was examined by Patočka et al. (2006). Choosen types of cheeses rheologic properties were measured by Buchar (1996). Kfoury et al. (1989), Robert and Sherman (1988) pointed that rheologic properties of cheeses are twinned with their quality.

This article deals with physical properties which are very complicated characteristics of food materials. Knowledge of physical properties of food materials has a decisive importance for the realization of many technological processes, especially for monitoring of their quality.

MATERIALS AND METHODS

The word cheese written in Latin is *caseus*. Cheese is a generic term for a diverse group of milk-based food products. Cheese is produced throughout the world in wide-ranging flavours, textures, and forms. Cheese consists of proteins and fat from milk, usually the milk of cows, buffalos, goats, or sheep. It is produced by coagulation of the milk protein casein. Typically, the milk is acidified and addition of the enzyme rennet causes

coagulation. The solids are separated and pressed into final form. Some cheeses have molds on the rind. Most cheeses melt at cooking temperature. Hundreds of types of cheese are produced. Their styles, textures and flavours depend on the origin of the milk (including the animal's diet), whether they have been pasteurized, the butterfat content, the bacteria and mold, the processing, and ageing. Herbs, spices, or wood smoke may be used as flavouring agents. The yellow to red colour of many cheeses is from adding annatto. For a few cheeses, the milk is curdled by adding acids such as vinegar or lemon juice. Most cheeses are acidified to a lesser degree by bacteria, which turn milk sugars into lactic acid, than the addition of rennet completes the curdling. Vegetarian alternatives to rennet are available; most are produced by fermentation of the fungus *Mucor miehei*, but others have been extracted from various species of the *Cynara* thistle family. Cheese is valued for its portability, long life, and high content of fat, protein, calcium, and phosphorus. Cheese is more compact and has a longer shelf life than milk (Fankhauser – Simpson, 1979).

There are many different kinds of cheeses that can be found, each with its own colour, texture, flavour and rind. Cheese can usually be classified in four ways: by texture, by covering, by ripening or by cooking types. Classifications of cheeses with some examples are shown below. When looking at a cheese by texture, you can find a variety of flavours and rinds. Under the covering classification, you can get an idea of the cheese inside by looking at the outside. Cheese can be easily chosen for a cheeseboard or platter when looking at the ripening. There are many ways to classify cheeses. Some classify cheeses by its texture, whether it's hard or soft, or by its ripening, etc. Here are the four main types of classification groups of cheeses and also their descriptions.

Classifications of Cheeses by Texture:

- Hard Grating Cheeses (Parmesan, Sbrinz).
- Firm/Hard (Emmental, Cheddar, Provolone).
- Semisoft (Brick, Muenster, Roquefort, Talleggio).
- Soft (Camembert, Brie, Hermelín, Plesnivec).
- Fresh (Ricotta, cottage)
- Processed (smooth cheeses made from mixing several cheeses or adding other ingredients: American, cheese spreads, Lunex, Karička)

Classifications of Cheeses by Covering:

- Hard/Leather/Waxed Rind (larger cheeses, longer maturity, pressed to remove moisture: Raclette, Gruyère, Gouda).
- Bloomy/Downy Rind (soft rinds, often 'fuzzy', usually softens with ages: Brie).
- Natural Rind (interior is soft to firm with a natural rind that has a soft grey/blue colour or that often changes colour with age: Sainte Maure, Pouligny St. Pierre).
- Saltwater Washed Rind (saltwater-bath as it ripens: Muenster, Feta).
- Blue Cheeses (blue/green veined, cheese is cultured with bacteria to give it its colours: Stilton, Roquefort, Gorgonzola).
- Fresh Cheese (no rind, high water content, unripened: fromage frais, Demi-sel, Ricotta, fresh goat cheese, mascarpone).

Classifications of Cheeses by Ripening:

- Bacteria ripened from outside (Cheddar, Parmesan).
- Bacteria ripened from inside (Limburger, Liederkranz).
- Mold ripened from outside (Stilton, Saga Bleu).
- Mold ripened from inside (St. André, Explorateur).
- Unripened (Cottage).

Plane source method – Transient methods represent a large group of techniques where measuring probes, i.e. the heat source and the thermometer, are placed inside the specimen. This experimental arrangement suppresses the sample surface influence on the measuring process which can be described as follows. The temperature of the specimen is stabilized and made uniform. Then the dynamic heat flow in the form of a pulse or stepwise function is generated inside the specimen. From the temperature response to this small disturbance, the thermophysical parameters of the specimen can be calculated.

Plane source method is based on using an ideal plane sensor (PS). The PS acts both as heat source and temperature detector. The plane source method is arranged for a one dimensional heat flow into a finite sample. The theory considers ideal experimental conditions – ideal heater (negligible thickness and mass), perfect thermal contact between PS sensor and the sample, zero thermal resistance between the sample and the material surrounding sample, zero heat losses from the lateral surfaces of the sample (Karawacki et al., 1992). If q is the total output of power per unit area dissipated by the heater, then the temperature increase as a function of time is given by (1) (Beck and Arnold, 2003)

$$\Delta T(x,t) = 2\frac{q\sqrt{at}}{\lambda} ierf\left(\frac{x}{2\sqrt{at}}\right) \quad (1)$$

Where a is thermal diffusivity, λ is thermal conductivity of the sample and *ierf* is the error function (Carslaw and Jeager, 1959). We consider the sensor, which is placed between two identical samples having the same cross section as the sensor in the plane $x = 0$. The temperature increase in the sample as a function of time (2)

$$T(0,t) = \frac{q\sqrt{a}}{\lambda\sqrt{\pi}}\sqrt{t} \quad (2)$$

which correspond to the linear heat flow into an infinite medium (Karawacki and Suleiman, 2001). The sensor is made of a Ni-foil, 23 μm thick protected from both sides by an insulating layer made of kapton of 25 μm thick made on SAS. Several corrections have been introduced to account for the heat capacity of the wire, the thermal contact resistance between the wire and the test material, the finite dimension of the sample and the finite dimension of the wire embedded in the sample (Assael and Wakeham, 1992; Liang, 1995).

RESULTS AND DISCUSSION

There are made various types of processed cheese with different fat content in Slovakia. The most famous types of processed cheeses are Lunex®, Syrokrém® and Karička® (www.mlieko.sk, 2010).

Measurements were performed on samples of processed cheese Lunex and Tekov – Unsmoked Hard Cheese. At first were measured samples of Lunex. Relations of thermal conductivity, thermal diffusivity and volume specific heat to the temperature during the temperature stabilisation in temperature range from 13

°C to 24 °C were analysed. For thermophysical parameters measurements was used instrument Isomet 2104 with plane sensor and measured material (processed cheese Lunex) was inserted into plane sensor. Thickness of all samples was 10 mm according to advices in user's manual.

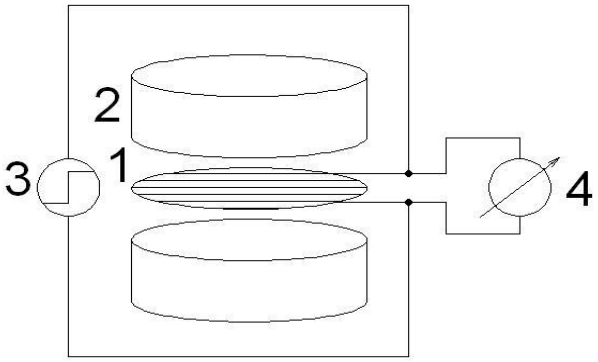

Figure 1
Plane source method
1 – plane sensor, 2 – samples, 3 – current source, 4 – milivoltmeter

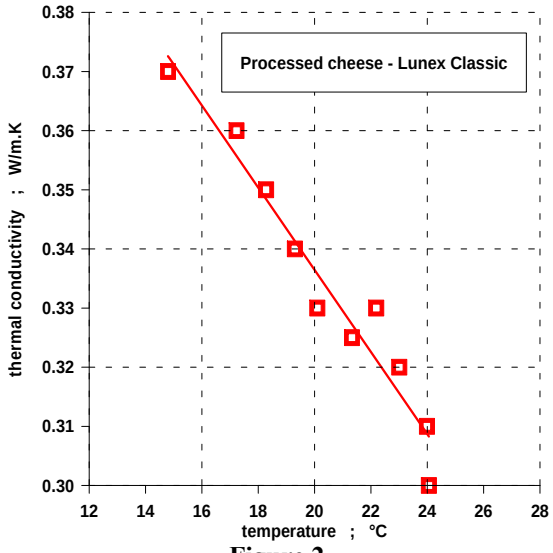

Figure 2
Temperature relation of thermal conductivity for sample - Lunex Classic

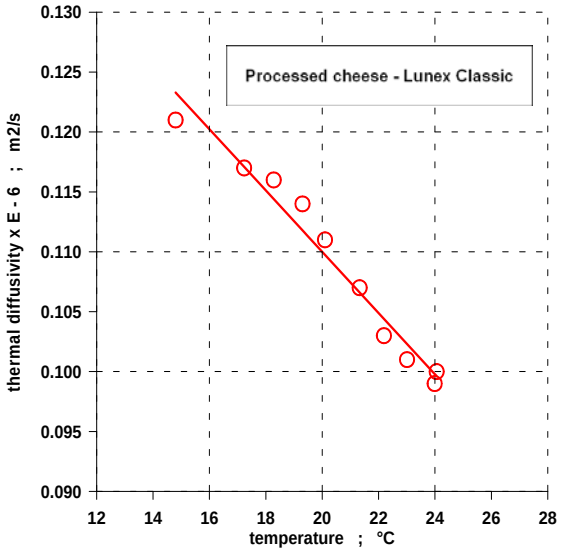

Figure 3
Temperature relation of thermal diffusivity for sample - Lunex Classic

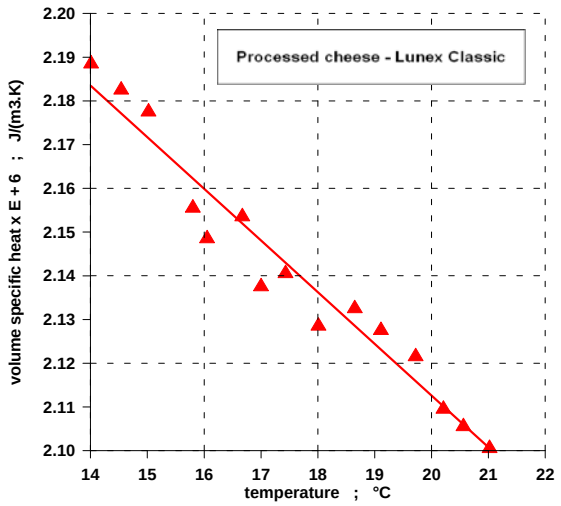

Figure 4
Temperature relation of volume specific heat for heat for sample - Hard Cheese Tekov

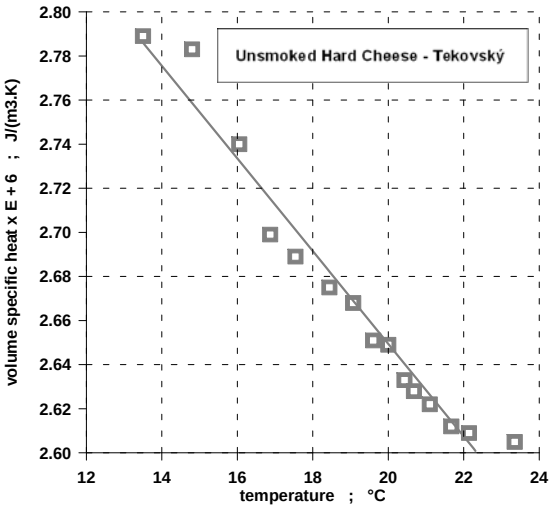

Figure 5
Temperature relation of volume specific heat for sample - Hard Cheese Tekov

The values of thermophysical parameters as thermal conductivity, thermal diffusivity and volume specific heat are presented on Figures (2 – 7). All measured relations have linear decreasing progress. Graphic relations have very similar coefficient of determination approximately from 0.95 to 0.96. These coefficients are near the lower limit value of determination coefficient which is acceptable. When the coefficient of determination is smaller than 0.95, it is better to choose other mathematical function for graphic representation. The highest coefficient of determination was found for linear decreasing progress in our case. Our results for all thermophysical parameters are coincident with values known from literature, for example Ginzburg (1985).

Tekov cheese is natural half hard, maturing, full cream cheese, smoked or unsmoked. Producer prefers hand manipulation because they want to protect the quality of cheese and the form of cheese. Tekov cheese includes: (53.5 – 58.5) % of dry mass, (43.0 – 47.5) % of fat content in dry mass and maximum 2.5 % of salt. Tekov cheese is made from pasteurized milk with admixture of acid milk cultures *Lactococcus* or *Streptococcus*. Measurement conditions were the same like in the first series of measurements for Lunex.

Next were measured samples: Low – fat leaf processed cheese, Low – fat leaf processed cheese – Sandwich, Processed cheese – Karička, Sheep cheese – natural, Slovak sheep cheese – Bryndza, Slovak organic sheep cheese – Bryndza. Same relations were examined. Results are shown in the Table 2, Table 3.

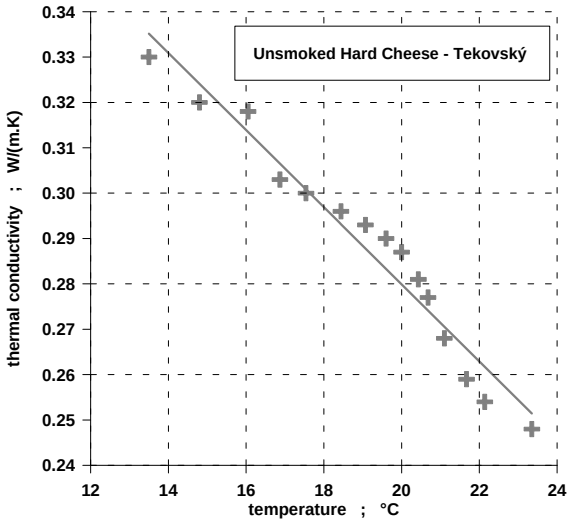

Figure 6
Temperature relation of thermal conductivity for Hard Cheese Tekov

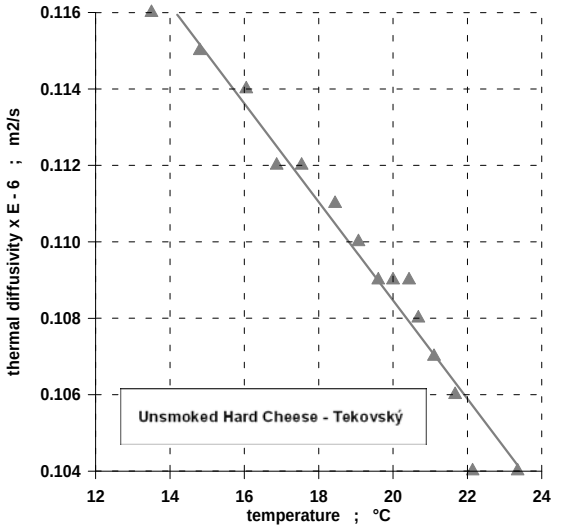

Figure 7
Temperature relation of thermal diffusivity for Hard Cheese Tekov

Table 1: Regression equations, average values and coefficients of determination

Sample	Relations of thermophysical parameters to temperature in temperature range (13,5 – 23,35) °C		
	Regression equations	Average values	R^2 - Coefficient of determination
Lunex Classic	$\lambda = -0.00695\,t + 0.475$ $a = -0.00255\,t + 0.1610$ $c\rho = -0.0118\,t + 2.3490$	0.334 $W.m^{-1}.K^{-1}$ 0.109 x 10^{-6} $m^2.s^{-1}$ 2.14 x 10^6 $J.m^{-3}.K^{-1}$	0.955669 0.969536 0.952612
Unsmoked Hard Cheese Tekov	$a = -0.00129\,t + 0.134$ $\lambda = -0.00850\,t + 0.450$ $c\rho = -0.0210\,t + 3.070$	0.288 $W.m^{-1}.K^{-1}$ 0.110 x 10^{-6} $m^2.s^{-1}$ 2.67 x 10^6 $J.m^{-3}.K^{-1}$	0.956638 0.966221 0.960669

Table 2: Measurement results of thermal conductivity and thermal diffusivity for cheese samples

Sample	λ $W.m^{-1}.K^{-1}$	$\overline{\vartheta}(\lambda)$ $W.m^{-1}.K^{-1}$	$\overline{\vartheta}_{r\%}(\lambda)$ %	a $m^2.s^{-1}$	$\overline{\vartheta}(a)$ $x10^{-6}$ $m^2.s^{-1}$	$\overline{\vartheta}_{r\%}(a)$ %
Low - fat leaf processed cheese	0.510	± 0.0014	± 0.28	0.107 x 10^{-6}	± 0.0001	± 0.093
Low - fat leaf processed cheese Sandwich	0.505	± 0.0015	± 0.30	0.112 x 10^{-6}	± 0.0009	± 0.804
Processed cheese Karička	0.700	± 0.0070	± 1.00	0.118 x 10^{-6}	± 0.0007	± 0.59
Sheep cheese Natural	0.540	± 0.0058	± 1.02	0.109 x 10^{-6}	± 0.0002	± 0.18
Slovak sheep cheese Bryndza	0.580	± 0.0028	± 0.48	0.122 x 10^{-6}	± 0.0004	± 0.33
Slovak organic sheep cheese Bryndza	0.460	± 0.0014	± 0.30	0.131 x 10^{-6}	± 0.0005	± 0.38
$\overline{\vartheta}$ - Probable error of the measurement, $\overline{\vartheta}_{r\%}$ - Relative probable measurement error						

Results of thermophysical parameters measurements for samples: Low - fat leaf processed cheese, Low - fat leaf processed cheese – Sandwich, Processed cheese – Karička, Sheep cheese – natural, Slovak sheep cheese Bryndza, Slovak organic sheep cheese Bryndza are presented in the Tables 2, 3. Presented values are averages from one hundred values for every measured sample. Averages were valued by probable measurement error of arithmetic average and probable error in %. Maximum value of thermal conductivity has Processed cheese – Karička 0.700 $W.m^{-1}.K^{-1}$. Very similar value of thermal conductivity had Low - fat leaf processed cheese 0.510 $W.m^{-1}.K^{-1}$ and Low- fat leaf processed cheese – Sandwich 0.505 $W.m^{-1}.K^{-1}$. There were big differences between Slovak sheep cheese Bryndza made by using commercial high technology and Slovak organic sheep cheese Bryndza made from organic milk by using traditional handmade technology. Handmade cheese Bryndza had lower thermal conductivity 0.460 $W.m^{-1}.K^{-1}$ than commercial made Slovak cheese Bryndza 0.580 $W.m^{-1}.K^{-1}$ because of higher content of organic ingredients and because of higher fat content. Very similar value of thermal conductivity had Sheep cheese – natural and Slovak sheep cheese Bryndza, both made by standard production technology.

Thermal diffusivity had very similar values for Low - fat leaf processed cheese and Low - fat leaf processed cheese – Sandwich, Processed cheese – Karička and Sheep cheese – Natural from interval (0.107 – 0.118) x 10^{-6} $m^2.s^{-1}$. The highest thermal diffusivity had handmade Slovak organic sheep cheese – Bryndza 0.131 x 10^{-6} $m^2.s^{-1}$. Volume specific heat is calculated from other thermophysical parameters of cheese and density of cheese, so values of specific heat was highest for Slovak organic cheese – Bryndza 2.6811 x 10^6 $J.m^{-3}.K^{-1}$. In generally the temperature changes effects physical properties of cheeses. Modification of physical properties can be caused by changes of water content and proteins content during the temperature stabilisation.

Table 3: Measurement results of volume specific heat for cheese samples

Sample	$c\rho$ x10^6 $J.m^{-3}.K^{-1}$	$\overline{\vartheta}(c\rho)$ x10^6 $J.m^{-3}.K^{-1}$	$\overline{\vartheta}_{r\%}(c\rho)$ %
Low - fat leaf processed cheese	2.5841	± 0.0010	± 0.039
Low - fat leaf processed cheese Sandwich	2.5917	± 0.0012	± 0.046
Processed cheese Karička	2.6101	± 0.0017	± 0.150
Sheep cheese Natural	2.5811	± 0.0019	± 0.074
Slovak sheep cheese Bryndza	2.2622	± 0.0043	± 0.190
Slovak organic sheep cheese Bryndza	2.6811	± 0.0034	± 0.130
$\overline{\vartheta}$ - Probable error of the measurement, $\overline{\vartheta}_{r\%}$ - Relative probable measurement error			

CONCLUSIONS

In generally the structure, ingredients used for making cheese and technological process has important influence on physical parameters of cheeses. The most important physical properties are: thermal, rheologic and textural. Patočka et al. (2006) had examined rheologic behaviour of dairy products. Buchar (1996) examined rheologic properties for chosen types of cheeses (Edam, Moravian block, smoked cheese, Gouda). Kfoury et al. (1989), Robert and Sherman (1988) pointed that rheologic properties of cheeses are twinned with their quality. Our results showed that thermophysical parameters are in significant connection with duality of cheeses. Detailed knowledge about thermophysical characteristics of cheeses during thermal manipulation can improve technological and storage processes. Information about physical characteristics can be used for quality protection of food materials.

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Teaching of Physics in Grammar Schools with Help of Food Investigation Measurements

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Abstract. Education of natural sciences is extremely important for understanding the whole world around us. In teaching of physics in the schools the experiments are of primary importance, and the pupils are definitely satisfied if the investigated materials are food samples, wellknown for them. The paper deals with 3 simple experiments of physical type. The following foodstuffs were investigated: beet sugar, apple, tomato, fruit syrups. For teaching the following experiments were prepared and carried out:

- determination of sugar content by density measurement in solutions
- examination of fruit firmness
- application of a microwave oven for determination of water content by temperature measurement

Keywords:

density, fruit firmness,
microwave,
physical methods,
sugar concentration,
water content

INTRODUCTION

Int the previous paper and lecture (Szabo, Izsak, 2016) information was given about measurements of physical type, carried out for teaching of pupils using food samples for determination of the concentration, based on boiling point, creation of galvanic battery using agricultural products, differentiation between raw and cooked eggs, without breaking the egg-shell. This work again deals with 3 measurements, using simple physical methods for investigations and connections between the measured parameters for evaluation of the results of investigations. We are sure that the experiments are of primary importance in the education, helping not only in understanding the different topics for the pupils, but the interesting demonstration creates an enjoyable atmosphere, as well. Let us mention some publications (Bozi et al, 2016)(Izsak et al, 2016), concerning the improvement of teaching of natural sciences with food experiments.

SUGAR CONCENTRATION DETERMINATION BY DENSITY MEASUREMENT

Prepare 10%, 20% and 30% solutions of beet sugar (sucrose) - or even 10 g / 100 ml, 20 g / 100 ml and 30 g / 100 ml of sugar solutions - and use an easy to implement, but sufficiently precise technique, picnometric method for measure the density of these solutions. We will see that the 10 % solution has about 1:04 g / cm^3, the 20 % one 1:08 g / cm^3,

and the 30 % solution about 1.12 g / cm ^{3} density. Thus, there is a close correlation between the concentration and the density, and a simple physical measurement can be applied and monitored, without chemical analysis in the determination of the sugar concentration. Point out the following:

1. Unknown sugar concentration can be determined on the base of tabular data (eg. Chemists pocket book or internet) or calibration curve

2. The density determination method in principle is valid only for binary (two-component) system, but a wide variety of foodstuffs is known, when out of the water actually there is only one dominant component, and thus the process as a routine technique, with acceptable accuracy can be well used. E.g. sugar content degree in grape must or alcohol content of dry wine with determination of density.

3. In case of other materials than sugar the density values are different for the same concentrations, e.g. salt (NaCl) for 10% solution has approx. 1:07 g / cm^3, and for 20 % one 1.15 g / cm ^{3} measurable density.

4. Very slightly the density of the test solutions is of course influenced by temperature, as well - the tabular data generally apply to 20 ^{o}C - but the difference, measured between 15 and 20 ° C in case of 20% sugar solution is insignificant in density - 1.08233 and 1.08094 g / cm^3 - and the negligible value is within the measurement error.

5. For determination of sugar content also other physical and chemical analytical measuring methods and techniques are known, e.g. the polarimetric test which can be used for optically active substances (such is sugar). In this case the modification of the vibratioanal plane of polarized light is measured and from this is the concentration calculated. But well-known and simple procedure is also the refractometric method, when the refractive index is measured.

INVESTIGATION OF HARDNESS (FIRMNESS) OF FRUITS

Everyday experience that the quality and shelf-life of the fruits is closely related to hardness. As today practically any kind of fruits can be purchased in every season, so the measurement with the wanted fruit can be performed at any time during the school year. Of course, you should choose a determined type of fruit and testing its various versions, concerning the hardness. We used with the pupils Jonagold apple samples for the tests.

For testing the hardness we need a not too complicated measurement tool: a microphone in a wooden box made with a circular opening at the top that is coated with a light material of soft, spongy texture, to produce free vibration. The fruit to be tested is placed on this soft material. The fruit is hit easily with a stick - excitation – so a sound vibration is generated, which is recorded by the microphone. (If the microphone is connected to a computer, with a voice-evaluation program the characteristic frequency of the vibration generated sound can be determined.) Note that the registered sound vibration to be generated should be the vibration of the fruit, and not the sound audible in the air (Felföldi, 1996).

The hardness shows how much power is generated due to the size of penetration of the test object. So N/m m is the unit of measurement. Easy to see that the same is obtained if the mass and the square of the measured frequency of the sample are multiplied:

$$\frac{N}{m} = \frac{kg \cdot \frac{m}{s^2}}{m} = kg \cdot \frac{1}{s^2}.$$

So what we have to do during the measurement is the determination of the weight of the fruit and the frequency of the acoustic vibrations.

For the students it can be a useful information that instead of measuring the force and the penetration the mass and frequency can be measured, as well, that is, try to draw attention to the importance of the relationship between the physical quantities. In addition, it also does not hurt to emphasize how important is to find for investigation of foods (fruits in this case) non-destructive methods. Of course there are well-known equipments (e.g INSTRON or fructometer) for the rheological and textural measurements, but these are the devices, what probably do not have the school labs. The described measurement technique is applicable of course also in case of vegetables (e.g. tomato).

Otherwise, if the measurements are carried out with the fruit samples over several days, the pupils can compile a "series", and on this base you can determine how old (how many days) can be the sample of the given variety, and it is even possible to estimate how long it can be stored for the applied storage conditions (temperature, relative humidity of the air).

MICROWAVE OVEN FOR DETERMINATION OF WATER CONTENT BY MEASUREMENT OF TEMPERATURE

In the last decades the use of microwave technique is a daily routine even in the home kitchens for increase of the temperature of different foodstuffs and meals. This is a fast, simple, economical heat-transfer technique, with minimal need of washing-up. The essence of the techniques is the following: if we switch on the apparatus it will be created a magnetic field with high energy (the frequency is appr. 2 x 10^9 Hz) of microwave range. The foodstuffs contain in general high amount of water, and the energy-transfer is realized in consequence of resonance (interaction) between the water molecules with dipoles (high permittivity) and the microwave radiation, rotating the water molecules. The rapid movement and friction of the molecules produces the heat development. Of course the applied electrical power depends on the intensity and time of the treatment.

Because the resonance (the direct energy transfer) is valid dominantly for the water content in the investigated food sample, therefore the temperature-measurement can be applied also for the estimation of the water content. Although theoretically this measurement method is applicable for water determination in any case (circumstances and samples), however in practice it can be carried out with the necessary accuracy only in that case – because of complexity of correction factors – if the conditions and the mass of the samples are the same. So e.g. in case of liquid samples with 40%, 60 % and 80 % water concentration – fruit juice and fruit syrup samples – the differentiation can be carried out easily with determination of the temperature. The following formula is used for calculation:

$$Q = c \times m \times T$$

where:
Q – input of heat energy
c – specific heat
m – mass
T – measured temperature-difference

Of course in case of real foodstuffs the sample contains many components, there

are other components (e.g. sugar), as well, having much less specific heat parameters, than in case of water. These components do not get warm themselves (or only slightly) during the treatment, but from the water- which warms up continuously during the treatment – heat will be uptake. So the energy of the microwave machine is used not only for the increase of the temperature of the water inside the sample. Other energy-loss is based on the temperature-uptake of the structural materials of the oven (e.g. rotating glass-teller for sample holding) and the container of the sample. Because of these uncertainties of the characteristic parameters the precise determination of the water content is not possible, but in case of similar conditions the siginificant differences in the water content can be measured and proved.

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By the beginning of the 20th century the production and processing of paprika became a powerful industry and by this time even commercial categories developed, and ground paprika and paprika strung up in garlands were sold at different paprika markets. Colourful packaging materials, decorative boxes and, to combat fraud and deception, guarantee/tax seals appeared. In addition, a chemical laboratory was also established in Szeged to lay down the scientific foundations of paprika research.

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