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IMPACT OF THE SPEED OF THE MEASURING HEAD OF THE TEXTURE MEASURING DEVICE ON THE OBTAINED VALUES OF BASIC DIFFERENTIATORS OF THE TEXTURE PROFILE ANALYSIS OF CAPRESI CHEESE

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ABSTRACT

The objective of the paper was to obtain the impact of the velocity of a measuring head on measuring values of basic differentiators of the texture profile analysis (TPA) such as: hardness I and II, cohesiveness, adhesiveness, elasticity, chewiness and gumminess as well as resilience. The investigated material was subjected to double compression to 50% of original height at the following head speeds: 0.5; 0.83 1.0; 1.2; 1.5 (mm·s^{-1}). Cubic samples of cream cheese of Italian type Capresi with the side length of 15 (mm) were analysed. The obtained test results proved that statistically significant differences (at α=0.05) were reported only in few cases between the results obtained for particular analysed levels of the measuring head speed. However, one may report clear trends of changes of TPA differentiators values with increase or decrease. The increase of hardness differentiators I and II may be reported with the increase of the measuring head speed (however without confirmation of statistically significant differences at α=0.05). A similar trend may be also reported for gumminess and chewability differentiator on account of the head speed from 1.0 to 1.5 (mm·s^{-1}).

Introduction

Primary sensory properties of food include color, taste, smell and texture. These properties are nowadays closely linked to food quality (Szczesniak, 1963). Instrumental methods of measuring texture are currently more and more widely used for measurments and quality control in food engineering (Kress-Rogers and Brimelov, 2001; Marzec, 2008).

A classic method of analysing texture is to gather a group of trained experts to evaluate each organoleptic characteristic. This method is worked-out in detail and described with a series of standards, however quite cumbersome in aplication. Analytical apparatus, in this case a human, despite having an enormous potential, always more or less introduces an uncertainty as to the obtained result (Marzec, 2008).

In the case of food texture which is closely related to mechanical properties, instruments to determine strenght properties were introduced. These methods allow easier, faster and less control measurements of food texture which in turn enables the end product to be of a better quality (Mazur and Andrejko, 2003; Mazur, 2009; Mazur et al., 2011).

A common procedure is to press a sample to 50% of its original height (however, it is not a rule as many researchers use 25-80% height in their work). Names, terminology and even units of measurements have underwent various modifications in time (Szczesniak, 1963; Bourne, 2002), which was presented in table 1. Moreover, different researchers very often employ different perspectives on each determinants of TPA which leads to errors in refering units to specific determinants.

In the case of head speed range used by the researchers there is also considerable difference (tab. 1).

Table 1
The list of selected variants of methodologies of texture profiled analysis of samples on the example of cheese

Research team	Material	Parametres of samples and test
Serano et al. (2004)	Cheddar Cheese	Cuboid sample 20 (mm); Compression – 50%; Velocity of the measuring head 1.0 ($mm \cdot s^{-1}$).
Kahyaoglu et al. (2005)	Gaziantep Cheese	Cylindrical samples - diameter 22 (mm); and hight 20 (mm); Compression to 25%; Velocity of the measuring head 1.67 ($mm \cdot s^{-1}$).
Cais-Sokolińska et al. (2006)	Mozzarella Cheese	Cylindrical samples - diameter 17 (mm); and hight 12 (mm); Compression to 50%; Velocity of the measuring head 0.5 ($mm \cdot s^{-1}$).
Sołowiej (2007)	Cheese analogues	Cylindrical samples - diameter 15 (mm); no information on smaple height; Compression – no info; Velocity of the measuring head – 1.0 ($mm \cdot s^{-1}$).
Shirashoji et al. (2010)	Cheddar Cheese	Cylindrical samples - diameter 16 (mm); and hight 17.5 (mm); Compression to 80%; Velocity of the measuring head – 0.8 ($mm \cdot s^{-1}$)

A sizeable difficulty in comparing results of Texture Profile Analysis obtained by different researchers, even in the same group of products or even the same product, is brought about by incomplete information as to the applied methods or their different variants, especially a sample size and shape and measuring head speed (Serano et al., 2004; Kahyaoglu et al., 2005; Cais-Sokolińska et al., 2006; Sołowiej, 2007; Shirashoji et al., 2010). Determing the impact of the measuring head speed on values of TPA determinants and potential standarising of this issue requires further research and analysis.

Objective of the study

The objective of the study was to show the impact of the measuring head speed on values of basic Texture Profile Analysis (TPA) determinants, such as hardness I and II, adhesiveness, springiness, cohesiveness, gumminess, chewiness and resilience.

Scope of research

Determining basic properties of material under study (water content, pH, basic chemical composition).

Measuring of Texture Profile Analysis determinants: hardness I and II, adhesiveness, springiness, cohesiveness, gumminess, chewiness and resilience of samples of Italian-type Capresi cheese using 5 different measuing head speeds of textere measuring device.

Material and methods

Material under investigation was Italian-type cheese Capresi. Investigation concerned three types of cheese, each of them was from one production batch. Material was stored in refrigeration conditions in temperature of 6ºC ±1ºC. Water content in cheese was determined by drying method in accordance with standard PN-EN ISO 5534: 2005. pH control was realised using pH-meter CP411 in accordance with standard PN 73/A-86232:1973. Texture analysis was carried out using the TPA test with texture analyser TA XT PLUS. Material was subjected to double pressing to 50% of its original height. Measuring head speeds were consistent with the range employed by majority of researchers of this type of material, i.e.: 0.5; 0.83 1.0; 1.2; 1.5 $mm \cdot s^{-1}$ (Serano et al., 2004; Kahyaoglu et al., 2005; Cais-Sokolińska et al., 2006; Sołowiej, 2007; Shirashoji et al., 2010). Analysis was done on cube samples of Italian-type cheese Capresi with the side lenght of 15 mm. Parametres such as hardness I and II, adhesiveness, springiness, cohesiveness, gumminess were acquired quantitatively by looking at a force-time graph, chewiness and resilience were calculated from the relationship (March, 2008). Measurements were done in six iterations. Method of evaluating statistical significance of impact of the measuing head speed on the TPA determinants was variance analysis ANOVA. Basic chemical composition was acquired from the producer.

Results and discussion

The analysed cheese was characterised by the following physical properties and chemical composition (tab. 2).

In the analysed batches of cheese differences in water content, pH and chemical composition were within standard deviations.

Table 2

Basic physical properties and chemical composition of the researched raw material

Name	Cheese I	Cheese II	Cheese III	SD
Water content u, ($kg \cdot kg_{s.m.}^{-1}$)/(%)	2.44/70.92	2.43/70.86	2.42/70.8	0.016
Proteins, (%)	13.6	13.6	13.7	0.06
Carbohydrates, (%)	3.7	3.7	3.7	0.07
Fat, (%)	3.6	3.6	3.7	0.09
pH	4.2	4.17	4.21	0.021

Average values of the specific TPA determinants were presented in table 3 along with highlighted homogeneous groups acquired as a result of the test which was carried out – straight cross section ANOVA, post-hoc, Tukey HSD test.

For four variants of the measuring head speed, i.e. 0.5 and from 1 to 1.5 $mm \cdot s^{-1}$ an increase in value of hardness I, however the observed trend is not statistically significant.

Table 3

The list of average values of TPA differentiators of the cream cheese of the Italian type Capresi with marking uniform groups (α=0.05)

Parameter TPA	Velocity of the measuring head ($mm \cdot s^{-1}$)				
	0.5	0.83	1.0	1.2	1.5
Hardness I (N)	5.842^{a}	6.617^{b}	5.823^{a}	6.228^{ab}	6.395^{ab}
Hardness II (N)	4.052^{c}	4.578^{d}	4.064^{c}	4.301^{cd}	4.265^{cd}
Adhesiveness (mJ)	-0.22	-0.34^{ef}	-0.31^{f}	-0.37^{e}	-0.35^{ef}
Springiness	0.817^{g}	0.803^{g}	0.801^{g}	0.798^{g}	0.794^{g}
Cohesiveness	0.424^{j}	0.368^{h}	0.378^{h}	0.389^{hi}	0.408^{ij}
Gumminess (N)	2.478^{kl}	2.432^{kl}	2.197^{l}	2.427^{kl}	2.610^{k}
Chewiness (N)	2.023^{m}	1.953^{mn}	1.760^{n}	1.936^{mn}	2.075^{m}
Resilience	0.134^{r}	0.108^{p}	0.118^{op}	0.122^{o}	0.129^{or}

Average values for particular levels of TPA differentiators marked with the same letters do not differ statistically significantly

With the speed of 0.83 $mm \cdot s^{-1}$ of the measuring head speed the highest values of this determinants were reported, statistically signifant differences occured for values obtained with the measuring head speeds of 0.5 and 1 $mm \cdot s^{-1}$.

Similar occurences were reported for texture determinants – hardness II.

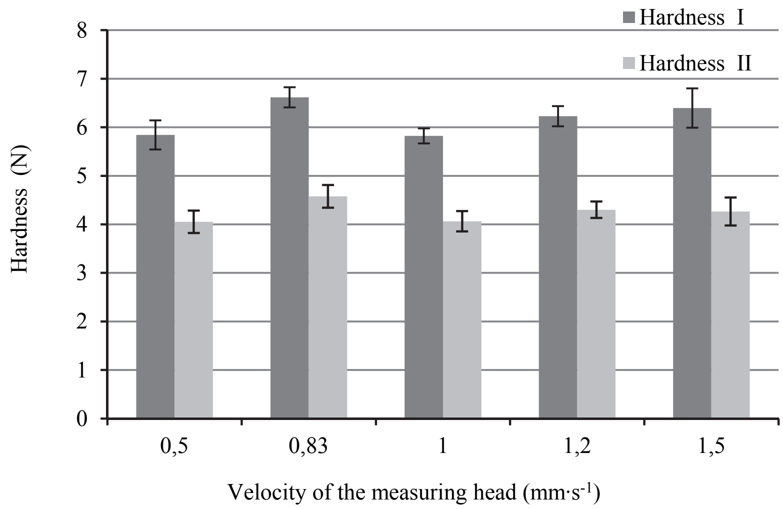

Figure 1. Values of hardness I and II of cream cheese Capresi depending on the applied velocity of the measuring head

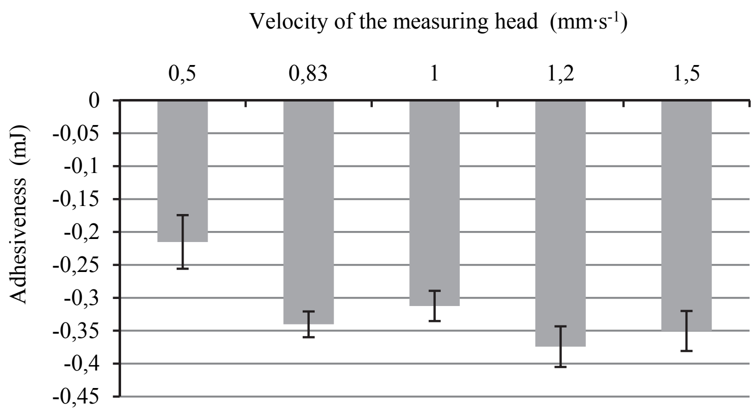

Figure 2. Values of adhesiveness of cream cheese Capresi depending on the applied velocity of the measuring head

The highest values of adhesiveness -0.22 mJ were reported during measurements with the measuring head speed of 0.5 mm·s^{-1} demonstrating statistically significant differences with respect to results obtained with other measuring head speeds.

Statistically signifant differences were observed between results obtained with speeds 1 and 1.2 mm·s^{-1}. As for the latter the lowest values of adhesiveness among the studied cases were reported -0.37 mJ.

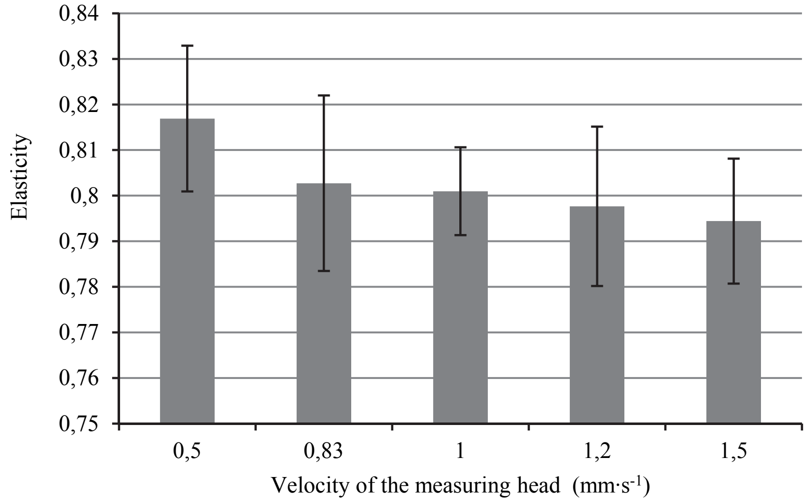

Figure 3. Values of elasticity of cream cheese Capresi depending on the applied velocity of the measuring head

For the entire range of the analysed measuring head speeds of a texture measuring device, with rising speed a decrease in the value of springiness was reported, however statistically significant differences cannot be ascertained using α=0.05.

The highest values of cohesiveness 0.42 were reported during measurements with the head speed of 0.5 mm·s^{-1} demonstrating statistically significant differences with respect to results obtained with the measuring head speeds from 0.83 to 1.2 mm·s^{-1}.

In the case of four variants of the measuring head speed, i.e. 0.83 to 1.5 mm·s^{-1}, an increase in value of cohesiveness was reported, however statistically significant differences occured only for the results obtained with the speed of 1.5 mm·s^{-1} when compared to results obtained with speeds 0.83 and 1 mm·s^{-1}.

The lowest values of gumminess 2.2 N were reported during measurements with the head speed 1 mm·s^{-1} demonstrating statistically significant differences only for the results obtained with extreme among the considered measuring head speeds 0.5 and 1.5 mm·s^{-1}.

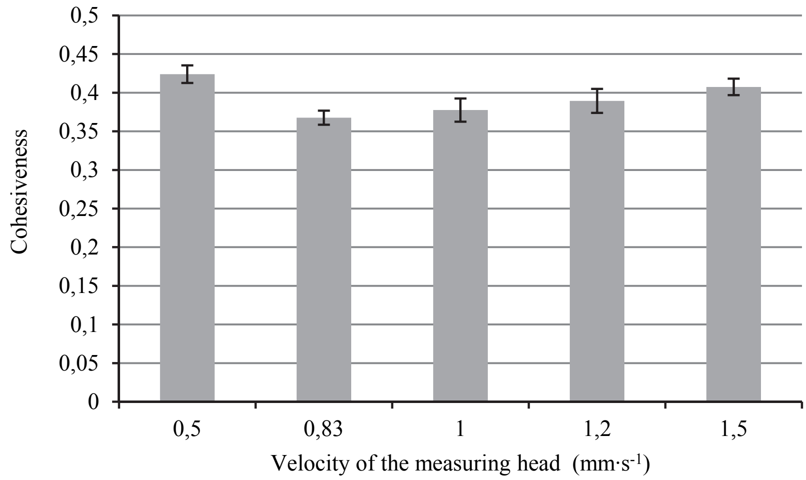

Figure 4. Values of cohesiveness of cream cheese Capresi depending on the applied velocity of the measuring head

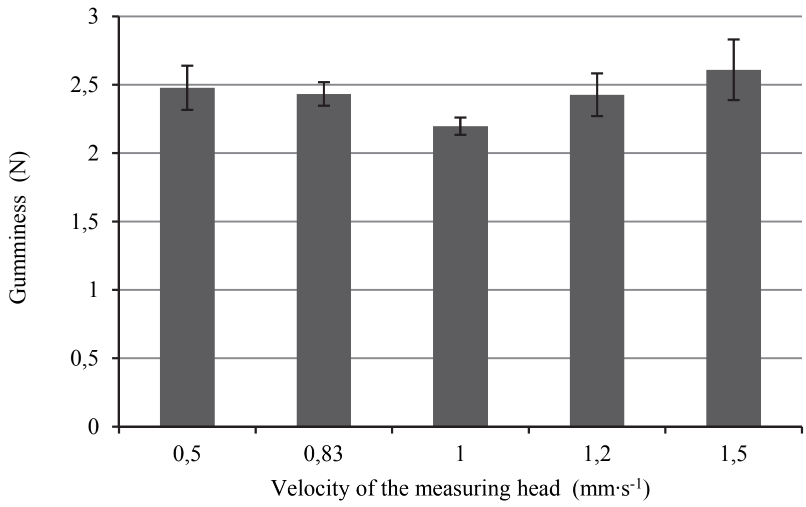

Figure 5. Values of gumminess of cream cheese Capresi depending on the applied velocity of the measuring head

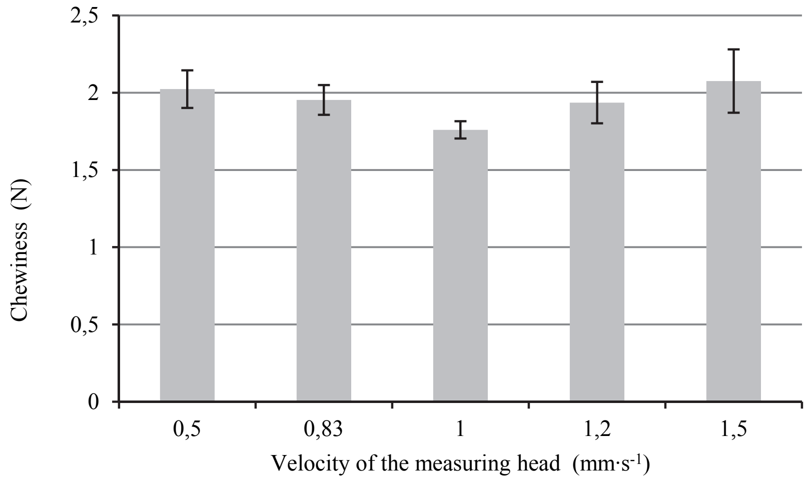

Figure 6. Values of chewiness of cream cheese Capresi depending on the applied velocity of the measuring head

A similar trend as the one observed with gumminess with changes in measuring head speed can be observed also for TPA determinants chewiness.

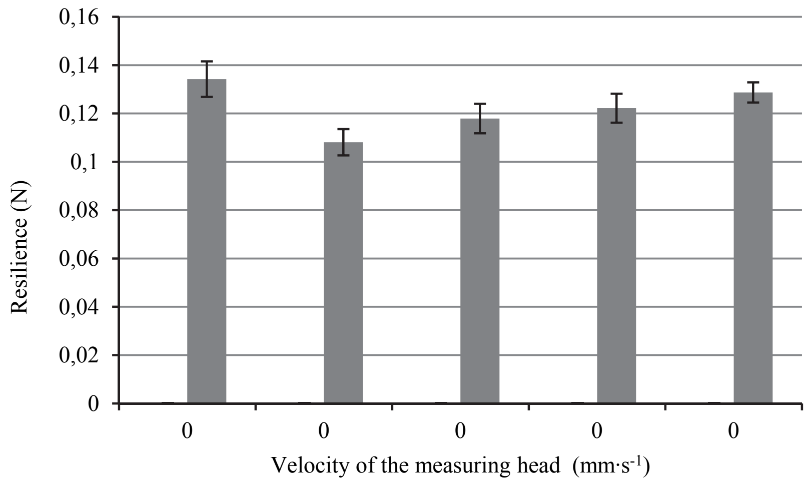

Figure 7. Values of resilience of cream cheese Capresi depending on the applied velocity of the measuring head

The highest values for resilience (0.13) were reported during measurements with the head speed of 0.5 mm·s^{-1} demonstrating statistically significant differences with respect to the results obtained with the measuring head speeds from 0.83 to 1.2 mm·s^{-1}.

In the case of four variants of the measuring head speed, i.e. 0.83 to 1.5 mm·s^{-1}, an increase in the value of resilience was reported as the measuring head speed was increasing.

Statistically signifant differences were not confirmed for results obtained with the head speeds 0.83 and 1 mm·s^{-1} and additionally 1 mm·s^{-1} when comparing to 1.2; 1.5 mm·s^{-1} and additionally with speed 1.2 when compared to 1.5 mm·s^{-1}.

Conclusions

The conducted study allows development of the following conclusions:

1. The obtained test results proved that statistically significant differences (at α=0.05) were reported only in few cases between the results obtained for particular analysed levels of the measuring head speed. However, one may report clear trends of changes of the TPA differentiators values with increase or decrease.
2. The increase of hardness differentiators I and II may be reported with the increase of the measuring head speed (however without confirmation of statistically significant differences at α=0.05). A similar trend may be also reported for the gumminess and chewability differentiator on account of the head speed from 1.0 to 1.5 (mm·s^{-1}).
3. The inrease in the value of the cohesiveness and resilience differentiator was reported as a result of the increasing measuring head speed from 0.83 to 1.5 mm·s^{-1}.
4. The decrease in the value of the TPA differentiators as the measuring head speed increases can be observed for springiness (statistically significant differences were, however, not confirmed using α=0.05). A decrase in the value of resilience was also reported as the measuring head speed rose from 0.5 to 0.83 mm·s^{-1}.
5. A deeper analysis in relation to, for example, the structure of the sample under study is required for values obtained in the TPA test with some levels of the measuring head speed of a texture measuring device, that diverge from trends of other study series. For described material divergences from the trend observed in other study series were reported for the following cases:
   – values of determinants cohesiveness and resilience with the measuring head speed of 0.5 mm·s^{-1},
   – values of determinants hardness I and II and adhesiveness with the measuring head speed of 0.83 mm·s^{-1},
   – values of determinants chewability and gumminess with the measuring head speed of 1.0 mm·s^{-1}.

Investigating only statistically significant differences, one should accept a general conlusion that there is no impact of the measuring head speed on the TPA determinants such as hardness I and II, adhesiveness, springiness, cohesiveness and resilience, gumminess and chewiness for Italian-type cheese Capresi. However, the observed trends require a deeper analysis and the use of a wider range of applied measuring head speeds and more iterations, which may allow for obtaining a more unequivocal answer to the issue of impact of the measuring head speed on the TPA determinants.

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WPŁYW PRĘDKOŚCI GŁOWICY POMIAROWEJ TEKSTUROMETRU NA UZYSKIWANE WARTOŚCI PODSTAWOWYCH WYRÓŻNIKÓW PROFILOWEJ ANALIZY TEKSTURY SERA CAPRESI

Streszczenie. Celem pracy było wykazanie wpływu prędkości głowicy pomiarowej na wartości pomiarowe podstawowych wyróżników profilowej analizy tekstury (TPA), takich jak: twardość I i II, kohezyjność, adhezyjność, elastyczność, żujność i gumiastość oraz odbojność. Badany materiał poddawano dwukrotnemu ściskaniu do 50% pierwotnej wysokości przy prędkościach głowicy: 0,5; 0,83 1,0; 1,2; 1,5 ($mm \cdot s^{-1}$). Analizie poddano sześcienne próbki sera śmietankowego typu włoskiego Capresi o długości boku 15 mm. Uzyskane wyniki badań wykazały, że statystycznie istotne różnice (przy α=0,05) zanotowano tylko w nielicznych przypadkach pomiędzy wynikami uzyskanymi dla poszczególnych analizowanych poziomów prędkości głowicy pomiarowej, jednak można zaobserwować wyraźne trendy zmian wartości wyróżników TPA w miarę jej wzrostu czy spadku. Zaobserwować można wzrost wyróżników twardości I i II w miarę zwiększania prędkości głowicy pomiarowej (jednak bez potwierdzenia statystycznie istotnych różnic przy α=0,05). Podobny trend obserwować można także dla wyróżnika gumiastość oraz żujność w zakresie prędkości głowicy od 1,0 do 1,5 ($mm \cdot s^{-1}$).

Słowa kluczowe: TPA, ser śmietankowy Capresi, prędkość głowicy pomiarowej