

**SENSORY AND QUALITATIVE INDICES (HARDNESS AND COLOUR)  
EVALUATION OF CAKES WITH JERUSALEM ARTICHOKE  
(*HELIANTHUS TUBEROSUS L.*) POWDER**

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**Abstract.** Jerusalem artichoke powder (JAP) from Jerusalem artichoke (*Helianthus tuberosus L.*) roots is a nutritive valuable product that can be used for a healthy product development. The influence of JAP on the quality and degree of liking of cakes was investigated. Sensory evaluation of cakes was realized in two stages: the first - to define the quality attributes of the cakes with JAP from the point of view of the experts, the second – to find out the consumers' views on the cakes, whose quality has been improved in accordance with the recommendations of the experts. As a control sample, the classic home cake was evaluated. Control sample was compared with the cakes, where the amount of wheat flour prescribed by recipe was partly substituted with JAP at different concentrations. Experts evaluated cakes and defined the highest acceptable concentrations of JAP in cakes. For the consumers it was offered to assess the cakes with JAP at concentration 30% and with different taste and aroma enhancers. Cakes with 30% of JAP additive were the most favoured by the sensory properties: aroma, texture, softness elasticity, porosity and softness, surface crust, appearance, colour, shape, and size. Results of analysis of variance showed that there no significant differences in the degree of liking between the cakes with JAP and the cakes with taste and aroma enhancer additives ( $p > 0.05$ ). There had been performed hardness analysis and colour measurement for cakes with JAP. The observed results declare high influence of aroma and taste enhancer on cakes structure and colour.

**Key words:** cake, Jerusalem artichoke powder, sensory analysis.

### Introduction

Jerusalem artichoke powder (JAP) made from Jerusalem artichoke roots is a valuable product, rich in inulin, as well as vitamins and minerals. Using 3–11 grams of inulin per day may improve intestinal activity, as inulin stimulates '*Bifidobacterium*' development, improves fat exchange, reduces blood cholesterol and improves calcium absorption, thereby decreasing risk of osteoporosis (Bekers et al., 2004).

To influence human health positively, JAP can be added to favourite and may be not so healthy foods, including pastry products, which consumption in Latvia is increasing every year and in 2008 was 6.6 kg per household member as shown by the Central Statistical Bureau data (Consumption of food products average per household member per year, 2010).

As one of the most popular pastries are cakes that can be enriched with JAP, thus producing a healthy product. JAP increases the nutritional value of cakes substantially, reducing 'empty' calorie ingesting and giving also benefit for health.

Enrichment of daily products, including cakes has become popular. Earlier studies showed that it is possible to replace typical component of cake by a valuable product, for example, wheat flour can partly be substituted by almond flour (Jia et al., 2008), rice flour (Sae – Eaw et al., 2007) or barley flour, etc.; butter can be substituted by gum or olive oil, etc.; full cream milk - by skimmed milk; sugar - by sucrose syrup or encapsulated aspartame, or extract of stevia (Abdel-Salam et al., 2009), etc. The cake enrichment has a specified purpose, for example, fat reducing, sweets decrease (Jia et al., 2008; Wetzal et al., 1997), calorie quantity decrease (Abdel-Salam et al., 2009) etc.

Sometimes a new ingredient improves the quality of the cake – for example, unique aroma or taste,

appetizing colour, excellent texture and softness, enlarged volume. But the most common reason for enrichment of cakes is nutritional improvement with vitamins, minerals, dietary fiber, valuable bacteria, and other health-enhancing substances. For example, cakes with dietary fiber as lupin, oat fiber, soy polysaccharides, etc. provide users with high amount of dietary fiber, vitamins A, B<sub>1</sub>, B<sub>2</sub>, B<sub>6</sub>, B<sub>12</sub>, E, D<sub>3</sub>, nicotinamide, and folic acid, etc. (Wittig de Penna et al., 2003). Sometimes, for enrichment of cakes specific components are used to make cakes useful for people with health problems – overweight, allergy, diabetics, etc. The diabetics should use low - calorie functional yogurt cakes, because the obtained results showed a decrease in urea and aspartateaminotransaminase values (Abdel-Salam et al., 2009). For example, cakes with rice flour are suitable for allergic people, as rice flour has non - allergenic properties, is free of sodium, cholesterol, and gluten (Sae – Eaw et al., 2007).

The above-mentioned beneficial effects on health may also be observed with Jerusalem artichoke. The full potential of Jerusalem artichoke has not been used, so it has perspectives in future.

Consumers should eat the cakes with JAP in the highest acceptable concentration so to gain the highest benefit for health. Addition of JAP in cakes is not, of course, unlimited; it is limited by the technological factors (Bicāne, 2007) and the sensory requirements to cakes (Linden, 1995).

The aim of current research was to investigate the influence of JAP on the quality and degree of liking of cakes.

### Materials and Methods

Experiments have been carried out in the Laboratory of Food Sensory Evaluation, Laboratory of

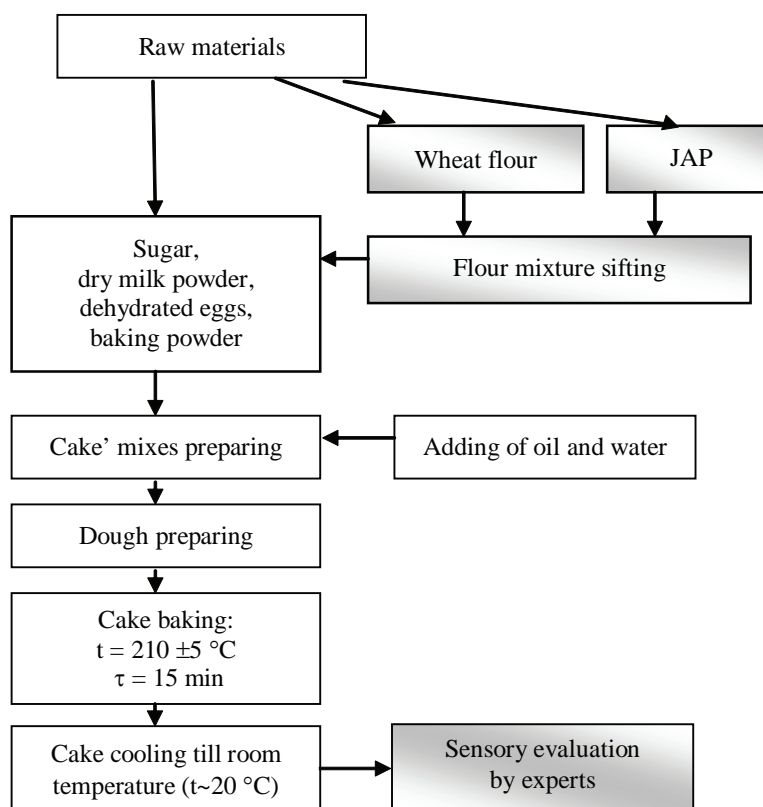


Figure 1. Technological scheme of preparing cakes for sensory evaluation by experts.

Food Analysis, and Research Laboratory of Packaging Material Properties at the Department of Food Technology of the Latvia University of Agriculture.

Sensory evaluation of cakes was realised in two stages: the first - the quality attribute of the cakes with JAP was defined from the point of view of the experts; the second, to find out consumers opinions about the cakes with JAP and aroma enhancers. Texture analysis and colour measurement was performed for improved cakes. Figure 1 shows technological scheme of preparing cakes for sensory evaluation by experts, but Figure 2 - technological scheme of preparing cakes for sensory evaluation by consumers.

#### *Cake preparation.*

For cake production the following materials were used: JAP, wheat flour - type 405C, sugar, dry milk powder, dehydrated eggs, drinking water, vegetable oil, and baking powder.

In the first stage of the experiment the following materials were used: the classic home cake mixture served as a control sample, but in other samples the classic cake ingredient – wheat flour – was partly replaced by JAP at concentrations of 10, 20, 30, 40, and 50% (Figure 1).

In the second stage of the experiment, the following ingredients were used: JAP, wheat flour - type 405C, sugar, dry milk powder, dehydrated eggs, drinking water, vegetable oil, baking powder, and a variety of flavours – vanilla powder, banana pure concentrate, mocha concentrate, cocoa powder, lemon and rum essences (Figure 2).

The experimental cakes were baked in an electric oven at the temperature of  $210 \pm 5$  °C for 15 minutes.

After cooling till room temperature ( $t \sim 20$  °C), the samples were used for analysis.

#### *Colour measurement.*

The colour of cakes with JAP supplemented with varied aroma enhancers was determined by measuring with the Tristimulus colorimeter *Color Tec PCM/PSM* (Accuracy Microsensors, Inc). The CIE Lab colour value included  $L^*a^*b^*$  system, where  $L^*$  determined lightness - darkness,  $a^*$  – redness - greenness,  $b^*$  – yellowness – blueness. Colours were measured in crumb of cake in the middle of slices. It was carried out at least ten readings in three replicates for each cake type.

#### *Evaluation of hardness.*

Hardness of crumb for cake with JAP and varied aroma enhancers was determined using a texture analyzer TA.XT.plus (Stable Micro Systems Ltd). The method is based on compression test (Pre-Test speed and Test speed were  $1 \text{ mm sec}^{-1}$ , Post-Test speed was  $10 \text{ mm sec}^{-1}$ ), using 25 mm DIA CYLINDER ALUMINIUM (type P/25) measuring the hardness of the cakes. The TA.XT.plus texture analyzer was equipped with a load cell of 50 kg. The results were expressed as maximum force in Newtons (N). In these tests Trigger force was 0.04903 N. The outcome was determined from approximately ten readings of three replications for each cake type.

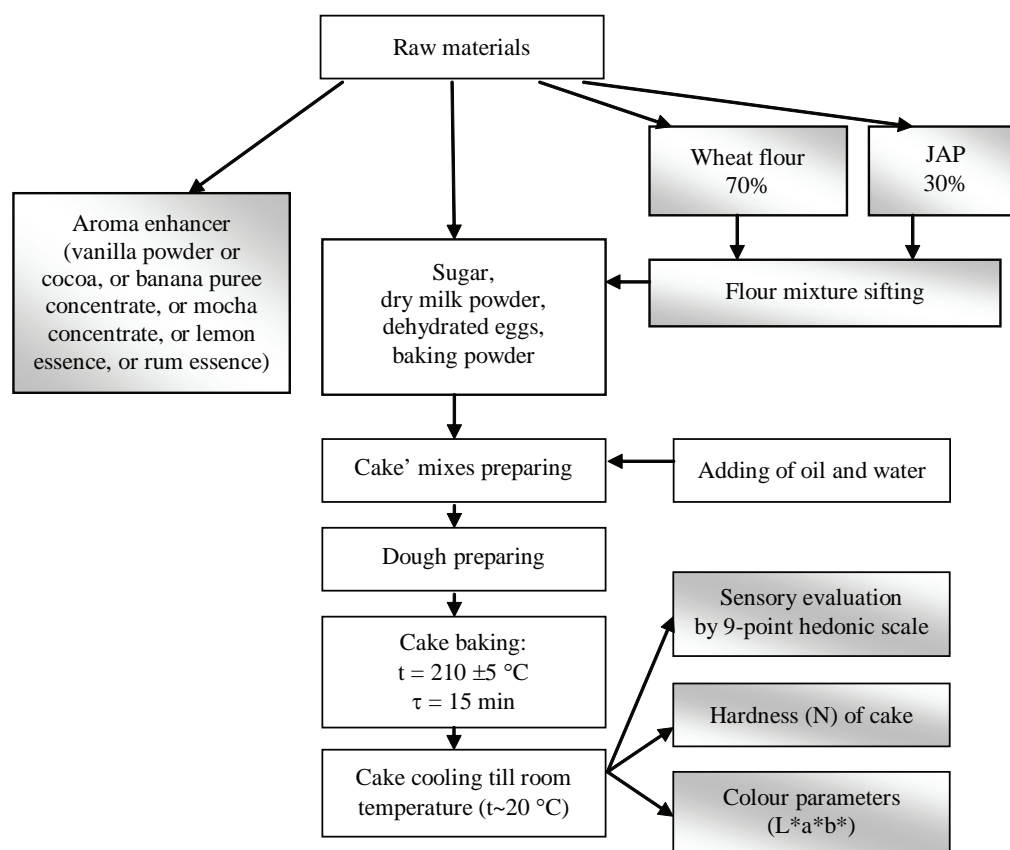


Figure 2. Technological scheme of preparing cakes for sensory evaluation by consumers.

*Sensory evaluation - Quantitative Descriptive Analysis.*

The sensory profiles of cakes with JAP were evaluated by experts (n = 5). Descriptors, description and references were constructed by a panel. The descriptors included appearance (colour, shape, and size), porosity and softness, surface of crust, texture, softness elasticity, crumbliness, aroma, and taste. The structured 5 - point scale (0 – insufficient quality, 5 – very good quality) was used in scoring the quality of each attribute (Strautniece, 2004). All experts were offered six coded samples: control - a classic home cake, and the rest of cakes with different concentrations (10%, 20%, 30%, 40%, and 50%) of JAP.

*Sensory evaluation - Acceptability test.*

The acceptability on taste and overall liking of the cakes with JAP and varied aroma enhancers was evaluated by 50 male (n = 15) and female (n = 35) panellists of the age between 21 and 67.

Each panellist was served with 6 samples (cakes with JAP at the concentration of 30% in variety of cake flavours) in a randomized serving sequence. The improved cakes were offered to consumers for sensory evaluation using a 9-point hedonic scale to determine consumer degree of liking of each kind of samples, i.e., 9 – extremely like, 5 – neither like nor dislike, and 1 – extremely dislike (Meilgaard et al., 1991; Strautniece, 2004).

*Statistical analysis.*

The results were processed by mathematical and statistical methods. Data were processed using one - way analysis of variance (ANOVA) and two-factor without replication analysis of variance (General Linear Model) using the statistical analysis software SPSS 14.0 for Windows; significance was defined at  $p < 0.05$ .

**Results and Discussion**

In sensory evaluation of cakes with JAP experts defined the flavour profile and the highest acceptable concentration of JAP. The obtained results showed that the cakes with JAP have a good score. The results of experts' evaluation are shown in the star diagram (Figure 3). Star diagram describes cakes using a range of attributes - taste, aroma, texture, softness elasticity and porosity, surface crust, and appearance – colour, shape, size.

As the experts' evaluation showed, JAP amount had almost no influence on the aroma, porosity, softness, and texture and crumb elasticity of cakes - the high quality (5-point evaluation) for all samples. The aroma enhancers often made the aroma too intense, but cakes with JAP preserved the pleasant and characteristic aroma. The quality of appearance of cakes decreased proportionally to increase of the JAP concentration. The taste became worse, colour is got darker, shape

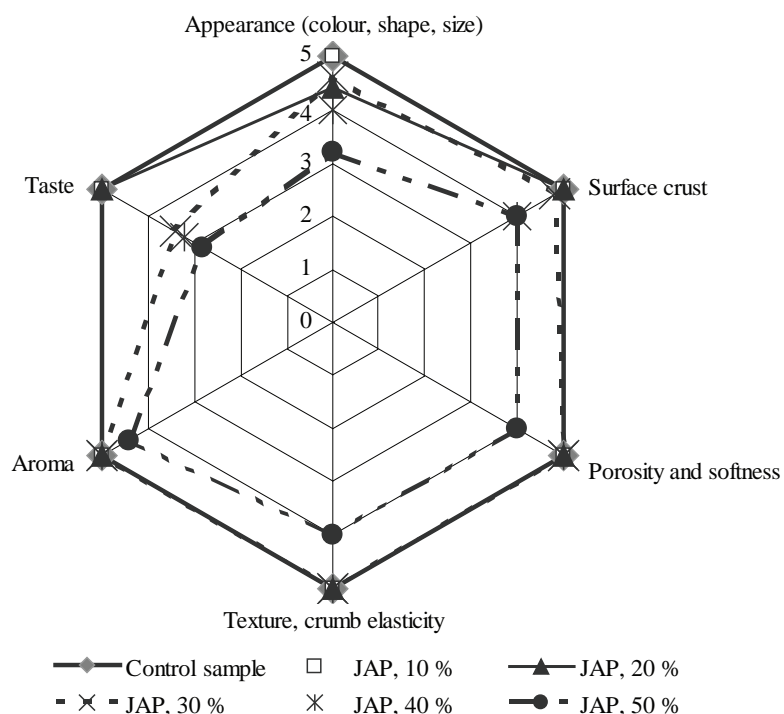


Figure 3. The results of expert evaluation of cakes with JAP using a structured 5 - point scale.

flowed out, and size decreased with increasing of concentrations of JAP in cakes (Figure 3).

The experts determined that the highest acceptable concentration of JAP in cakes is 30%. When increasing content of JAP the cakes needed to be improved with other product that is important for an excellent and enjoyable taste in cakes. If the amount of JAP additive exceeded 30%, the flow ability of dough increased too much, this changed the cake's shape and reduced the volume and size. This could be explained with increase in the amount of fibres in cakes. In that case, experts recommended improving the taste of cakes using several additives.

As Jerusalem artichoke is not known to all people, according to the experts' advice cakes with JAP were

supplemented by different additives - flavouring, essences, concentrates, etc.

Results of analysis of variance showed that  $F_{\text{calculated}} = 0.81$  does not exceed  $F_{\text{critical}} = 1.40$ , therefore there do not exist significant differences between cake samples in the degree of liking. That means that the consumers liked all cakes with JAP similarly (Table 1).

The acceptance test for all samples has been done by a hedonic scale and results ranged from 6 till 7, it means, 'little like' – 'average like'. Overall sensory quality of cakes was 6.82, the highest result was 7.00 – for cakes with banana flavour, but cakes with cocoa flavour had the lowest rating – score 6.32 (Figure 4). The assessment of the cakes suggests that people could accept the new product.

Table 1

**Results of analysis of variance of cake samples evaluated using hedonic scale**

Source of variation	Degree of freedom, df	Sum of squares, SS	Mean squares, MS	Variance ratio, F
Cakes with JAP	6	14966.75	2494.46	74.45
Panellists	49	1321.76	26.97	0.81
Error	294	9850.96	33.51	
Total	349	26139.47		

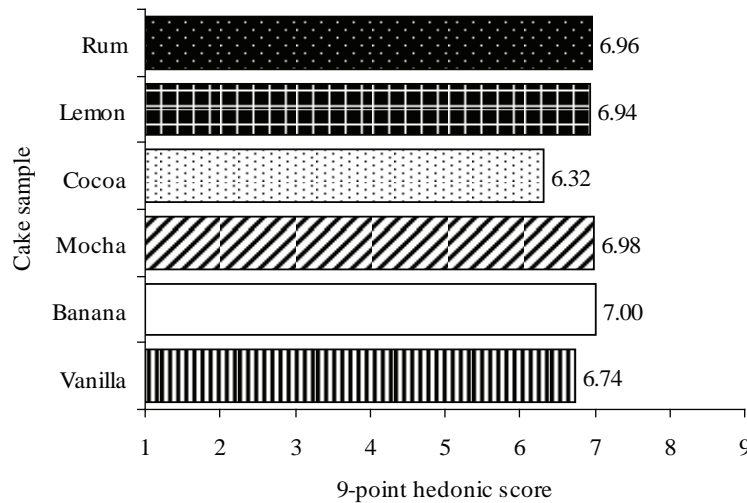


Figure 4. The results of consumer evaluation of cakes with JAP and varied aroma enhancers using a structured 9-point hedonic scale.

General Linear Model tests showed that gender and age has no significant influence on the sensory evaluation of cakes ( $p < 0.05$ ).

Figure 5 demonstrates the average opinion of males and females on cakes with JAP and various ingredients (vanilla and cocoa powder, banana puree concentrate, and mocha concentrate, lemon and rum essence). In general, men gave higher sensory evaluation rating for cakes with JAP than women.

Mocha and rum taste women liked the best, but most women have highly evaluated cakes with bananas and lemon taste. Men stayed loyal to their favourite cakes flavours; they gave the highest scores to the cake with rum and mocha taste, which could be

connected to liking of their favourite drink – rum and coffee. Women have stricter requirements for food, so their rating for cakes is lower. Women most approved mocha flavour, and then followed cakes with vanilla flavour. Both women and men choose fewer samples with cocoa taste. Among of all cakes enriched with JAP, vanilla taste was the most favourite for both genders.

The results of textural analyses (hardness, N) are presented in Figure 6. The cake without JAP and aroma enhancer was used as a control sample. The varied aroma enhancers substantially influenced the hardness of cakes with JAP. The results of the experiment showed that the aroma enhancers affect the structure

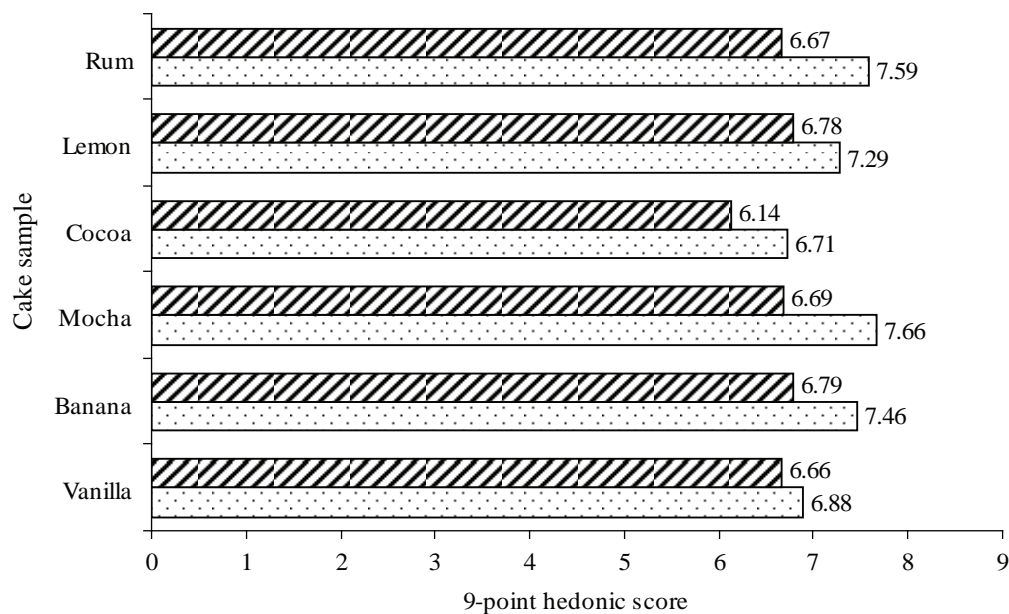


Figure 5. The results of male and female evaluation of cakes with JAP and vanilla or cocoa powder, banana puree concentrate, mocha concentrate, lemon or rum essence by using a structured 9-point hedonic scale (▨ male □ female).

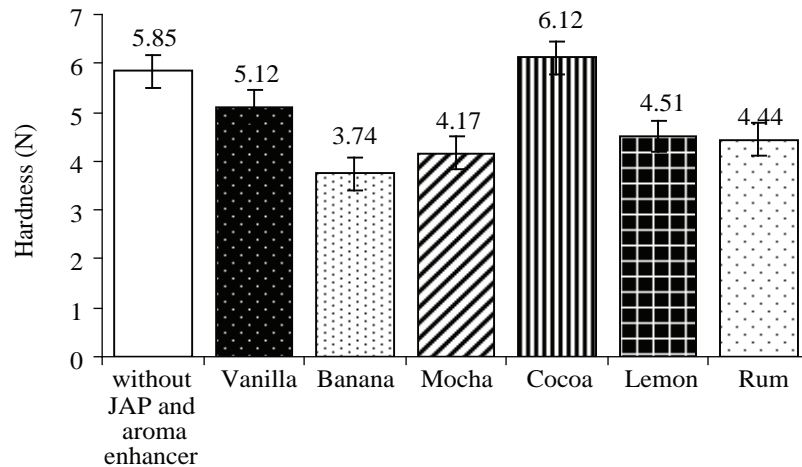


Figure 6. Hardness of the crumb of cakes with JAP and varied aroma enhancers.

of the cake, for example, fruit concentrate addition - banana puree concentrate- makes the cakes more airy and softer than the samples with other enhancers (Figure 6). The cocoa and vanilla in powder form makes the cake's structure harder. The control sample and the sample with cocoa had the highest hardness; nevertheless, the structure of the cakes with cocoa was excellent, porosity was regular, and volume of cakes increased. The results of hardness were similar in samples with essences (lemon and rum).

Changes in colour intensity ( $L^*a^*b^*$ ) in the samples is demonstrated in Figure 7. Addition of aroma enhancer resulted in the highest effect on colour components. Colour component  $L^*$  shows that samples with banana puree concentrate is lighter than other samples; then followed cakes with rum essence, lemon essence and vanilla sugar. The darkest colour is for cakes with cocoa, which is three times darker than sample with banana.

Colour component  $a^*$  show at samples red or green colour. The samples with mocha and cocoa had

positive value which indicates the presence of red colour. All other samples had a little bit green colour.

The yellow colour observed in all samples except one – sample with cocoa. The sample with cocoa had three times lower yellowness as other samples that is shown by the  $b^*$  value in Figure 7.

The results of variance shows that colour components  $L^*$ ,  $a^*$ ,  $b^*$  has been significantly affected by taste and aroma enhancers ( $p < 0.01$ ), because  $F_{\text{calculated}} = 33.39 > F_{\text{critical}} = 6.36$ .

### Conclusions

1. The results of this study indicate that JAP and aroma enhancer do not influence significantly ( $p > 0.05$ ) sensory quality, but it has high influence on cake texture and colour components.
2. Content of JAP amount till 50% has no significant influence only on such sensory properties as cakes aroma, porosity, hardness and crumb elasticity.
3. With increasing concentrations of JAP in cakes, unwanted changes were observed in cakes quality

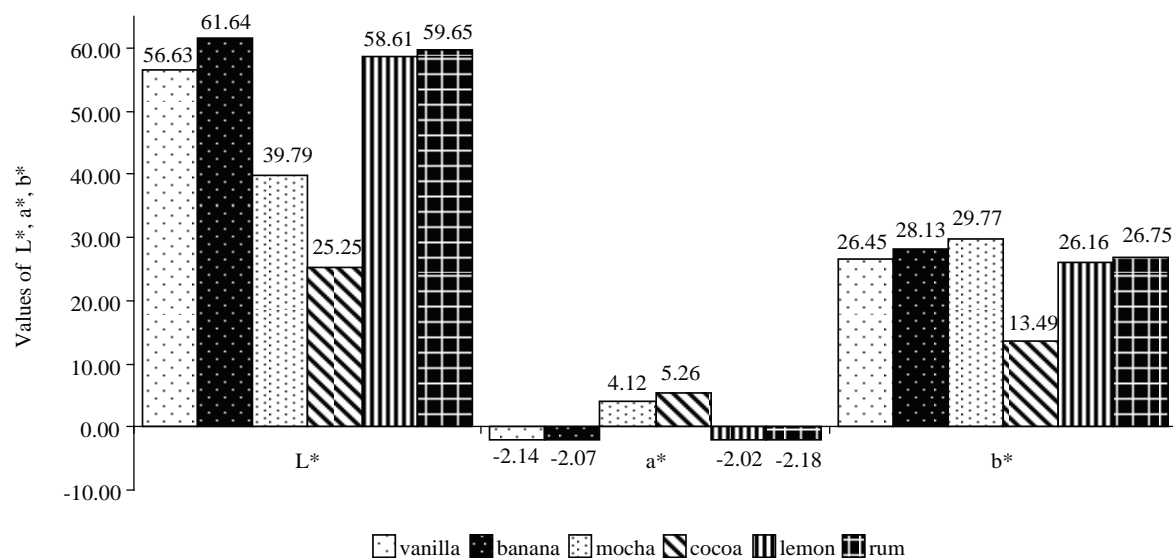


Figure 7. Results of colour analyses for cakes with JAP and taste and aroma enhancers.

- taste became worse, cake colour got darker, shape flowed out and cake volume was low.
4. The cakes retain good quality if amount of JAP does not exceed 30% of total amount of flour.
5. In the hedonic evaluation all samples received score from 6 to 7, its means, 'little like' – 'average like'.

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