mgr inż. Damian Maksimowski

Dissertation's title: Development of a method for obtaining liquid type instant cold brew coffee beverages based on coffee with enhanced sensory and health-promoting properties

Field of science: Agricultural science

Discipline: Nutrition and Food Technology

01.07.2024

Kay words: Coffee, cold brew, extraction, concentrate, 3-CQA, acrylamide, OAV, implementation

Promotor: dr hab. inż. Maciej Oziembłowski prof. Uczelni

Opiekun pomocniczy: mgr Tomasz Nietubyć

Doktorat Wdrożeniowy

Abstract

Cold brew coffee is a competitive beverage category with different sensory characteristics compared to traditionally hot brewed coffees. In this dissertation, a new recipe of instant cold brew coffee with good sensory and health properties was developed. Special attention was paid to the acrylamide content of roasted coffee, optimization of the roasted coffee bean extraction process and the comparison of two concentration techniques (thermal concentration and cryoconcentration) with regard to changes in the chemical composition of selected compounds: acrylamide, chlorogenic acid (3-caffeoylquinic acid, 3-CQA), caffeine and the profile of volatile compounds, which were determined by liquid chromatography LC-MS and HS-SPME gas chromatography GC-MS techniques. All development work was carried out on to a key product in Etno Cafe's portfolio - a classic version of the cold brew coffee drink.

Optimization of the cold brew coffee extraction process made it possible to verify the parameters recommended by the Specialty Coffee Association (SCA), which determine the optimal extraction percentage in the range of 1.15-1.35 % TDS (total dissolved solids). Using Pareto charts, it was found that the extraction time [h] mainly determines the efficiency of the process. Based on the results, three time values [6h, 9h, 12h] were identified for analysis in further stages of the study. The best in terms of implementation were the 12th and 9th hour of extraction, respectively. The results obtained for the 24-hour extraction time showed no statistically significant differences compared to the 12th hour ($p=0.05$).

Analyses for the content of acrylamide in roasted coffee showed that the concentration of this chemical compound was 289 μg/kg in coffee with a roasting profile at 210^{o}C, which was on average 80 μg/kg higher than variants at 220^{o}C and 230^{o}C.

A wide range of analyses in the next stage were carried out on the of 3-CQA and caffeine content in the extracts and the concentrates prepared from them. In each experimental trial, as the extraction temperature increased, the efficiency of the process increased. In most cases, the concentration of 3-CQA increased with the smaller particle size of the grains used in the extraction process, while for caffeine, grain size showed no significant effect on its extraction rate. Moreover, for caffeine, the higher concentration in the extract also significantly depended on the higher roasting temperature of the grains. According to the literature, the highest concentrations of 3-CQA in the extract were found for the 210^{o}C roasting profile, which ranged from 0.606 to 0.639 mg/ml (in variants with brew: ratio, degree of coffee bean grinding, temperature and extraction time of 5g×1.0mm×25^{o}C×12h and 6g×1.0mm×5^{o}C×6h), while the lowest for the 230^{o}C roasting profile ranged from 0.318 to 0.334 mg/ml (in variants of 6g×1.5mm×5^{o}C×6h and 5g×1.5mm×25^{o}C×12h), which is related to the low persistence of chlorogenic acid at higher processing temperatures. Importantly, in the case of the cryoconcentration process, the results of 3-CQA content between the 210^{o}C and 220^{o}C roasting profiles were at comparable levels and were above 1.5 mg/ml. In contrast, an average of one and a half to two times less 3-CQA was observed during thermal concentration of extracts on an evaporator under reduced pressure compared to the cryoconcentration process.

Comparing the results obtained for caffeine content, the average concentration of this compound in the extracts after roasting for the 230^{o}C was found to be 0.795 mg/ml, for the 220^{o}C roasting profile at 0.827 mg/ml, and for the 210^{o}C roasting profile at 0.633 mg/ml. After the cryoconcentration process, for the 230^{o}C roasting profile the caffeine content was at 1.834 mg/ml, for the 220^{o}C roasting profile at 1.867 mg/ml and for the 210^{o}C roasting profile at 1.756 mg/ml. After thermal concentration, the caffeine content of the concentrates for the 230^{o}C roasting profile was at 2.783 mg/ml, for the 220^{o}C roasting profile at 2.41 mg/ml, and for the 210^{o}C roasting profile at 2.247 mg/ml.

The third stage of the work involved analyzing the acrylamide content of roasted coffee extracts obtained at 220^{o}C and 230^{o}C roasting profiles. It was found that the process of extracting this chemical compound from coffee into solution was influenced by the variables of bean fineness, temperature and extraction time. The average difference for all experimental samples considered between roasting temperatures was 1.29 ng/ml. In each case, higher concentrations were recorded against extracts obtained from coffee roasted at 220^{o}C, while the highest value was 10.63 ng/ml. As a result of the work carried out, variants with the lowest concentration of acrylamide were defined, whose content was, respectively, for the 220^{o}C roasting profile: 4.84 and 6.29 ng/ml, and for the 230^{o}C roasting profile: 4.42 and 5.11 ng/ml.

The block cryoconcentration technique developed in the fourth stage made it possible to obtain satisfactory (i.e. at a relatively low level) acrylamide content at an average level of 3.73 ng/ml. Nevertheless, a significantly higher level of acrylamide reduction was observed in the case of thermal concentration - the average concentration was at the level of 2.88 ng/ml. The obtained samples with enhanced health-promoting properties were evaluated in a two-stage sensory test performed by experts, professionally affiliated with Etno Cafe (the fifth stage of the research). A ten-point numerical scale was used, in which the corresponding levels of

quality (desirability) and intensity were assigned corresponding numbers (1 - low quality/desirability, low intensity; 10 high quality/desirability, high intensity). The expert evaluation showed that the concentration technique resulted in a final product with a higher degree of desirability. The concentrate was characterized by a sweet taste and a fruity-floral aroma typical of cold brew coffee. At the same time, an emerging problem during the production of thermal concentrates was pointed out, related to the intensity of the bitter taste and roasted aroma, which was reflected in the low-rated sensory distinction of the "aftertaste", sensation after swallowing. The study of the cryoconcentrate formulations selected for implementation in terms of quality and quantity of aroma components by gas chromatography using supersurface phase analysis techniques made it possible to clarify the improved sensory properties of instant cold brew coffee drinks "liquid" type. Three key compounds stood out: 2-ethyl-3,5-dimethylpyrazine, guaiacol and isovalerialdehyde, which had significantly the highest and also highly dominant OAV values.

The implementation value of the research was to obtain a liquid instant coffee recipe developed on the basis of the beverage cryocentration technique using the parameters of the extraction model of 6g×1.0mm×25^{o}C×12 coffee roasted at 220^{o}C, which was also produced on a prototype technological device developed and constructed during the research.