**Development of a multifunctional cooking appliance:
 evaluation of food quality indexes and cooking functions**

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Two activities related to the identification of quality indexes, in representative foods, for high temperature cooking functions are presented. The first activity aims to identify an objective method for measuring crispness that can be correlated to the sensory perception of this attribute in products cooked by air frying. The second activity concerns the identification and evaluation of qualitative indexes linked to browning and thermal damage, cooked at high temperatures in domestic appliances.

**Sviluppo di un apparecchio di cottura multifunzionale:
valutazione di indici di qualità degli alimenti e di programmi di cottura**

Vengono presentate due attività legate all’individuazione di indici di qualità per funzioni di cottura ad alta temperatura. La prima attività ha lo scopo di individuare un metodo oggettivo per la misura della croccantezza correlabile alla percezione sensoriale di questo attributo in un prodotto modello sottoposto a frittura ad aria.  La seconda attività riguarda l’individuazione e la valutazione di indici qualitativi, legati all’imbrunimento e al danno termico, della pizza nella cottura a temperature elevate in forni domestici.

**Key words**: high temperature cooking, thermal damage, color, mechanical-acoustic properties

**1. Introduction**

In accordance with the PhD thesis project, as presented in Aliberti (2022), this report  regards 1) the development of a method able to discriminate crispness degree of an air fried food through the correlation between mechanical-acoustic parameters and sensory perception; 2) the identification of analytical indexes to evaluate and compare quality characteristics of pizza (i.e., weight loss, color development and thermal damage), baked using high temperature conditions (>300°C) in two home-cooking appliances, both compared to the conventional baking.

**2. Materials and Methods**

**2.1 Crispness evaluation**

Frozen chicken nuggets were used as a model food and air fried (Philips Airfryer XXL) using different time-temperature conditions (from 180°C to 200°C for 10 to 20 minutes). Mechanical-acoustic tests were carried out on a TA.XTplus Texture Analyzer (Stable Micro Systems, Surrey, U.K.) coupled with an Acoustic Envelope Detector (Stable Micro Systems, Surrey, U.K.). Energy, Number of Force Peaks (NFP), Force at 1st Peak and at 2nd Peak were obtained from the cutting test response (Varela et al., 2008). Maximum Sound Pressure Level (Smax), N° of Sound Peaks (NSP), Linear Distance of Sound (LDS), were captured modifying the method described by Varela et al. (2008). Cooking process indexes (weight loss, WL; whole and crust moisture, Mw and Mc) were also evaluated. A ranking test was used for sensorial evaluation of crispness: 24 trained assessors were asked to rank five samples from lowest to highest crispy. Data from mechanical-acoustic tests were analyzed by one-way analysis of variance (ANOVA), followed by Fisher’s LSD test to highlight significant differences (P< 0.05) among samples, by STATGRAPH plus 5.1 (Statistical Graphics Corp., Herndon, VA, USA). Ranking data (as the sum of induvial ranks, ∑ ranks) were analyzed by Friedman analysis of variance to verify the existence of significant preference differences among the samples (Lawless & Heymann, 2010). The Fisher's Least Significant Difference was used to identify the samples that differed among themselves at 5% of significance.

**2.2 High temperature pizza cooking**

Homemade pizzas were prepared following a traditional recipe. The cooking performance was followed at different high temperature conditions. Three ovens were used: an electric high temperature pizza oven (P134H, EffeUno Srl, Limena, PD, Italy) working at 450°C (HiT), a commercial oven (BIM19700DXMS, Beko Srl-Arçelik AŞ, Istanbul, Turkey) with an automatic pizza function, working at 310°C (MeT), and a conventional baking oven (AKZ9 6270 IX, Whirlpool Corporation, Mi, USA) working at 250°C (LoT). Each appliance was preheated before the baking tests. WL% was evaluated gravimetrically; Browning Index, BI and Intensity Mean, IM were evaluated on pizza crust by image analysis software Image-Pro® v10 (Media Cybernetics, Rockville, MD, USA) to assess color development. The content of5*-*hydroxymethylfurfural, HMF (determined by HPLC) and the Maillard Reaction Products, MRPs (determined spectrophotometrically) of pizza crust were considered as thermal damage indexes (Giovanelli & Cappa, 2021). Data were analyzed by one-way analysis of variance (ANOVA), followed by Fisher’s LSD test to highlight significant differences (P < 0.05) among samples at the final cooking time.

**3. Results and Discussion**

**3.1 Crispness evaluation**

Table 1 reports the data obtained by the mechanical-acoustic tests on chicken nuggets air fried at different t/T conditions, together with the sensory test results. Data trends and statistical significance are similar for Energy, NSP, LDS and ∑ ranks. Crispness increases from least crispy nuggets (180°C x 10min) to most crispy nuggets, obtained at 190°C x 20min. Coherently, WL% increase while Mw% and Mc% decrease. Among mechanical properties, energy is directly proportional to WL% (R2= 0.947) while regarding acoustic properties, NSP and LDS are inversely correlated to Mw% (R2= 0.976 and 0.960, respectively). Sensory data are statistically correlated to Energy (R2= 0.950), NSP (R2= 0.965) and LDS (R2= 0.981). The correlation between sensorial perception of crispness and textural and acoustic characteristics is verified and will allow to estimate sensorial crispness by an instrumental objective evaluation method.

***Table 1*** Results of instrumental and sensory tests of air fried chicken nuggets samples at different time-temperature conditions.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | **Mechanical test** |  | **Acoustic test** |  | **Sensory test** |
| **Sample** |  | **Energy**(10-3Nꞏm) | **NFP** | **Force 1st peak**(N) | **Force 2nd peak**(N) |  | **Smax**(dB) | **NSP** | **LDS**(10-3 dBꞏm) |  | **Σ ranks** |
| 180°Cx10’ |  | 218±30a | 3.7±0.8a | 16.0±1.5a | 15.0±1.7a |  | 71.8±5.0a | 53.1±17.1a | 6481±714a |  | 24a |
| 180°Cx15 |  | 299±33b | 3.7±1.2a | 21.4±3.0b | 25.5±6.7b |  | 81.0±2.7b | 120.9±38.4b | 10400±2265b |  | 53b |
| 190°Cx15 |  | 325±41bc | 5.1±1.8ab | 23.1±2.0b | 29.3±6.9b |  | 82.1±2.9bc | 186.7±53.3c | 14543±3029c |  | 74bc |
| 190°Cx20 |  | 442±54d | 10.7±2.4c | 30.4±4.2c | 40.6±10.9c |  | 84.1±1.3c | 260.9±40.3d | 18979±2434d |  | 117d |
| 200°Cx15 |  | 342±61c | 6.8±2.7b | 23.1±2.4b | 32.4±11.6b |  | 81.7±3.0bc | 184.6±45.6c | 15211±2893c |  | 92c |

**3.2 High temperature pizza cooking**

Cooking tests show similar final WL for HiT and MeT and evidence that thermal damage indexes increase at all baking temperatures. HFM level is similar in pizza baked at MeT and LoT; at HiT, HMF level increases sharply after 2 min cooking time. The increase in MRPs with cooking time is similar to HMF formation. Considering the optimal cooking time at each temperature, HiT and MeT pizza reached a similar percentage WL (9.1-10.6%), lower than that obtained at LoT (15%). HiT cooking resulted in the highest levels of HMF and MRPs; similar and definitely lower values were detected in LoT and MeT cooking. Concerning color development, the samples differed significantly: both IM and BI indexes showed the lowest and highest values in HiT, which appeared darker, while pizza crust baked at MeT was slightly browner than the pizza crust baked at LoT.

***Table 2*** Cooking parameters of pizzas cooked at different time-temperature conditions.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sample** |  | **T**(°C) | **t**(min) |  |  | **WL**(%) | **HMF**(g/kg dw) | **AU 280**(AU/kg dw) | **AU 360**(AU/kg dw) | **AU 420**(AU/kg dw) |  | **IM** | **BI** |
| HiT |  | 450 | 2.5 |  |  | 9.1±1.0a | 37.6±3.0b | 1047.0±126.0b | 202.3±21.1b | 80.9±9.8c |  | 101.0±13.0a | 54.6±6.2b |
| MeT |  | 310 | 8 |  |  | 10.6±0.1a | 2.5±0.2a | 675.5±4.0a | 60.3±1.2a | 14.8±1.2a |  | 164.9±20.2b | 29.2±6.3a |
| LoT |  | 250 | 14 |  |  | 15.0±1.2b | 2.0±0.6a | 765.4±80.0a | 118.2±2.9b | 64.4±2.4b |  | 176.4±7.2b | 24.6±2.3a |

These data indicate that very high baking temperatures can produce significant thermal damage, potentially harmful for health.

**3. Selected References**

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**4. Acknowledgements**

*Progetto finanziato nell’ambito PON: "“Ricerca e Innovazione” 2014-2020, Asse IV “Istruzione e ricerca per il recupero” con riferimento all’Azione IV.4 - “Dottorati e contratti di ricerca su tematiche dell'innovazione” e all’Azione IV.5 “Dottorati su tematiche green”. DM 1061/2021”.*