

## Study of medium-high shelf life ready-to-use dough rolls for making “pizza napoletana”

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### Abstract

The aim of this work was to investigate the possibility of developing an innovative technology to obtain ready-to-use dough rolls with a medium-high shelf life, useful for pizza-making within the disciplinary procedures of *Pizza Napoletana* production. For this purpose, dough obtained according to the classic recipe was leavened for 20 min at 25°C, divided into 250 g dough rolls, and further leavened for 8 (C8) or 16 h (C16) at 22°C before packaging. The packed samples were stored at 2.0 ± 0.5°C for 28 days. Every 7 days, colony-forming units, pH, total titratable acidity, volume, and the consistency of the dough rolls were evaluated. After 28 days, the samples with the longer leavening time (C16) exhibited similar characteristics to the fresh product. In addition, the ability of the dough to develop a pizza rim was evaluated through cooking tests after 28 days of storage: the rims of the C16 rolls were similar to that of the fresh product. These results represent an important starting point for large-scale marketing of ready-to-use dough rolls, allowing consumers to taste a real “Pizza Napoletana” (TSG) product even in pizzerias outside the Campania region.

**Keywords:** bakery product; dough roll; leavening; Neapolitan pizza; shelf life

### Introduction

The Neapolitan pizza is the most popular product of Italian gastronomy in the world. Its diffusion around the world has led to the development of many variants of the original technology, adapting the process to different consumer tastes and processing techniques compatible with regulations adopted in various regions and countries. To protect the art of making pizza in Neapolitan style, the European Commission Regulation no. 97/2010 (EC, 2010) entered the name “Pizza Napoletana” in the register of traditional specialties guaranteed (TSG) to define and thus preserve its original characteristics. In 2017, the UNESCO recognized the Neapolitan pizza-making technology (art) as an “Intangible Cultural Heritage of

Humanity.” However, achieving the true taste of this product remains linked to fresh consumption in pizzerias mainly in the Campania region. The disciplinary procedures of production that define the standards for raw materials and technological parameters do not prohibit the possibility of using semifinished products for the production of “Pizza Napoletana,” or dough rolls produced outside the premises where the pizza is rolled, garnished, and cooked. To satisfy the growing demand for excellent quality pizzas all over the world and strengthen the commercialization of this product, a study was conducted on the possibility of developing innovative solutions, compatible with the disciplinary procedures of production, that allow us to obtain ready-to-use dough rolls with a medium-high shelf life for making pizza.

Refrigerated dough is becoming increasingly popular among producers because it allows consumers to save time (Shimura *et al.*, 1999). A common problem of refrigeration (5–8°C) is the leavening phase in which the leavening agent continues its activity (Domingues, 1997) and generates large quantities of carbon dioxide, and the final structure is modified by several parameters (Gugerli *et al.*, 2004). For this purpose, the dough rolls obtained from the traditional recipe were left to rise for 8 (C8) and 16 h (C16) before packaging and kept for 28 days at  $2 \pm 0.5^\circ\text{C}$ . Colony-forming units, pH, total titratable acidity, volume, and consistency of the mixes were evaluated at scheduled times of 7 days. Finally, the growth of the raised rim after 28 days of storage compared to the fresh dough roll leavened in 16 h was evaluated through image analysis during the cooking time.

## Materials and Methods

### Materials

To prepare the dough roll samples in this work, the following ingredients were used: type 00 soft wheat flour with nominal humidity of 12% w/w, supplied by Mulino Caputo (Antimo Caputo Srl, Naples, Italy); fresh brewer's yeast (Lesaffre Italia, Trecasali, Parma, Italy); fine salt (Italkali, Petralia, Palermo, Italy); and deionized water.

### Chemicals

Plate count agar (PCA), potato dextrose agar (PDA), and De Man, Rogosa e Sharpe agar (MRS) were purchased from HiMedia Laboratories. NaCl, NaOH, and sodium–potassium tartrate of analytical grade were purchased from Carlo Erba (Italia).

### Pizza dough preparation

The Neapolitan pizza dough was prepared as described by Falciano *et al.* (2022). Soft wheat flour type 00 (60.0%) was combined with 38.0 % of deionized water at 16–18°C, 1.9% fine salt, and 0.1% fresh brewer's yeast. The brewer's yeast was dispersed in water for about 3 min before mixing. The mixing was carried out in a spiral mixer (Grilletta IM5, Famag Srl, Milan, Italy) placed at speed 1 for 18 min. The dough was then left to rest at 25°C for 20 min. Subsequently, it was divided into rolls of 250 g, placed in 60 × 40 cm plastic trays (Giganplast, Monza and Brianza, Italy), and leavened in a climatic chamber (KBF 240, Binder, Tuttlingen, Germany) at 22°C and 80% of relative humidity for 8 (C8) and 16 h (C16). The leavened rolls were then packaged in the polystyrene trays sealed using a packaging machine (TSM105,

Minipack Torre S.p.A., Dalmine, Bergamo, Italy) with a micro-perforated film and stored at  $2 \pm 0.5^\circ\text{C}$  for 28 days.

### Determination of concentrations of viable microbes

Ten gram of dough rolls samples were homogenized with 90 mL of sterile water using a stomacher (BagMixer, Interscience, France). Serial dilutions of homogenized samples in 0.85% NaCl solution were used for determining the microbial count using the following media: plate count agar (PCA) for estimation of total aerobic mesophilic bacteria; potato dextrose agar (PDA) containing 14 mg/L of tartaric acid, 50 mg/L of chloramphenicol, and 50 mg/L of Rose Bengal for yeasts and other fungi; and Agar De Man, Rogosa e Sharpe (MRS) for lactic bacteria. Exactly 1 mL of appropriate dilutions was spread plated in triplicate. Counts of total aerobic mesophilic bacteria and lactic bacteria were obtained after 48 h of incubation at 37°C, while the count of yeast and other fungi was obtained after 5 days of incubation at 30°C (Ben Omar and Ampe, 2000). All values were obtained by counting on the plate. Results were calculated as the means of three determinations.

### Determination of pH, total titratable acidity, volume, and consistency

The values of pH were determined using a pH meter (Hanna Instruments pH211), equipped with an immersion probe, calibrated using standard solutions at pH 7.00, 4.01, and 10.00. After calibration, the electrode was rinsed with distilled water, dried, and then immersed in the sample.

Total titratable acidity (TTA) was measured on 10 g of sample, which was homogenized with 90 mL of distilled water for 3 min in a Stomacher apparatus (BagMixer, Interscience, France) and expressed as the amount (mL) of 0.1 M NaOH needed to achieve a pH of 8.3 (Ercolini *et al.*, 2013).

The volume was measured during storage in a fridge at  $2 \pm 0.5^\circ\text{C}$  by placing the dough rolls in a graduated jar. It was expressed as the ratio of  $V_1/V_0$ .

$$V_1 - \text{volume at } n^\circ \text{ time, mL}$$

$$V_0 - \text{volume at 0th time, mL}$$

The consistency of the dough during storage was measured as described by Gys *et al.* (2003) and Simsek (2009), using a Brabender farinograph with a 50 g mixing bowl (Brabender GmbH & Co. KG, 810153). An 80 g piece of dough was placed in the farinograph mixing bowl and allowed to mix for approximately 5 min. The consistency

was measured in Brabender Units (BU) 2 min after the start of mixing.

### Pizza preparation and monitoring of the raised rim height

For pizza preparation, the dough roll was manually laminated by a professional pizza maker (i.e., Mr. Enzo Coccia, Pizzeria La Notizia, Naples, Italy) to ensure data reproducibility and garnished with 70 g of tomato puree and 30 g of sunflower oil. Subsequently, the pizza samples were cooked in a typical wood-fired pizza oven operating in pseudo-stationary conditions with a vault and floor temperature of 450 and 430°C, respectively, and the growth of the pizza rim was monitored as described by Falciano *et al.* (2023). Using a thermal imaging camera (FLIR E95 42°, FLIR System OU, Tallinn, Estonia) operating in video mode fixed on a support and using a metal reference ruler positioned near the pizza sample inside the oven, the variation was evaluated in the instantaneous height (h) of the raised rim during the baking phase. The images of the pizza sample were extrapolated from the registered video for an overall baking time of 80 s. The images were captured every 2 s during the first 20 s, every 4 s ranged from 20 to 40 s, and finally every 10 s from 40 to 80 s. These were then analyzed using a free, open-source image processing software ImageJ (Java2HTML v. 1.5, National Institutes of Health, Bethesda, MD, USA). The results were expressed as the ratio of  $h_1/h_0$  and compared by the control (Ctr) obtained by using dough rolls with 16 h of leavening without refrigeration.

$h_1$  – height of rim at scheduled time, cm

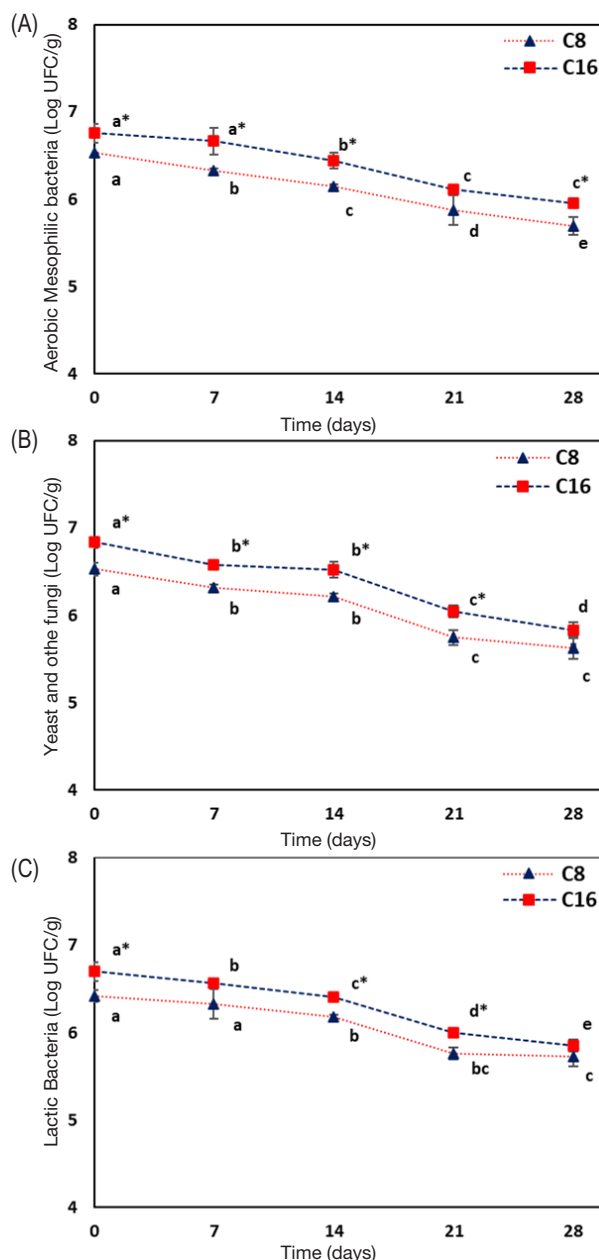
$h_0$  – height of rim at 0th time, cm

### Statistical analysis

All experimental results are reported as means and standard deviation of at least three independent experiments. Statistical analysis was performed using SPSS version 19.0 (SPSS Inc., Chicago, IL, USA). A one-way ANOVA with Duncan's multiple comparison test at 95% confidence level ( $P \leq 0.05$ ) was performed in order to evaluate the differences of each sample (C8 and C16) during the storage time. Moreover, Student's t-test was used to evaluate statistical differences between samples at each incubation time, and P values  $< 0.05$  were considered statistically significant.

### Results and Discussion

Figure 1 shows the evolution of total aerobic mesophilic bacteria (panel A), yeast and other fungi (Panel B), and lactic bacteria (Panel C) during 28 days of storage. The

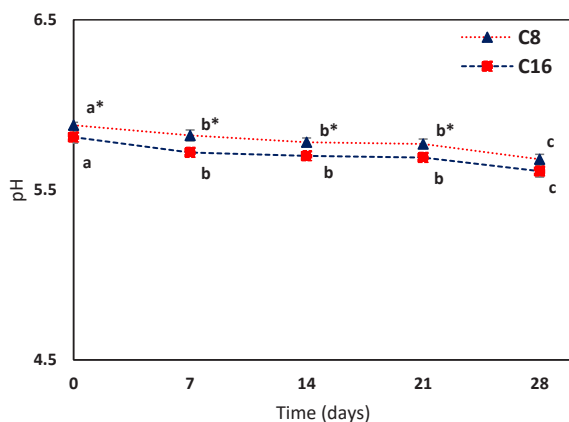


**Figure 1.** Evolution of total aerobic mesophilic bacteria (A), yeast and other fungi (B), and lactic bacteria (C) expressed as Log UFC/g of the dough rolls samples leavened for 8 (C8; ▲) and 16 h (C16; ■) during 28 days of storage at  $2 \pm 0.5^\circ\text{C}$ . Each value is represented as mean  $\pm$  SD ( $n = 3$ ). <sup>a-e</sup> For each sample (C8 and C16), different letters indicate statistically significant differences between values during the storage time (Duncan's test,  $P < 0.05$ ). "\*" indicates statistically significant differences between samples at each storage time ( $P < 0.05$ ; Student's t-test).

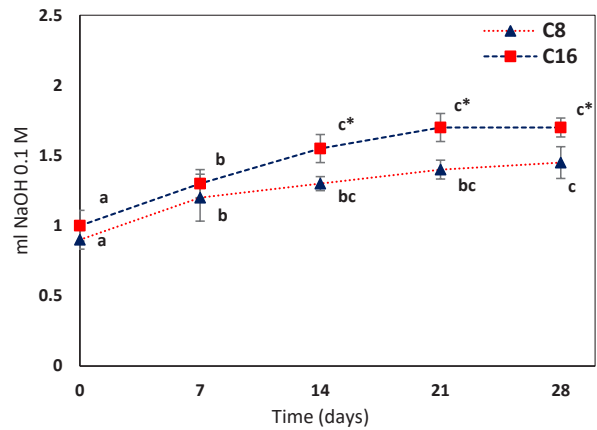
initial concentration of microorganisms was significantly higher ( $P < 0.05$ ) in C16 than in C8 probably due to the longer leavening time. During the storage, a linear decrease of microorganism of about 1 Log UFC/g was observed in all samples.

Furthermore, given that the quantity of aerobic mesophilic bacteria and lactic acid bacteria was similar, it can be assumed that the bacteria present in the samples are mainly represented by lactic acid bacteria. Despite the decreasing curves, the microbes remain alive and viable during 28 days of storage. Some researchers have shown that the viability of yeasts is reduced at freezing temperature ( $-20^{\circ}\text{C}$ ). This is because due to the freezing of the aqueous phase, the organic compounds concentrate and the yeasts face osmotic stress which leads to their autolysis (Selomulyo and Zhou, 2007), while at temperatures between 1 and  $12^{\circ}\text{C}$  the yeast cells continue to grow slowly and carry out their metabolic activity during the entire storage time. Gugerli *et al.* (2004) reported that the lowering of temperature from 30 to  $5^{\circ}\text{C}$  reduces 93–95% maltose production and 99% maltose consumption, and therefore both fermentation and amylase activity are slowed down under refrigerated conditions.

Figure 2 shows the results of pH levels of samples during different refrigerated storage periods. Initially, the pH of C8 was significantly higher ( $P < 0.05$ ) than C16. During the storage, in both samples, a significant decrease ( $P < 0.05$ ) was observed after 7 days and then the pH remained constant until 21 days, and decreased significantly ( $P < 0.05$ ) at 28 days where the samples do not show any significant differences. During leavening, the physico-chemical parameters change, mainly due to microbial metabolism (Paramithiotis *et al.*, 2014), in particular, the production of lactic acid derived from the metabolic activity of lactic bacteria, reduced the pH and increased the values of the TTA (Maifreni *et al.*, 2004). In fact, TTA values (Figure 3) increased significantly



**Figure 2.** Evolution of pH of the dough rolls samples leavened for 8 (C8;  $\blacktriangle$ ) and 16 h (C16;  $\blacksquare$ ) during 28 days of storage at  $2 \pm 0.5^{\circ}\text{C}$ . Each value is represented as mean  $\pm$  SD ( $n = 3$ ). <sup>a-c</sup> For each sample (C8 and C16), different letters indicate statistically significant differences between values during the storage time (Duncan's test,  $P < 0.05$ ). <sup>\*\*</sup> indicates statistically significant differences between samples at each storage time ( $P < 0.05$ : Student's t-test).



**Figure 3.** Evolution of TTA of the dough rolls samples leavened for 8 (C8;  $\blacktriangle$ ) and 16 h (C16;  $\blacksquare$ ) during 28 days of storage at  $2 \pm 0.5^{\circ}\text{C}$ . Each value is represented as mean  $\pm$  SD ( $n = 3$ ). <sup>a-c</sup> For each sample (C8 and C16), different letters indicate statistically significant differences between values during the storage time (Duncan's test,  $P < 0.05$ ). <sup>\*\*</sup> indicates statistically significant differences between samples at each storage time ( $P < 0.05$ : Student's t-test).

( $P < 0.05$ ) both in C8 and C16 after 7 days of storage even though there was no significant difference between the samples. Significant differences ( $P < 0.05$ ) between the samples were observed after 14 days of storage with higher values in C16. These results are in agreement with the greater number of lactic bacteria observed in C16 during the 21 days of storage that generated an increased amount of lactic acid in the sample.

The volume of dough rolls (Figure 4) is a function of the leavening time because of the carbon dioxide generated from yeast, and thus the values in C16 were higher and significantly different ( $P < 0.05$ ) than the one measured in C8 due to a higher yeast content, as expected. Nevertheless, no significant differences were observed during the storage time in both samples even though the yeast decreased significantly ( $P < 0.05$ ) after 28 days of storage (Figure 1B). These results suggest that although the microorganisms were alive during storage, their carbon dioxide production was inhibited. Moreover, the refrigeration process counteracted the collapse of the dough rolls that can be generally observed in unrefrigerated samples after 20–24 h (data not shown).

Figure 5 shows the consistency of dough rolls samples. The initial consistency values were significantly higher ( $P < 0.05$ ) in C8 (360 BU) than in C16 (338 BU) probably due to the shorter leavening time in C8 with respect to C16. In fact, it is well known that the texture of the dough is influenced by fermentation, leavening progress, and the amount of air incorporated. Moreover, doughs with lower density showed lower BU values

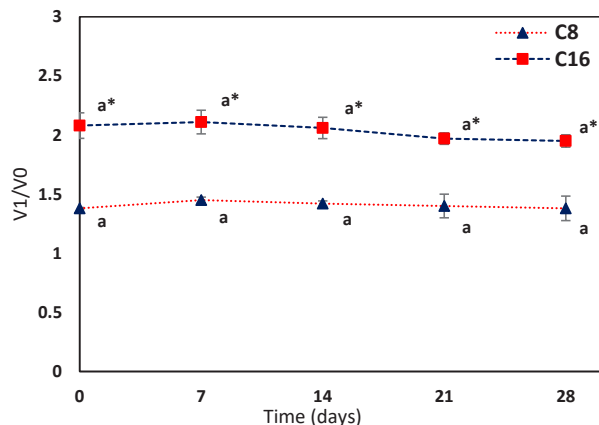


Figure 4. Evolution of Volume ( $V_1/V_0$ ) of the dough rolls samples leavened for 8 (C8; ▲) and 16 h (C16; ■) during 28 days of storage at  $2 \pm 0.5^\circ\text{C}$ . Each value is represented as mean  $\pm$  SD (n = 3). “\*\*” indicates statistically significant differences between samples at each storage time ( $P < 0.05$ : Student’s t-test).

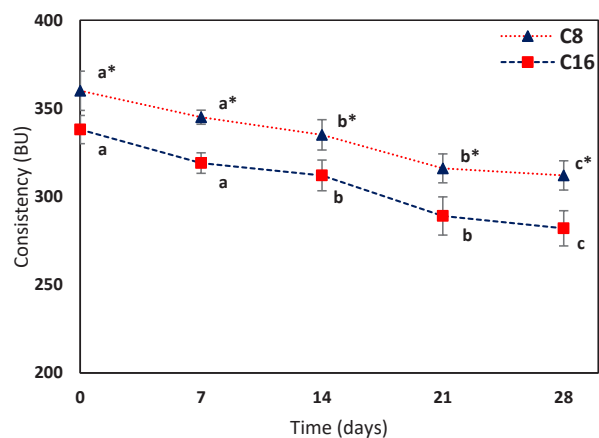


Figure 5. Evolution of consistency (BU) of the dough rolls samples leavened for 8 (C8; ▲) and 16 h (C16; ■) during 28 days of storage at  $2 \pm 0.5^\circ\text{C}$ . Each value is represented as mean  $\pm$  SD (n = 3). <sup>a-c</sup> For each sample (C8 and C16), different letters indicate statistically significant differences between values during the storage time (Duncan’s test,  $P < 0.05$ ). “\*\*” indicates statistically significant differences between samples at each storage time ( $P < 0.05$ : Student’s t-test).

(Mirsaedghazi *et al.*, 2008). During the storage, a significant decrease of consistency ( $P < 0.05$ ) was observed in both samples with values 312 and 288 BU for C8 and C16, respectively, after 28 days of storage. The decreasing consistency can be attributed to the enzymatic activity that degrades the initial structure during storage (Courtin *et al.*, 2006). However, the final values did not have a negative effect on the handling and rolling of the pizza disc.

Figure 6 shows the evolution of the pizza rim expressed as the ratio  $h_1/h_0$  of pizza samples prepared from samples

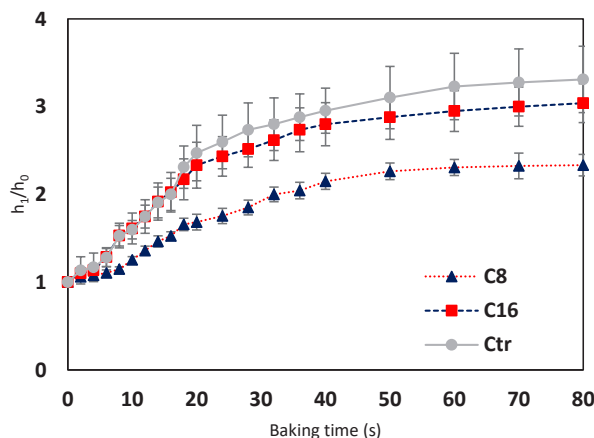


Figure 6. Average value and standard deviation (n = 24) of the ratio between the instantaneous ( $h_1$ ) and initial ( $h_0$ ) heights of the raised rim of pizza samples (▲: C8; ■: C16; ○: Ctr) during their baking in a pilot-scale wood-fired oven.

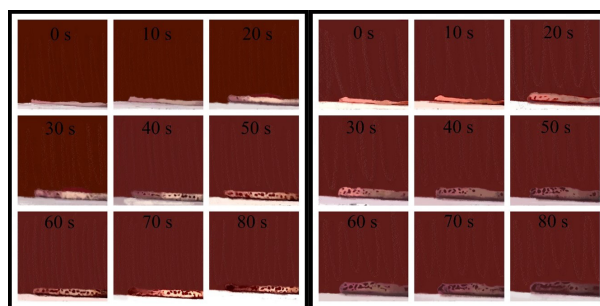


Figure 7. Cross-sectional pictures of the pizza rim of the C8 (left) and C16 (right) samples at different cooking times in the range of 0–80 s.

C8 and C16 at the end of the 28 days of storage compared to a fresh dough roll leavened for 16 h (Ctr). The trend of C16 was similar to the Ctr, and at the end of baking time (80 s), the samples C8, C16, and roll Ctr showed average values of 2.33, 3.04, and 3.31, respectively. During baking time, the pizza rim develops according to the amount of gas produced during leavening and incorporated in the dough rolls. Therefore, C8 showed lower values due to the shorter leavening time. These results can be visually observed in Figure 7 in which the evolution of the pizza rim of samples C8 and C16 was represented during the baking time.

## Conclusions

The results show that storage of preformed leavened dough rolls at  $2 \pm 0.5^\circ\text{C}$  for 8 or 16 h did not compromise the microbiological and physico-chemical characteristics of both samples over the 28 days of storage. However, the volume and ability to develop a high edge during the

cooking time of the C16 were similar to those of a fresh product. It can be concluded that keeping the 16 h leavened dough rolls at  $2 \pm 0.5^\circ\text{C}$  for 28 days is a valid technological strategy for their preservation. These results represent an important starting point for the large-scale marketing of ready-made dough rolls which could be applied to the production of the “Pizza Napoletana” (TSG) product, even in pizzerias outside the Campania region.

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