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# Review Article
# Effects of Conventional and Non-conventional Strains and their Compounds on the Properties and Quality of Bread

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## Abstract
Bread is one of common food source in the human diet. The bread industry has established numbers of bread products containing conventional and non-conventional strains. However, bread starter culture needs to strictly control and regulated for supplying further optimization of bakery fermentation industry. In addition, several compounds have been produced by micro-organism during dough fermentation which influenced the properties and quality of dough and final products. Therefore, this review focused on the effects of conventional and non-conventional strains as starter culture and their compounds on the properties and quality of dough and final bread.

Key words: Conventional strains, non-conventional strains, bread, starter culture, dough, fermentation

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## INTRODUCTION

Bread has been considered as the main food for humans for a long time ago. It has a good nutritional value due to its major constituents i.e., carbohydrates, proteins, vitamins, minerals, fats and water which represents the substrate for micro-organism growth[1]. Lactic Acid Bacteria (LAB) and yeasts play an essential role in the fermentation of bakery products[2]. The LAB improved the quality and nutritive value of dough[3]. Furthermore, it is safe and has been adopted for the fermentation of raw materials[4], besides it acts as a preservative in fermented food[5].

*Saccharomyces cerevisiae* essential in the process of converting sugar in the dough to ethanol and carbon dioxide which is responsible for dough leavening in the time of fermentation[6]. *Saccharomyces cerevisiae* is one of the main yeast used in baking fermentation and there are also other strains that have an active and valuable role in industrial fermentation processes[7]. The non-conventional yeast strains are of great responsiveness compared to the *S. cerevisiae*, as they underwrite to the generation of diversity and complexity required today in the market compared to traditional strains. In addition, they limit the aromatic features of the final product besides give the fermented dough a distinctive taste[8].

There are many factors that affect the quality of the fermentation process. The beneficial effect of fermented dough includes the nutritional, sensory and functional characteristics of baked goods. In addition, the wheat farming system affects the mechanism and quality of the dough fermentation process. This indicates that the dough is affected by the environmental effects[9]. The factors that contribute to the mechanism and quality of fermentation are the continuous development to shorten its time and increase the production of baked goods at low costs. In addition, the ability of micro-organisms to adapt in different environments plays an important role in dough fermentation[10]. For example, there are certain additives that enhance the fermentation process such as adding the fungal α-amylases, it works to promote fermentation by increasing the level of fermented sugar and the formation of reactors that enhance and intensify the flavor of bread and the color of the crust[11]. Moreover, yeast concentration and temperature have a significant effect on the odor and shell of the loaf[12].

Fermented bakery products are depending on the starting culture components, which can be used to improve the aroma, the level of acidity and helps to increase the size of baked goods that result from the formation of gas[13]. Therefore, this review focused on the effects of conventional and non-conventional strains as starter culture and their compounds on the properties and quality of dough and final bread.

## MICRO-ORGANISMS IN DOUGH FERMENTATION

***Saccharomyces cerevisiae*:** For a long time ago, the human has been using *S. cerevisiae* (species of yeast) for bakery products. *Saccharomyces cerevisiae* plays an important role in converting sugar to ethanol and carbon dioxide in the dough which is used in the process of making bread[6]. All human since thousands of years have been using *S. cerevisiae* in their baked bread for their meal and that is the key behind the importance of using *S. cerevisiae* yeast as a starter culture in fermented dough[5]. *Saccharomyces cerevisiae* is a well-studied yeast species used in bakery[5,6,14]. The ability of *S. cerevisiae* to utilize phytic acid as one of the hydrolysis processes carried out by yeast was studied[14]. Thirty types of *S. cerevisiae* strains were isolated from different origin i.e., wine yeast, feed yeast and baker's yeast. This study confirmed that the biomass of the bakery yeast was changed due to the usage of the phytic acid[14]. There are some approaches can improve *S. cerevisiae* to help in the bakery industry. However, even though technology has given us the opportunity to modify genetically these type of yeast, yet they are not acceptable for human consumption[6]. Edeghor *et al.*[5] studied the effects of *S. cerevisiae* and *Lactobacillus bulgaricus* in the sensory properties of bread. Three samples of bread were prepared using *S. cerevisiae*, *L. bulgaricus* and a combination between *S. cerevisiae* and *L. bulgaricus*. The study proved that using *S. cerevisiae* and *L. bulgaricus* could enhance the quality of the bread and extend its shelf life as well[5].

**Lactic acid bacteria:** The LAB play an important role in the fermentation process in the dough which commonly known as sourdough[15] and help to enhance the texture, flavor and shelf life of baked products[3]. They act as a preservative in fermented food which produces several organic acids such as lactic, acetic and propionic acids as an end product of fermentation and provide an acidic environment that prevents various pathogenic and spoilage micro-organisms to grow[15]. In addition, they documented as safe to ferment raw materials[4]. The bread quality depends on the type of micro-organisms involved in the fermentation and one of the most important factors in sourdough bread is the selection of the starter LAB[3]. Edeghor *et al.*[5] reported that fermented dough with *Lactobacillus bulgaricus* showed the highest amount of moisture, ash and fiber content but the lowest in

carbohydrate content. However, the dough showed longer validity due to the presence of *L. bulgaricus*. In another study, *L. plantarum* improved the quality of maize sourdough fermentation, the results showed that loaf height was significantly ($p<0.05$) higher by 25-26% than maize bread made from chemically acidified maize dough or maize dough without sourdough or chemical acidification[15].

The LAB in sourdough produce exopolysaccharides (EPS), carbon dioxide and organic acids. The EPS enhance the quality of bread by improving the rheological properties, increasing the volume, loftiness and decreasing the firmness of bread[3]. Twenty-two LAB strains were isolated from Jeung-pyun a Korean traditional rice cake to be used as starter culture for sourdough fermentation[3]. These LAB strains were divided based on EPS production in wheat peptone medium. *Leuconostoc mesenteroides* L10, *L. mesenteroides* S5-9, *L. citreum* L51, *L. citreum* S4-5, *L. gasicomitatum* L27, *L. lactis* I15 and *Lactobacillus curvatus* I7 showed the highest amount of EPS on wheat agar medium. However, *L. mesenteroides* L10, *L. mesenteroides* S5-9, *L. citreum* L14, *L. citreum* L48, *L. citreum* L50, *L. citreum* L51, *L. citreum* S4-5, *L. gasicomitatum* L27, *L. curvatus* I7 and *Lactococcus lactis* I15 showed the highest amount of EPS production in the broth. In addition, *L. lactis* EFEL005, *L. brevis* EFEL004 and *L. citreum* EFEL006 exhibited good fermentation properties with high cell growth (>8.5 Log CFU $g^{-1}$), high EPS production, increase in the volume of dough and dextran concentration[3] up to 0.16%. It was reported that EPS production from different LAB isolated from cereal-based sources improved the quality of bread by reducing the firmness and increasing the freshness and volume after storage[16].

**Non-conventional strains:** The selection of the ideal strains for fermentation is crucial because it contributes to the properties of the final product such as texture, aroma, taste, appearance[17]. Yeast strains produce during fermentation different types of compounds with different proportions and concentrations. These compounds are necessary for sensory quality of bakery products i.e., bread. *S. cerevisiae* is the most common industrial yeast species used for fermentation. Nevertheless, there are other unconventional species that contribute significantly to industrial fermentation such as *Dekkera bruxellensis*, *Yarrowia lipolytica*, *Kluyveromyces lactis* and *Scheffersomyces stipites*[6]. These yeast and others are used in industrial fermentation processes and carry a large range of improvement. However, industrial processes are rarely used the most appropriate strains with the best performance because many of the species are used based on a historical basis. Moreover, there is considerable attention to increasing the production and manufacture of non-traditional compounds as well as changes in consumer preferences through the selection or improvement of strains with novel properties [6]. Steensels *et al.*[7] studied 301 different yeast strains of *S. cerevisiae*, *S. paradoxus* and *S. pastorianus* for their production of different aroma-active compounds. The results showed that they were able to produce different essential odor compounds during fermentation such as ethyl acetate and isoamyl acetate differs by an order of magnitude between ordinary yeasts[7]. *Torulaspora delbrueckii* and *S. bayanus* characterized by combining the interesting appearance with the aroma during the dough fermentation process. In addition, the aroma produced by the mvaries from other commercial species that used as alternative yeast in dough fermentation[8]. Two samples of bread were produced by fermented dough with a non-conventional yeast strains *Torulaspora delbrueckii* Y273 and *S. bayanus* Y156[8]. The bread loaf fermented by *S. bayanus* (Y156) showed a marginally smaller size compared to the control whereas the size of the bread fermented by *T. delbrueckii* (Y273) was almost similar to control bread. Moreover, bread fermented by *T. delbrueckii* had a nutty smell while *S. bayanus* bread was more aromatic with a fruity smell. These two strains produce different aroma characteristics than traditional yeast in the case of liquid fermentation[8].

**Bread and dough enhancers:** The production of flavor during the fermentation process is influenced by several factors such as fermentation temperature, initial yeast concentration, amount of oxygen available, fermentor design and the composition of the medium (containing sugar, density, nitrogen and fat concentration). Regulating common fermentation parameters for flavor formation i.e., medium formation and ventilation may be expensive and also have some unwanted side effects. So, controlling yeast's inherent flavor production is the best strategy for enhancing flavor[7].

The addition of fungal α-amylases purified from *Rhizopus oryzae* FSIS4 enhanced the quality of the dough fermentation by increasing the level of fermented sugar in the dough and producing strengthen flavor and color of bread crust[11]. In addition, the dough fermented in the presence of fungal α-amylase produced a small hole bread while the bread obtained by the commercial α-amylase had a large hole[11]. In both cases, carbon dioxide was produced ideally in the dough, resulting in the appearance of the air structure in the bread, making the form of the texture like the honeycomb. Moreover, the addition of *R. oryzae* FSIS4 α-amylase increased the bread volume and height/width ratio by

Table 1: Summary of some compounds produced by micro-organism during dough fermentation

| Micro-organism | Application | Compounds produced | References |
|---|---|---|---|
| *Saccharomyces cerevisiae* | Wheat bread | Glycerol | Aslankoohi *et al.*[19] |
| *L. plantarum* FST 1.7 | Wheat bread | Lactic acid, phenyllactic acid and the two cyclic dipeptides cyclo (L-Leu-L-Pro) and cyclo (L-Phe-L-Pro) | Dal Bello *et al.*[22] |
| *L. paracasei*, *L. plantarum* and *L. brevis* | Bread made from non-conventional flours (quinoa and Kamut®) | Diacetyl, acetoin, 2,6-dimethyl-4-heptanone, 5-methyl-3-hexanone, 4-methyl-3-penten-2-one) | Di Renzo *et al.*[23] |
| NM | Masticated rye breads (whole-meal rye bread) | Ribitol pyridoxine, l-asparagine, l-histidine, betaines, thiamine, phenylethanolamine, glucose 6-phosphate, tri- and tetrasaccharides, 4-aminobutylguanidine, 5 -*S*-methyl-5 -thioadenosine and spermidine | Pentikainen *et al.*[24] |

NM: Not mention

0.72 and 0.2, respectively as compared to the control (Without α-amylase) and 0.49 and 0.1, respectively ($p<0.001$) than bread induced by the commercial α-amylase[11]. This may be related to the action of the enzyme during the starch gelatinization process which reduced the viscosity of the dough[18].

To obtain an ideal size of bread, the dough must be able to with stand the rapid expansion of the cells during the initial cooking process as well as improve and maintain cells gas[11]. Birch *et al.*[12] found that increased fermentation temperature from 5-15 or 35°C led to an increased in the production of lipid oxidation compounds (1-heptanol, hexanal, heptanal, octanal, decanal and 2-pentylfuran), resulting in the increased of aroma active compounds with hexanal and heptanal characterized as off-odors. However, decreased the fermentation temperature to 5°C caused an increase in the formation of the three esters ethyl acetate, ethyl hexanoate and ethyl octanoate in bread, which were characterized as pleasant aroma[12].

**Compounds produced by a micro-organism during dough fermentation:** For centuries the yeasts and other microbes have been used to produce fermented foods such as bread[8]. Yeasts are the most important micro-organisms responsible for alcoholic fermentation. The *S. cerevisiae* plays an important role as a leavening agent by producing carbon dioxide through the alcoholic fermentation of sugars. It produces glycerol during semi-solid state bread dough fermentation (Table 1) to prevent dehydration via balancing between the intracellular osmolality and the environment. Aslankoohi *et al.*[19] reported that the production and accumulation of glycerol in yeast cells is important for increase fermentation performance and level of gas retention in the dough as well as it had an impact on the sensory profile and firmness of bread after storage[20,21]. In addition, the efficiency of glycerol production reduced in the salt-free dough with higher water activity compared to the normal dough, this is depending on the ability of yeast cells to adapt to the osmotic stress in the dough.

*L. plantarum* FST 1.7 showed an ability to produce the anti-fungal compounds (Table 1) against *Fusarium culmorum* and *Fusarium graminearum* found on bread which lead to increase in the retention time and the bioavailability of minerals of the sourdough bread[22]. Di Renzo *et al.*[23] reported that *L. paracasei*, *L. plantarum* and *L. brevis* were able to grow in quinoa and Kamut® flours reached more than 9.0 log CFU $g^{-1}$ after 24 h fermentation. In addition, *L. paracasei* showed a positive characteristic of desired volatile compounds that highly recognized in the bakery products which derived from flour type with different ketones such as, diacetyl, acetoin, 2,6-dimethyl-4-heptanone, 5-methyl-3-hexanone, 4-methyl-3-penten-2-one. A great number of peptides and amino acids were released from masticated rye breads samples (whole-meal rye bread) with post-prandial physiological effects[24] (Table 1).

## CONCLUSION

The utilization of different strains of yeast and species of lactic acid bacteria as bread improver and dough enhancer is representing potential advantages and appreciated alternatives for the bakery industry. There are several strains of Saccharomyces that could enhance the bread dough fermentation. In addition, lactic acid bacteria have the ability to protract the baking shelf life and enhancing the physical properties of bakery products by the compounds released during the fermentation process. This study can be beneficial for the bakery industry and researchers. It demonstrated one of the important areas of using mixtures of conventional and non-conventional strains that had beneficial effects related to compounds produced by these strains during fermentation which affected the properties and quality of dough and final bread. Therefore, further studies are needed to incorporate probiotic strains which may have unique effects on the properties and quality of dough and final bread.

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