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LIGHT MICROSCOPY OBSERVATIONS ON THE MECHANISM OF DOUGH DEVELOPMENT IN CHINESE STEAMED BREAD PRODUCTION

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Abstract

Doughs used for production of Chinese steamed breads contain less added water (10% to 15% reduction) than equivalent doughs used for production of European-style breads. This reduction in amount of water available for gluten hydration affects the mechanism of dough development. During mixing, the gluten in steamed bread doughs is not initially pulled away from the starch and subsequently developed into a continuous network. The majority of the gluten surrounds the starch at all stages during mixing. Although there is little visible change in dough microstructure bread quality is still influenced by mixing.

Introduction

Many workers have used microscopy to study the changes that take place during mixing of the traditional wheat flour based breads that are commonly produced in Western countries. The changes in dough structure which occur during processing of these products is well documented (Angold 1979). However, it would appear that the pattern of dough development is modified in the case of Chinese steamed breads.

In traditional European-style wheat flour breads, the total amount of water added to the dough usually varies between 55% and 65% of flour weight. However, in Chinese steamed breads, less water is added to the dough as Chinese people prefer a rather more chewy bread texture (Lukow et al. 1990; Faridi and Rubenthaler 1983; Shi et al. 1990). Typically, the amount of water present in the final dough is about 50% for "southern" and 45% for "northern" style Chinese steamed breads (Wang and Ya 1988; Huang and Miskelly 1991). This difference in water addition would appear to have a significant effect on the mechanism of dough development.

At the Bread Research Institute we are using light microscopy to investigate some of the factors which influence the quality of steamed bread. In China, quality requirements for steamed bread vary slightly on a regional basis, but it is important that the bread should have a smooth, shiny external skin that is devoid of any blisters or other blemishes. The crumb, although more dense than that of European-style bread, should be uniform in texture, chewy yet not stick to the teeth when eaten.

Key Words: Chinese steamed bread, dough, gluten development, light microscopy, mixing, steamed bread, water absorption.

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Chinese steamed breads. Details of the process have been published elsewhere (Anon 1989; Huang and Miskelly 1991) but can be briefly summarised as follows. Flour (300 g), water (usually 80% of Farinograph water absorption but may be adjusted if judged to be necessary) and compressed yeast (1.5%) are mixed in a Farinograph mixer (speed 1) for half the "optimum" mixing time. The optimum mixing time is determined for each flour and is based on evaluation of bread quality from preliminary mixing trials. The dough is then allowed to ferment for 90 minutes (30°C; 85% R.H.) prior to remixing for half the original "optimum" mixing time. The dough is then hand divided into 6 (70.0 g) pieces and each piece passed 5 times through a pair of sheeting rolls (roll diameter 120 mm; roll gap 7.2 mm). After each pass through the sheeting roll the dough is folded in half prior to the next sheeting pass. The fully sheeted dough is then rounded (20 times; Extensograph rounder), allowed to proof (25 minutes; 30°C; 85% R.H.) and steamed (20 minutes) in a porous, bamboo container which is placed over a wok containing vigorously boiling water.

In the course of examining dough samples from a number of flours it was interesting to observe that there was relatively little difference in dough microstructure even when development time was varied by over 50%, although bread quality varied appreciably. This relative lack of structural change during mixing was shown in all flours examined. The initial extensive formation of coarse gluten fibrils (Moss et al. 1987), typical of the early stages of dough development for European-style bread, was absent in the case of doughs used for Chinese steamed breads and the changes that took place during dough development were much more subtle.

To investigate in greater detail the pattern of dough development in the initial stages of mixing and the possible role of level of water addition, samples were taken at selected intervals during mixing of full-formula doughs in a Farinograph mixer (speed 1) at two levels of water addition (51% and 60%).

Table 1. Flour analytical data

<table>
<thead>
<tr>
<th>Flour</th>
<th>Extraction Rate (%)</th>
<th>Protein (%)</th>
<th>Moisture (%)</th>
<th>Colour Grade</th>
<th>Farinograph Water Abs (%)</th>
<th>Devel. Time (min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>76.2</td>
<td>14.7</td>
<td>13.8</td>
<td>2.2</td>
<td>64.5</td>
<td>8.9</td>
<td></td>
</tr>
</tbody>
</table>

Figures 1 to 6. Photomicrographs of flour (300 g), water, yeast (1.5%, compressed) doughs mixed in a Farinograph mixer.

Legend to Figures

Water addition and mixing time as indicated in legend. (Figs. 1 to 3 - 60% water addition; Figs. 4 to 6 - 51% water addition).

Figs. 1 & 4. 2 minutes mixing.
Figs. 2 & 5. 4 minutes mixing.
Figs. 3 & 6. 6 minutes mixing.

Key to Figures

I - isolated gluten masses
S - pockets of starch granules
O - open gluten network
C - continuous gluten network
Bar = 50 μm.

Fig. 1. The mixer has pulled the gluten away from the majority of the starch granules to form isolated gluten masses (I). Note pockets of starch granules (S) that are not supported by protein (the small black "dots" are yeast cells).

Fig. 2. Further mixing has produced a coarse, open gluten network (O) but some isolated gluten masses (I) are still present.

Fig. 3. Additional mixing has resulted in the formation of a continuous gluten network (C) that surrounds the majority of the starch granules. Gluten distribution is not completely uniform as there are still some coarse gluten strands (arrowed) present in the network.

Fig. 4. The majority of the gluten surrounds the starch as did the storage proteins in the wheat grain. In some areas a few gluten strands (arrowed) are present but overall the microstructural appearance and distribution of the protein in the dough is similar to that seen in flour.

Figs. 5 and 6. Gluten distribution is very uniform in both samples and surrounds virtually all the starch granules as it did in the majority of sample shown in Fig. 4.

Analytical details of the flour are given in Table 1. The doughs were cryostat sectioned after fixation with buffered glutaraldehyde and the sections stained with Ponceau 2R to demonstrate gluten (Moss 1985).
Microstructure of Chinese steamed bread dough

Discussion

The pattern of dough development at the two water levels is illustrated in Figures 1 to 6. It can be seen that at the higher level of water addition (Figs. 1 to 3) the dough shows the pattern of development that is typical of European-style bread doughs. The protein matrix, which surrounds all the starch granules in the wheat grain, is pulled away from the starch by the mixer as the gluten becomes hydrated and cohesive. The gluten initially forms coarse, isolated strands which gradually become finer and more interconnected as mixing proceeds and ultimately a fine, interconnected gluten network is formed.

At the lower water addition (Figs. 4 to 6), typical of steamed bread doughs, there is very little of the initial
"pulling away" of the gluten from the starch. In some isolated areas of the dough a few gluten fibrils can be seen during the early stage of mixing (Fig 4) and these are probably caused by localised increased concentrations of water. However, in most of the dough the gluten still surrounds the majority of the starch granules, as it did in the wheat grain. As mixing progresses the few isolated gluten fibrils become incorporated into the gluten network which at all stages during the mixing cycle surrounds the majority of the starch granules (Figs. 5 and 6).

Although the above results relate to the initial mixing stage preliminary investigations have indicated that no further, visible, structural changes take place during the remixing.

The mechanism of dough development in the case of steamed breads bears some similarities to that of noodle doughs (Moss et al. 1987). Water addition for noodle doughs is very low (31%) and the main function of mixing is hydration of the flour particles and uniform distribution of ingredients. The function of gluten development in noodle doughs is carried out by the sheeting rollers and it has been observed that there is no pulling away of the gluten from the starch and the continuous, extensible, gluten matrix is formed by the pressure of the rolls fusing adjacent endosperm particles.

Conclusion

The microscopic appearance of doughs used for the production of Chinese steamed breads does not show marked changes as mixing progresses. However, the nature of the gluten matrix does presumably change as bread quality is influenced by mixing time. A more detailed microstructural study of steamed bread doughs is planned in order to improve our understanding of the mechanism of dough development and how it influences bread quality.

Acknowledgements

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References


Discussion with Reviewers

P. Resmini: Do the authors think that the type of microstructure shown in Fig. 6 is (i) able to withstand steaming better or (ii) is responsible for the chewy texture of steamed bread, when compared to the microstructure shown in Fig. 3?

Authors: The microstructure shown in Fig. 6 is typical of that seen in fully mixed doughs, prior to final proofing. However, we are not sure whether this structure is more suited to steaming compared to the more fibrillar structure seen in Fig. 3. The chewy nature of steamed bread is due to several factors including the dense texture which is, in part, due to the low levels of yeast used in steamed breads. Steaming also results in a higher crumb moisture when compared to oven baked, European-style breads. Nevertheless, even in European-style bread doughs an extremely fine, thin protein matrix can result in considerable loss of gas during proofing which, consequently, results in...
Microstructure of Chinese steamed bread dough

a more dense, chewy bread crumb.

P. Resmini: Although the remixing of dough for Chinese bread doesn’t produce important structural changes, do the authors observe significant modifications in structure after remixing European bread dough?

Authors: When European-style bread doughs are remixed, major structural changes can occur but the magnitude and nature of the changes is dependent on such factors as rate of work input, presence of yeast and time interval between initial mixing and remixing. The protein matrix can become more interconnected or it can become initially fragmented and then be re-connected.

D. J. Gallant: The general structure shown by Chinese steamed bread dough is very interesting because it shows some similarities with noodle doughs, as mentioned. In one of our experiments (with durum wheat and sorghum) on noodle doughs developed only through sheeting rolls we observed that the more passes (up to 50) through the sheeting rolls, the more uniform the gluten dough became. Have you other experiences with such materials from China?

Authors: We have examined the pattern of gluten development in noodle doughs and agree with the observations of Dr. Gallant. The pattern of gluten development in the "roller dough" process used in parts of South America has also been studied. In this breadmaking process conventionally mixed bread doughs are passed through sheeting rolls to enhance gluten development. Initially, this sheeting can "un-mix" the gluten but further passes can then re-develop the gluten network until it becomes extremely uniform. The latter produces bread of the desired, extremely fine texture. More detailed information on this phenomenon has been published elsewhere (Stenvert NL, Moss R, Pointing G, Worthington G, Bond EE. (1979). Bread production by dough rollers. Bakers Digest, 53 (April), 22 - 27).