From vegetables to baked goods

IN THE CONTEXT OF A RESEARCH PROJECT FUNDED BY THE GERMAN FEDERAL MINISTRY OF ECONOMICS AND TECHNOLOGY, THE INSTITUTE FOR CEREAL PROCESSING LTD. (IGV), NUTHETAL, GERMANY, HAS DEVELOPED A PROCESS FOR MANUFACTURING NATURAL FOOD COMPOUNDS

The basic idea of this process development is to combine into a single manufacturing process the fermentation of cereals in the form of pre-doughs and sourdoughs already established in bakery technology with the manufacture of naturally/spontaneously acidified (soured) vegetables and/or fruit by fermentation technology. The purpose of this coupling of the two fermentation systems is to generate metabolic products in vegetable/fruit-based pre-doughs and/or sourdoughs that can be expected to yield both technological and nutritional physiological benefits when they are incorporated into baked goods.

The aim was the natural enrichment of "secondary vegetable substances" in pre-doughs and sourdoughs. In this respect the selection of the raw materials, the key technology in the form of special mixing and comminution techniques, and the fermentation were decisively important in the process development. The necessary mechanical cell disruption and homogeneous blending of the vegetable and flour constituents was finally achieved by implementing a standard commercial cutter (AW CU 20 cutter / Alexanderwerk) into the overall technological "vegetable fermentation" procedure. Various milled cereal products and fruits as well as vegetables were tested, singly and in meaningful combinations, to select suitable raw materials. With a view to the end product design, white cabbage, carrots and apples were chosen for the further investigations, and these were fermented with standard flours customarily used in bakery technology (Type 550 wheat flour and Type 997 rye flour).

In addition to the objective of manufacturing an immediately processable, nutrient-enriched ready-to-use preparation, the IGV basically wanted to direct the fermentation process in such a way that it was capable of being integrated directly into the operating procedures in the factory. At the same time, in a similar way to pre-dough and sourdough bakery technology, the intention was for the fermentation product to be directly usable to manufacture baked goods, i.e. without any additional process steps (post-treatment/drying). For this purpose the parameters affecting the process technology, such as floor time, temperature and various starter additives, were determined on the basis of field tests. Taking the microbiological, sensory and baking technology assessment into account, this led to the definition of the fermentation ranges listed below (see table 1).

In addition to ensuring direct processing, the fermentation ranges that were determined also ensure the objective of reproducibly manufacturing nutrient-enriched pre-dough and sourdough preparations with adequate microbial stability (shelf life).

Fermentation procedure and ferment (leaven)

The IGV compared spontaneous/native fermentation with fermentation using lactobacilli and yeasts and with the use of starter cultures in the vegetable-flour mixtures. In addition to a low fermentation performance (result after seven days), a marked discolouration and to some extent a slimy surface (Kamm yeasts) is observable in the spontaneous fermentation of a fermentation batch (white cabbage – flour leaven). The odour is slightly cabbage-like and foul. It became apparent with all the fermentation batches (white cabbage/carrot/apple) that the substrate-specific microflora (in the flour/vegetable/fruit mixture raw material) was unable to bring about the desired fermentation performance with sufficient formation of acid (to self-conserve the system) within a defined period of time. Alternatively, the batches fermented with the addition of starter cultures showed considerably greater fermentation activities.

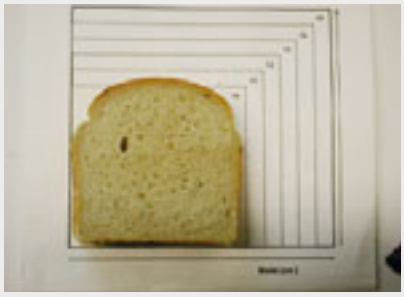
table 1: Classification of process parameters in view of the project's objectives

parameters	fermentation type I.	fermentation type II.	fermentation type III.
starter additive	yeasts	lactobacilli	yeasts + lactobacilli
fermentation level	single-stage	multi-stage	two-stage
temperature range	15–25 °C	20–25 °C	15–25 °C
minimum fermentation period	3 days	2–3 days	3 days
usage/raw materials (fruits and vegetables)	relevant to the procedure; preferentially carrot/apple singly and in combinations	relevant to the procedure; preferentially white cabbage/apple singly and in combinations	relevant to the procedure; preferentially white cabbage/carrot/apple in combinations
usage/grain products (bread grain, other types of cereals)	milled wheat products	milled wheat and rye products	milled wheat and rye products
ratio flour:raw materials	1:3	1:2 and 1:3	1:2 and 1:3
range of application/baked goods	wheat pastry	rye, rye mixed and wheat pastry	rye, rye mixed and wheat pastry

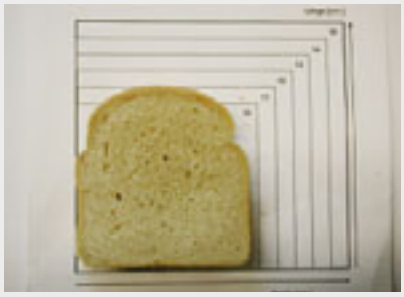
source: IGV

++ figure 1

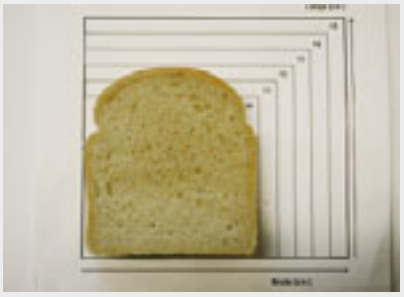
Use of pre-doughs from different fermentation systems in wheat bread



wheat bread (box) with addition of 15 % apple-flour ferment "spontaneous fermentation"
- relatively low volume, slightly solid
- very good crust tanning
- waddy-moist crumb structure
- relatively regular pore formation
- slightly fruity- odor/flavor (in the beginning gentle apple note)



wheat bread (box) with addition of 15 % apple-flour ferment "yeast fermentation"
- very good volume
- very low crust tanning
- normal-waddy crumb structure
- relatively regular open pore formation
- normal white bread odor/flavor (without specific aromatic note)



wheat bread (box) with addition of 15 % apple-flour ferment "lactobacilli fermentation"
- good volume
- low crust tanning
- slightly tight crumb structure
- relatively regular subtle pore formation
- slightly sourish aromatic odor/flavor

source: IGV

Fermentation product

In the assessment of extensive baking trials (see figure 1) using pre/sourdoughs from a wide variety of fermentation systems, it was discovered that the dominant flavour of certain products, e.g. cabbage varieties, in the baked goods end product can be reduced and, with appropriate process management possibly suppressed, through the type and quantity of the starter used. Thus the field of application would be expandable to the fine baked goods area, with a view to use in the future.

Process development – determination of relevant material and process technology influencing factors – determination of relevant process parameters

In the context of the application proposal, the requirement was to manufacture nutrient-enriched pre- and sourdough preparations with adequate microbial stability (shelf life with reproducible quality) that are suitable for use in baked goods. The relevant influencing factors/parameters listed below were used in the process design/process development:

+ Proportion/content of water (proportion of water in the substrate: defined here via the dough yield)
+ Variation of the fermentation temperature
+ Variation of the duration of fermentation (floor time)
+ Use of starter cultures
+ Substrate (raw material selection and combination, ratio of raw materials to one another)

Proportion of water (dough yield)

The basic idea of the new fermentation process that to be developed consists of making the water from the vegetable and/or fruit product available as process water for the sourdough or pre-dough preparation. In theory a pre-dough with a dough yield of TA = 180 could be prepared in this way from 100 g of flour and 100 g of fruit/vegetables, assuming that 80 g of water can be generated from 100 g of vegetables/fruit.

Based on these theoretical considerations, and in view of the application suitability, fermentation batches were fermented in various different ratios in the proportions of 1:1, 1:2 and 1:3 with regard to the proportion of flour to the proportion of vegetables/fruit. After assessing all the relevant parameters, an influence of the water content on the composition of the microflora was detectable only in the case of spontaneously produced vegetable pre-doughs and sourdoughs. Baked goods manufactured with the addition of starter batches in the ratio of 1:3 (flour : vegetables) were preferred both in their shaping, volume and crumb structure and in the roundness of their flavour.

Starter/mature sour

The following three fermentation methods were developed to manufacture vegetable/fruit-based pre-doughs/sourdoughs:

1. fermented pre-dough
   yeast fermentation (starter additive: yeasts)
2. fermented pre-dough
   sourdough fermentation (starter additive: Lactobacilli)
3. fermented pre-dough
   mixed fermentation (starter additive: yeasts + Lactobacilli
   ▷ time delay between additions)

In these fermentation processes, both the yeast fermentation and the sourdough fermentation show parallels with the established pre-dough and sourdough preparation processes of bakery technology, mainly with regard to their acidification performance, dough rheology and flavour characteristics. If bread loaves manufactured with the respective mixed leavens are compared, a distinct gradation in the qualitative flavour characteristics and baked product quality is detectable.

Raw materials composition – duration of fermentation (floor time)

The fermentation times until a constant pH was reached varied as a function of temperature, choice and ratio of raw materials, and the type of starter used. Adequate stability as ▶

in the sense of the task definition is achievable at a pH of 3.6. The fermentation results (pH reached) are presented as a function of the substrate availability of fermentation batches with different proportions of vegetables and/or fruit, determined after a fermentation period of five days under constant culturing conditions. In this respect, the fermentation batch "wheat flour – apple – white cabbage mixture (50:50)" reached the pH of 3.6 necessary to safeguard microbial stability.

In addition to the fruit and vegetable composition, the nature of the flour type used also affects the progress of fermentation. When using darker flours (e.g. rye flour – RM 1150), distinctly higher levels of acidity are reached and the pH value reduction takes place in a shorter period of time than with correspondingly paler milled flours (e.g. RM 997). This observation is attributable to the differing buffering capacity of flours depending on their extraction rate. Flours with different extraction rates have differing buffer capacities corresponding to their ash and phytate contents, in this respect there is practically a linear relationship between ash content (flour type) and buffer capacity.

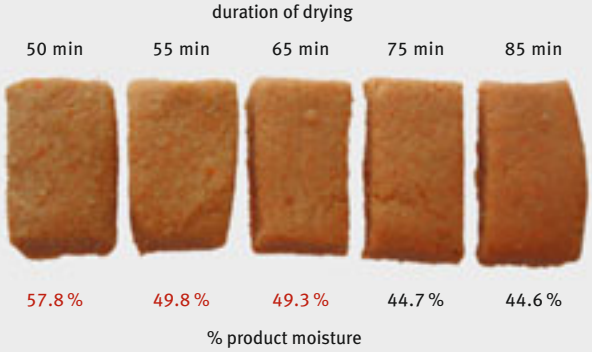
Effect of the process – freshness retention and shelf life

Freshness retention

Storage tests were carried out to assess the shelf life and freshness retention of the baked goods that had been manufactured. These tests consisted of evaluating the baked products from the point of view of microbial spoilage (visual examination – mould growth), development of crumb moisture and crumb firmness. Information about the actual freshness retention can be obtained indirectly by determining the crumb firmness. The development of crumb firmness as a function of time is determined using a texture analyser. The resulting force-distance graph is assessed in relation to firmness and elasticity. As an example, the force increase of the respective bread crumbs that were examined is illustrated over a period of seven days. The crumb firmnesses are to some extent distinctly higher compared to the other baked goods in the case of the reference sample (rye mixed bread with added rye sourdough) and sample B, and with increasing storage time as in sample C. This trend becomes more pronounced with increasing storage duration, which indicates more rapid ageing of the baked goods. Relatively low values with a small increase within the storage time of seven days are shown particularly by leaven additives D and E. Thus the raw materials composition, or more precisely the respective proportions of fruit and/or vegetables, of leaven additives D and E has a particularly favourable effect on freshness retention.

++ figure 2

Effect of the duration of the drying time on product moisture and sensory suitability



Comparing the different variation ranges regarding their effect on drying performance (reduction of moisture/min), it is notable that, especially when batch fermentation is with yeasts, a longer duration of drying is needed to reach appropriate moisture content.

Within the framework of the implemented control baking tests, it can be said that product moisture in the range of 49–58 % (as well as dough rheological as sensory) are particularly advantageous.

source: IGV

Drying – manufacture of ready-to-use preparations

In addition to process development, the project's main objective was to create nutrient-enriched pre-dough and sourdough preparations in dry or pasty presentation form, taking the ability to manufacture them industrially and the feasibility of the corresponding process into account at the same time. In this respect the studies focused on three drying technologies.

+ Freeze-drying
+ Vacuum process drying (VPT)
+ Vacuum drum drying

Based on preliminary studies it became clear that by implementing the vertical process dryer, adequate circulation within the drying process is complied with and the project's objective of generating pasty pre-dough and sourdough preparations in a way that protects the constituents is fulfilled.

The studies of suitability for drying by using VPT (vacuum process drying) took place using the variation ranges stated below:

+ Flour: vegetable ratio (1:2 and 1:3)
+ Batch variations using rye and wheat flour
+ Variations regarding the white cabbage, apple and carrot content
+ Starter variation (yeasts and lactobacilli)

It became clear during the studies that basically it is possible to generate ready-to-use preparations in a pasty presentation form reproducibly from all the variation ranges. However, the drying performance of the respective fermentation mixtures differs to some extent depending on the respective content composition (use of starter, flour type used and nature of the vegetable and/or fruit variety used).

Apart from the fundamental precondition that the sensory characteristics of the ready-to-use preparations that are to be manufactured are suitable for the production of high-quality baked goods, the studies of the creation of the pasty presentation form focused on guaranteeing shelf life. For this purpose the respective ready-to-use manufactured preparations were assessed from the microbiological and sensory point of view and also from the technological point of view after chilled storage for two months (4 °C to 6 °C).

The assessment of the chilled storage showed that both the processing and the sensory effects as well as the microbiological status of the pasty ready-to-use preparations remained in almost unaltered stability after a storage period of two months. +++

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