IMPROVED METHOD FOR TESTING MACARONI PRODUCTS[1]

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ABSTRACT

An apparatus is described which permits measurement of the mechanical properties of both uncooked and cooked spaghetti. Stretching and bending tests of a variety of cooked and uncooked samples are reported. It could be shown that addition of eggs during production has a great effect upon cooking qualities of spaghetti.

The quality of macaroni products is determined essentially by the following factors: (a) color and appearance; (b) mechanical properties of the uncooked product (of special interest in the packaging and transportation of macaroni products), and (c) behavior upon cooking (cooking loss, texture of the cooked material).

Whereas determination of color is relatively simple (1), evaluation of the mechanical properties of the uncooked and cooked macaroni products is much more difficult; apparently there are no generally accepted tests to measure these properties, and only few suggestions are found in the literature.

In a recent paper by Karacsonyi and Borsos (6) an apparatus was described for measuring the torsional strength of uncooked macaroni products. This property is of special importance for manufacturers because of its relationship to breaking during packaging and shipping.

From the consumer's standpoint, however, the properties of the cooked products are of primary interest. Repeated attempts have been made to correlate the cooking properties of macaroni products either to the water uptake (weight increase during cooking) or to the cooking loss (amount of solids lost to the cooking water) (1,4,5,7,8).

These tests, however, do not sufficiently characterize the properties of the cooked products. Therefore, Binnington, Johannson, and Geddes (2) have tried to measure the mechanical properties of cooked macaroni products with a specially constructed recording tenderness tester. Glabe, Goldman, and Anderson (3) have reported measurements of the tensile strength of cooked spaghetti with the Brookfield stress-strain gage. It is obvious that a device permitting measurement of mechanical properties of both uncooked and cooked products would be of advantage. Such an apparatus is described in this paper. Its application and utility have been tested on a number of macaroni products

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from various raw materials and of various shapes. Since the determination of the water uptake and cooking losses referred to above are simple and still in fairly wide use, some results with these tests also are included.

Materials and Methods

The spaghettis investigated have been dried under identical conditions in our pilot plant. Of special interest were spaghettis obtained from biscuit flour (milled from a domestic soft wheat), durum semolina, and spaghetti containing eggs (four fresh eggs per kg. durum semolina).

For determination of water uptake and cooking loss (1,4,5,7,8), 25 g. of macaroni products are cooked in a stainless-steel basket placed in a 600-ml. beaker, for 10, 20, and 30 minutes respectively. After cooking, the basket is removed and the cooked product rinsed with cold water and then weighed after excess water is shaken off. The difference between weight of the cooked material and weight of macaroni product used is equivalent to water uptake. The cooked materials are then dried to determine the percentage of cooking loss (difference between dry substance before and after cooking).

For measurement of the bending strength of dry spaghetti and the

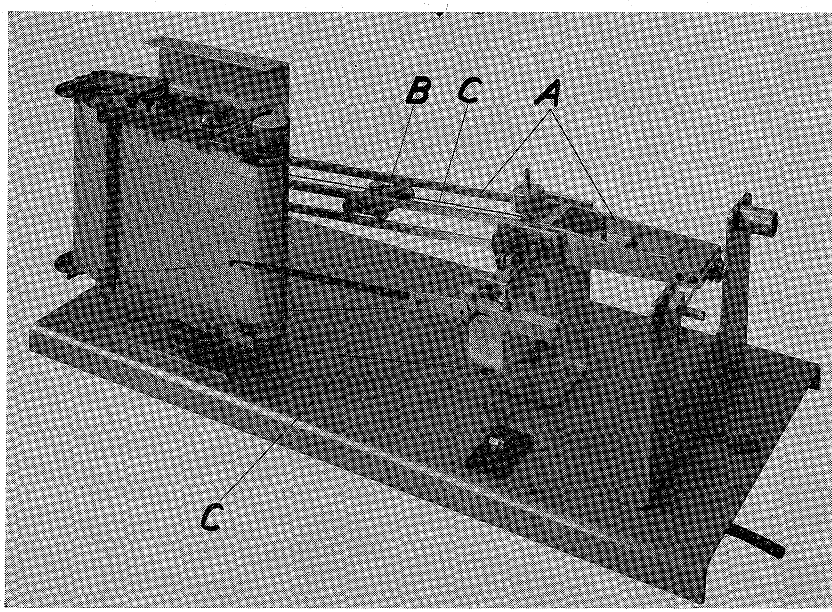

Fig. 1. Bending stress tester.

tensile strength of cooked spaghetti, a special apparatus was constructed, which records: (1) the bending of dry spaghetti under the influence of a continuously increasing force, and (2) the stretching of cooked spaghetti, also under the influence of a continuously increasing force. The main features of the apparatus are shown in Figs. 1 and 2.

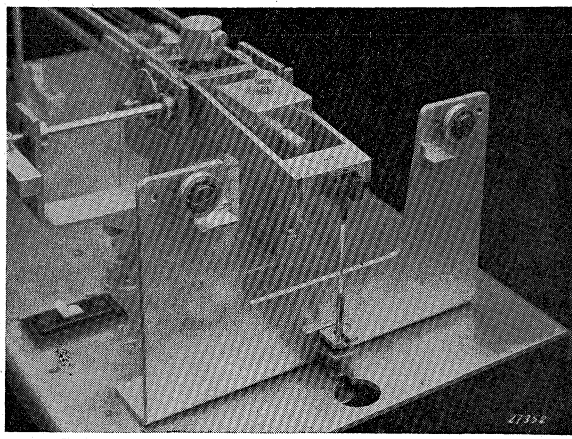

Fig. 2. Clamping device for stretching tests.

The continuously increasing force is a mobile beam *B* on the bending device *A*. The more the beam moves from the starting position, the more the strands of spaghetti are loaded. The bending device must be tared before the tests. The beam is connected by a thin strap *C* with the recording paper. This paper (and therefore also the beam) is driven by a motor with a given constant speed. The weight of the beam is 20 g.; additional weights can be attached, if higher forces are desired. The distance which the beam travels is recorded in a horizontal direction in a ratio 1:1 (1 cm. on the graph means that the beam actually moved 1 cm.). The deformation of the strands of spaghetti (either stretching or bending) is recorded in vertical direction in a ratio 2:1 (2 cm. on the graph corresponds to an actual bending or stretching of 1 cm.). The following procedures are used for the two types of measurements.

Bending Test with Uncooked Spaghetti. The spaghetti needed for this test should have the same moisture content and diameter in order to obtain comparable curves. After calibration of the bending device, the strands are clamped, and the measurement is started. The length of the strands between the two clamps is 10 cm.

Tensile Tests with Cooked Spaghetti. Again spaghetti with uniform diameter should be used. As it is very difficult to fasten cooked spaghetti, we first clamp the strands and then cook them together with the clamping device (Fig. 3). After being cooked for a certain time, the spaghetti is removed from the cooking water, carried in a beaker with water at 20°C., transferred to the calibrated apparatus, and clamped; then the measurement is started.

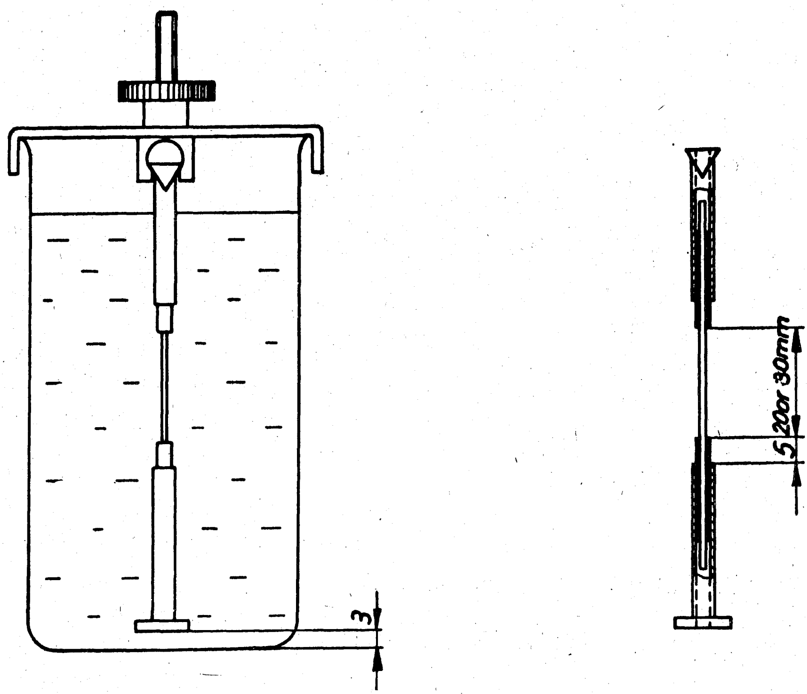

Fig. 3. Left, beaker for cooking procedure, clamped spaghetti in cooking position. Right, clamped spaghetti.

Results and Discussion

Testing of the Uncooked Spaghetti. Figures 4 and 5 represent two typical bending diagrams. They show considerably inferior physical properties for egg-containing paste products than for commercial durum grade goods. Regarding further tests with this apparatus and possibilities of its application for determination of the physical properties of raw spaghetti, we refer to a publication by Winston (9).

Testing of Cooked Products. Table I shows the cooking results (cooking loss and water absorption) for three completely different spaghetti qualities.

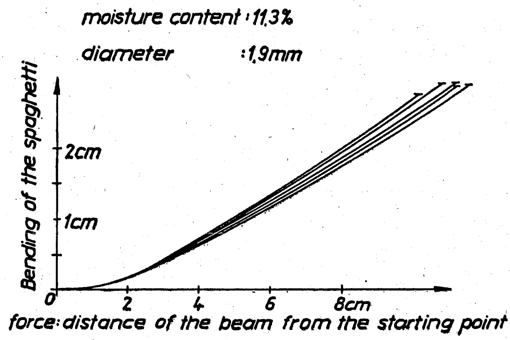

Fig. 4. Bending diagram of spaghetti from durum semolina.

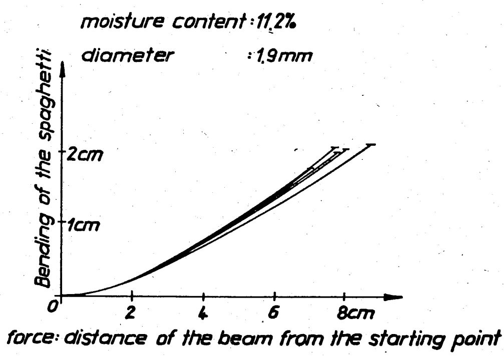

Fig. 5. Bending diagram of egg spaghetti, four eggs per kg.

TABLE I

Cooking Losses and Water Absorption for Spaghetti of Different Qualities

Sample	Water Absorption during Various Cooking Periods[a]			Cooking Losses after Various Cooking Times[a]		
	10 Minutes	20 Minutes	30 Minutes	10 Minutes	20 Minutes	30 Minutes
	%	%	%	%	%	%
1	129	215	278	4.5	6.4	8.2
2	127	188	256	4.6	6.2	7.7
3	120	183	227	4.2	5.7	7.4

[a] Expressed on 14.0% moisture content.

Sample 1 represents spaghetti made from a soft wheat of poor quality (biscuit flour containing 9.0% protein).[2]

Sample 2 represents spaghetti of a special grade of semolina (protein content 12.6%).

Sample 3 represents spaghetti of a special grade of semolina plus four whole eggs per kg. (protein content 14.1%).

[2] The protein contents (N $\times$ 6.25) are expressed on 14.0% moisture basis.

Sample 1 corresponds to a poor-quality soft-wheat paste product, while sample 3 represents a really first-class product. All figures of Table I are the mean values of five tests. The diameter of the spaghetti was always 1.9 mm.

As shown by the results, the differences in the cooking losses are not significant. Somewhat different conditions prevail in the swelling ability represented by the water absorption.[3]

Here some differences can be noticed, in that soft wheat products with lowest protein content are subject to the strongest swelling, while the egg-containing high-class products show least swelling. Table II shows the influence of the shape on the cooking qualities (cooking loss and water absorption). All samples consist of durum-grade macaroni products without egg.

TABLE II

INFLUENCE OF SHAPE ON COOKING RESULTS
(Cooking losses and water absorption)

Designation of Product	Over-All (External) Diameter	Wall Thickness	Water Absorption for Various Cooking Periods[a] (Minutes)			Cooking Losses for Various Cooking Periods[a] (Minutes)		
			10	20	30	10	20	30
	mm.	*mm.*	%	%	%	%	%	%
Vermicelli I	0.9	. .	342	448	519	8.3	10.3	11.7
Vermicelli II	1.1	. .	232	327	400	7.0	8.6	10.2
Spaghetti I	1.6	. .	134	220	292	5.6	6.5	8.3
Spaghetti II	1.9	. .	127	188	256	4.6	6.2	7.7
Macaroni	3.6	0.9	138	201	270	6.3	7.1	8.9
Short macaroni (Hörnli)	5.6	1.1	125	178	250	4.6	5.4	7.2

[a] Expressed on 14.0% moisture content. Compared with the values cited in the literature, we generally find somewhat higher figures for our cooking losses. This may be attributed to the fact that most other investigators work with temperatures of 95°C. and we cook the spaghetti in boiling water. Fair correlation is found with the results of Paulsen (8).

The figures of Tables I and II indicate, most clearly and definitely, that tests to determine cooking losses and water absorption do not sufficiently characterize the properties of cooked macaroni products, and that the influence of the shape on these tests is pronounced. Harris and Knowles (4) have made similar statements. The fact that in many countries the official testing methods are based on these tests (1,7) has prompted this re-examination.

The testing of the physical properties of alimentary paste products such as macaroni and spaghetti seems more appropriate. This difficult problem has already been scrutinized by Binnington, Johannson, and

[3] Binnington, Johannson, and Geddes (2) have already shown (1939) that the swelling ability (volume increase of the goods during cooking) practically corresponds to the water absorption. The amount of water absorbed therefore represents a direct measure for the swelling capacity.

Geddes (2) and, at least for macaroni, successfully solved. The tenderness tester simultaneously developed and described in detail in the same paper has meanwhile been adopted in *Cereal Laboratory Methods* (1). With the apparatus described in the present paper, however, the much more important types of spaghetti can be tested.

Testing of the Physical Properties of Cooked Spaghetti (Stretching Tests). Figures 6 to 12 show some typical load-extension diagrams.

The carriage load amounted in all cases to 46 g. The unsupported length of the clamped spaghetti (span between ends of silicon tube) was 3 cm. Further tests (not included) demonstrated a most striking

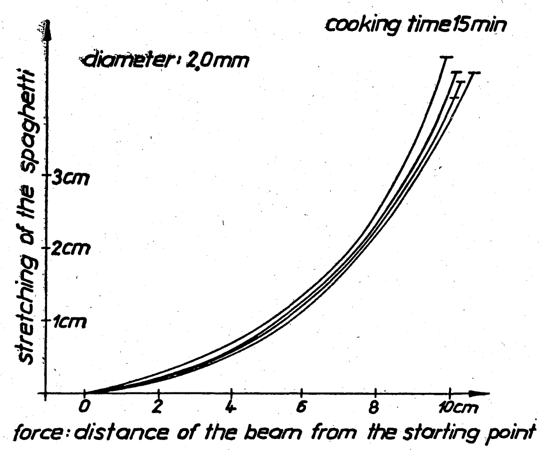

Fig. 6. Load-extension diagram of spaghetti from durum semolina (repeated five times).

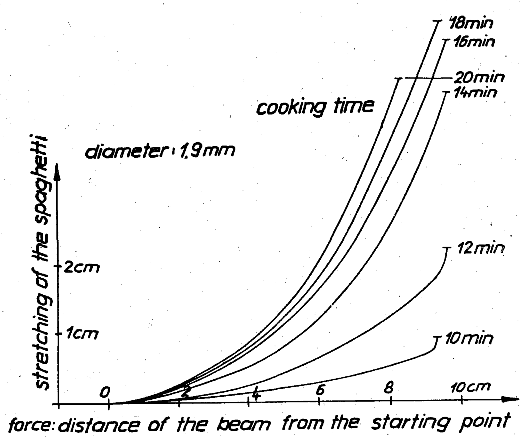

Fig. 7. Load-extension diagram of spaghetti from durum semolina.

dependence of the pull-test on the diameter of the spaghetti. Therefore, the spaghetti to be selected for this test must have a well-defined diameter.

Figure 6 shows the reproducibility of the stretching test. The stretching apparatus yields reproducible results for diameters of 1.8 mm. and higher, but it is hoped that further improvements of this apparatus will also enable its use for spaghetti diameter smaller than 1.8 mm.

Figures 7 to 11 show the difference between spaghetti from durum semolina, egg spaghetti, and that from biscuit flour. The pull

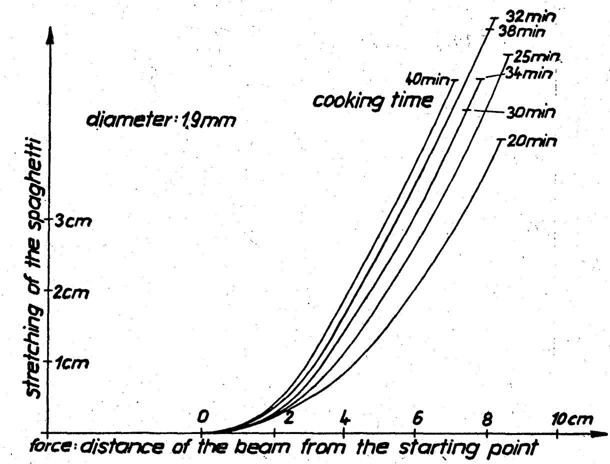

Fig. 8. Load-extension diagram of spaghetti from durum semolina.

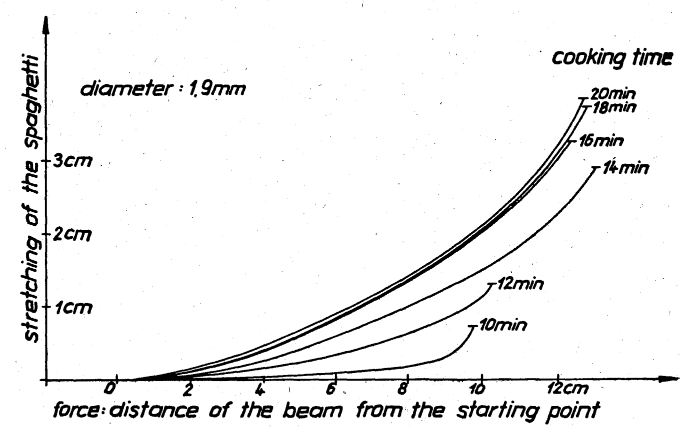

Fig. 9. Load-extension diagram of egg spaghetti, four whole eggs per kg.

diagrams mentioned above show in some parts very characteristic dissimilarities (in contrast to the cooking losses mentioned in Table I, which show too small variations). Particularly striking are the dissimilarities between egg-containing products and the other paste products. The difference between the strength of cooked egg spaghetti is especially pronounced after longer cooking times. In future, the load-extension diagram of egg spaghetti will therefore serve as standard diagram for our examinations of cooked spaghetti.

Figures 7, 8, and 11 show the difference of the cooking qualities

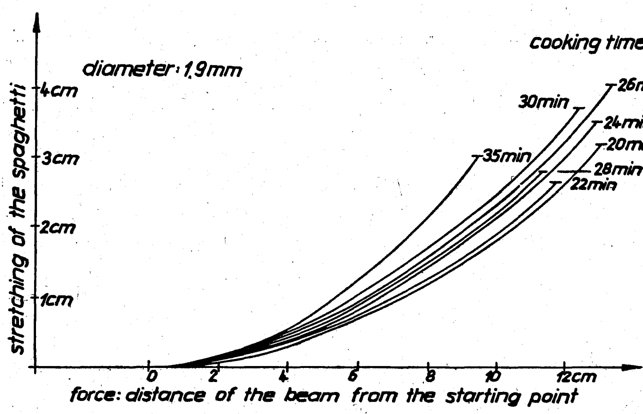

Fig. 10. Load-extension diagram of egg spaghetti, four whole eggs per kg.

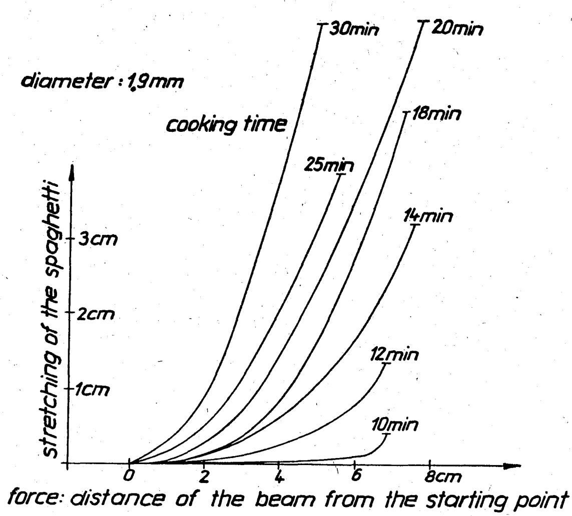

Fig. 11. Load-extension diagram of spaghetti from biscuit flour.

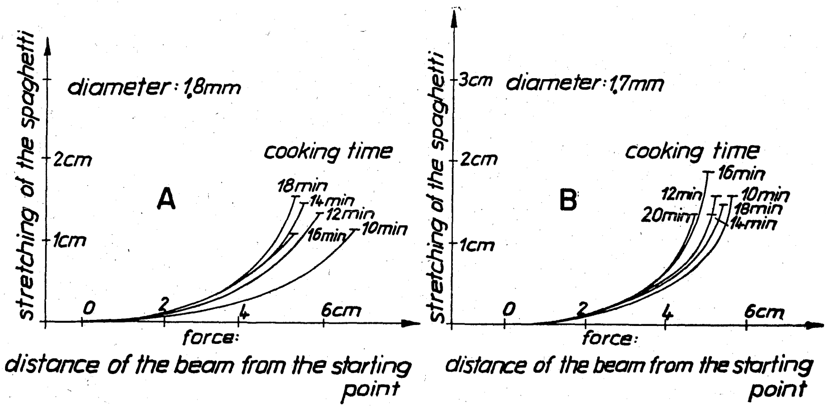

Fig. 12. Load-extension diagrams of spaghetti from durum semolina, intensely interspersed with air bubbles.

of spaghetti from durum semolina and biscuit flour. Spaghetti intensely interspersed with air bubbles is not suitable for stretching tests (Figs. 12A and 12B). However, a few bubbles in general are of little importance.

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