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Influence of Processing and Cooking on the Retention of Thiamine, Riboflavin and Niacin in Spaghetti

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ABSTRACT

The influence of several processing steps, conditions of preparation, and enrichment levels on the retentions of thiamine, riboflavin and niacin, and on the technological quality of spaghetti were studied. The best drying treatment and the most adequate enrichment level, in addition to the package type and the behaviour of the final product during 3 months' storage, were determined. The results revealed that the vitamin retention and the technological characteristics of spaghetti are independent of the vitamin level used and that the greatest losses of vitamins occur during the cooking step of spaghetti. After 3 months' storage in the dark, the cooked spaghetti prepared in these studies was a good source of the vitamins thiamine, riboflavin and niacin. They were retained at 96%, 78% and 94%, respectively, of the initial levels in the enriched wheat flour.

INTRODUCTION

Nowadays, the utilisation of wheat in the form of pasta is considerably more widespread than its utilisation in breadmaking. This is because pasta

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products are simpler to make and, if dried, they can be stored for relatively long periods of time, without undergoing considerable deterioration (Irvine, 1971). According to Antognelli (1980), the American National Nutrition Program indicates pasta products as being one of the cheapest ways to improve the diet and to minimise the problem of hunger in developing countries. The concept of fortification of staple foods was developed in the 1930s and early 1940s, as a result of the discovery, in the USA, of certain diseases (rickets, beriberi, pellagra) caused by vitamin deficiency. Thus, in 1940, the Food Nutrition Board endorsed a programme favouring additions of thiamine, riboflavin, niacin and iron to wheat flour (Watson, 1981). The enrichment of cereal products with B vitamins became feasible in the late 1930s, when the vitamins became commercially available. Before the 1930s, the enrichment of alimentary pastes was considered wasteful because as much as 50% of the added thiamin, 40% of the niacin and 30% of the riboflavin might be lost during cooking and draining (Brooke, 1968).

According to Tannenbaum (1976), in the USA, enrichment is defined as the addition of specific amounts of selected nutrients in accordance with a Standard of Identity, as defined by the United States Food and Drug Administration. In the USA, according to the Federal Standards of Identity, pasta products most contain 0·88–1·10 mg of thiamine, 0·37–0·48 mg of riboflavin and 5·95–7·49 mg of niacin by 100 g of product (Douglass & Matthews, 1982).

In Brazil, there are no standards of identity that determine which nutrients and how much of these nutrients must be added to the different kinds of food. In the present work, we enriched wheat flour with thiamine, riboflavin and niacin to obtain the average levels of these vitamins present in Brazilian wheat in the final spaghetti. According to Cuno *et al.* (1956) these levels are: 0·45 mg of thiamine, 0·26 mg of riboflavin and 4·23 mg of niacin per 100 g of wheat.

MATERIAL AND METHODS

Raw-materials

Wheat flour, type Special and tap water. Thiamine mononitrate, riboflavin and nicotinamide were supplied by Hoffman-La Roche. The three vitamins were dissolved in tap water and added to the flour to form the pasta dough.

Extrusion

A Ratiotrol pasta extruder with the following characteristics: mixer with double axis, screw with compression rate of 1:1 and constant space between

the threads, fitted with a die for spaghetti with holes covered with Teflon, was used.

Drying

A drier developed in the Cereal Technology Laboratory of the Faculty of Food Engineering—Unicamp, was used. The drier was placed inside an oven to control the drying temperature. The relative humidity was controlled by using saturated salt solutions. Three different drying treatments were studied using similar conditions to the ones studied by Dexter *et al.* (1981): (1) Low temperature (LT) where the spaghetti was held at 45°C for 27 h. (2) High temperature 1 (HT-1) in which the spaghetti was held at 75°C for 2 h before the temperature was reduced to 40°C during a period of 5 h, and held at this temperature for 6 more hours. (3) High temperature 2 (HT-2) where the spaghetti was held at 40°C for 30 min, at 55°C for 30 more min and at 70°C for 10 h before the temperature was quickly reduced to 45°C and held at this temperature for 1 h. Since the LT treatment showed greater vitamin retention and would be costly and have very little industrial applications, it was discarded and used as a control against which the other processes were judged. Only the HT-1 treatment was used for the packing and storage and vitamin addition levels studies.

During all the three drying treatments, the relative humidity started at 95% and was gradually decreased during the drying process until it reached 65%.

Packing and storage

The spaghetti was packed in cellophane bags and stored for 1, 2 and 3 months, under room temperature and light conditions found in the laboratory, with or without protection from light.

Vitamin addition levels

Four enrichment levels were used: *N*, 1, 2 and 3. The *N* level was calculated taking into consideration the average levels of thiamine, riboflavin and niacin, naturally occurring in Brazilian wheat, i.e. sufficient vitamin was added so, after extrusion, drying and cooking, the remaining vitamin was present at the average level found in Brazilian wheat. Levels 1, 2 and 3 were derived from level *N*: 1(70% of *N*), 2(120% of *N*) and 3(140% of *N*).

Vitamins quantification

Vitamins were analyzed according to AACC (1969): thiamine, method No. 86–80; riboflavin, method No. 86–70 and niacin, method No. 86–50.

Cooking tests

Cooking was performed according to AACC (1969), method No. 16-50.

A sample of 25·0 g of spaghetti, previously broken into approximately 3 to 10 cm length, was introduced into a 500 ml beaker with 250 ml of water at 98°C. The cooking time was determined by taking samples periodically and pressing them between two glass plates. The spaghetti showed a translucid appearance. The cooked spaghetti was transferred to a Buchner funnel to drain. After 10 min in the funnel, the cooked spaghetti and the cooking water were separated and used for the cooking tests.

Volume increase was determined by the difference of the volume displaced, in kerosene, by 10·0 g of uncooked and cooked spaghetti. The result obtained was multiplied by 10 in order to find the volume increase for 100 g of cooked spaghetti. Water absorption was calculated by determining the weight of the cooked spaghetti and the results were expressed in percent in relation to the uncooked spaghetti.

After drying the cooking water at 130°C for 1 h, the weight of the solids was determined and the residue in the cooking water was calculated and expressed as a percent of the uncooked spaghetti.

RESULTS AND DISCUSSION

Determination of the drying treatment

The technological characteristics of the spaghetti produced under different drying conditions are shown in Table 1. These results indicate that the products were of good quality when compared with those related by Ciacco and Chang (1986). Significant differences between the spaghettis produced under different drying conditions were not observed.

Table 2 shows the results obtained for the stability of naturally occurring thiamine, riboflavin and niacin, during processing and cooking, related to

TABLE 1
Technological Characteristics of the Spaghetti in Relation to the Drying Treatment Applied

Drying treatment	*Cooking time (min)*	*Volume increase*	*Water absorption (%)*	*Residue in the cooking water (%)*
LT	14	3·14	218	6·2
HT-1	14	3·28	224	6·1
HT-2	14	3·33	227	5·9

TABLE 2
Stability of Thiamine, Riboflavin and Niacin, Naturally Occurring in the Flour used, in Relation to the Drying Treatment Applied

	Drying treatment								
	Thiamine			*Riboflavin*			*Niacin*		
	LT	*HT-1*	*HT-2*	*LT*	*HT-1*	*HT-2*	*LT*	*HT-1*	*HT-2*
Natural level (mg/100 g)	0·133	0·133	0·133	0·057	0·057	0·057	1·232	1·232	1·232
Level after processing (mg/100 g)	0·109	0·107	0·107	0·055	0·048	0·044	1·225	0·884	0·881
Losses during processing (%)	18	20	20	4	16	23	1	28	28
Level after cooking (mg/100 g)	0·046	0·047	0·046	0·027	0·023	0·024	0·691	0·594	0·576
Losses during cooking (%)	58	56	57	51	52	45	44	33	35
Total losses (%)	65	65	65	53	60	58	44	52	53

the drying treatment used. Vitamin losses observed during the cooking process were greater than those observed during the several drying treatments. This is entirely in agreement with published observations. Niacin presented the smallest losses during cooking, followed by riboflavin and thiamine. The results obtained in the present work, together with those reported in the literature, indicate that losses during cooking occur by both thermal destruction and leaching into the cooking water. Only minor losses of the three vitamins were observed during the drying treatment at low temperature (LT). No significant differences were observed between the losses occurring during HT-1 and HT-2 drying treatments. The losses observed during drying contrasted with those obtained by Dexter *et al.* (1982). They observed riboflavin loss but no thiamine or niacin losses.

Determination of the enrichment level

The technological characteristics of spaghetti processed by HT-1 drying treatment, obtained in relation to the enrichment level used, are shown in Table 3. The results were similar to those in Table 1 and were independent of the enrichment level used.

The results obtained for the vitamin stability during processing (using the HT-1 drying treatment) and cooking, in relation to the enrichment level used

TABLE 3
Technological Characteristics of the Spaghetti Processed using the HT-1 Drying Treatment, in Relation to the Enrichment Level Used

Enrichment level	*Cooking time (min)*	*Volume increase*	*Water absorption (%)*	*Residue in the cooking water (%)*
1	14	3·27	225	6·5
N	14	3·24	222	5·7
2	14	3·24	221	5·5
3	14	3·35	235	6·8

are shown in Table 4. It was observed that the level of added thiamine did not affect the per cent vitamin loss during drying or cooking. Riboflavin and niacin losses during processing and cooking were greater than those shown in Table 2. The addition of vitamins caused greater per cent losses, especially during drying. The losses of the three vitamins occurring during processing and cooking were independent of the enrichment level used, and may be considered constant for the four enrichment levels studied.

Retention of the three vitamins and the technological characteristics of the spaghetti produced from enriched flour was independent of the enrichment level used. The next step of this work studied the stability of the three vitamins during storage, using the enrichment level *N*.

Storage

The technological characteristics of spaghetti produced using HT-1 drying treatment and enrichment level *N*, during storage with or without light influence is shown in Table 5. The technological characteristics of this spaghetti were not affected by the period of storage studied, with or without exposure to light.

Results obtained for the stability of the three vitamins during storage, with or without light influence, are shown in Table 6. No thiamine loss was observed during storage, with or without light. Some thiamine loss was expected since the room where the spaghetti was stored was not controlled for relative humidity, light intensity and temperature. Table 6 also shows the extreme influence of light on riboflavin stability during storage. After 3 months of storage, the spaghetti protected from light retained 78% of its initial level of riboflavin. When this material was not protected from light, it retained only 28% of the initial level of riboflavin. Such results were expected and, thus, confirmed that the enriched spaghetti must be stored in the dark in order to preserve the riboflavin. As expected, niacin was very

TABLE 4

Stability of Thiamine, Riboflavin and Niacin in the Spaghetti Processed using the HT-1 Drying Treatment, in Relation to the Enrichment Level Used

	Enrichment level											
	Thiamin				*Riboflavin*				*Niacin*			
	1	*N*	*2*	*3*	*1*	*N*	*2*	*3*	*1*	*N*	*2*	*3*
Initial level (mg/100 g)	0·943	1·283	1·513	1·743	0·477	0·647	0·767	0·887	6·542	8·812	10·332	11·842
Level after processing (mg/100 g)	0·785	1·058	1·236	1·464	0·357	0·481	0·598	0·666	4·369	5·632	6·481	7·329
Losses during processing (%)	17	18	18	16	25	26	22	25	33	36	37	38
Level after cooking (mg/100 g)	0·325	0·434	0·521	0·636	0·170	0·236	0·272	0·298	2·888	3·982	4·443	4·936
Losses during cooking (%)	59	59	58	57	52	51	55	55	34	29	31	33
Total losses (%)	66	66	66	64	64	64	65	66	56	55	57	58

TABLE 5
Technological Characteristics of the Spaghetti Processed using the the HT-1 Drying Treatment and the Enrichment Level *N*, in Relation to Storage

Storage (months)	*Cooking time (min)*	*Volume increase*	*Water Absorption (%)*	*Residue in the cooking water (%)*
1 (with light)	14	3·34	234	6·5
1 (without light)	14	3·33	226	6·2
2 (with light)	14	3·33	222	6·3
2 (without light)	14	3·27	220	5·9
3 (with light)	14	3·25	218	5·7
3 (without light)	14	3·42	236	6·1

stable during three months' storage, and it was not affected by the exposure to light.

CONCLUSIONS

The technological characteristics of spaghetti are independent of the drying treatment and the enrichment level used. Spaghetti dried by high temperature treatments was produced in one half the time. Losses of the vitamins used in the enrichment occur mostly during the spaghetti cooking. After 3 months' storage in the dark and after cooking, it was estimated that

TABLE 6
Stability of Thiamine, Riboflavin and Niacin in the Spaghetti Processed using the HT-1 Drying Treatment and the Enrichment Level *N*, in Relation to Storage

Storage (months)	*Vitamin level after storage (mg/100 g)*		
	Thiamine	*Riboflavin*	*Niacin*
1 (with light)	1·03	0·226	5·62
1 (without light)	1·07	0·457	5·68
2 (with light)	1·06	0·177	5·61
2 (without light)	1·08	0·448	5·63
3 (with light)	1·03	0·137	5·61
3 (without light)	1·07	0·417	5·66

the spaghetti produced by the HT-1 drying treatment and enriched with the enrichment level *N*, retains 96%, 78% and 94% of the average levels of thiamine, riboflavin and niacin, respectively, present in Brazilian wheat.

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