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The influence of formulation and processing on stability of thiamin in three styles of Asian noodles

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Abstract

Asian styles of noodle products represent the end-use of at least one eighth of all wheat produced globally and are potentially a good dietary source of essential nutrients. In order to investigate the factors influencing thiamin content, three styles of noodles were made under controlled laboratory conditions. The losses during preparation of dried white salted noodles were low. Boiling of these noodles resulted in a 43% decline in total thiamin level. In contrast, the relative losses of thiamin were high for yellow alkaline noodles and these occurred at each step in the process including dough mixing and drying. For instant noodles decreases also occurred at each step and these were smaller than for yellow alkaline but greater than for white salted noodles. The variation in ingredients and processing accounts at least partially for differences in thiamin levels of different noodle styles.

Keywords: Asian noodles; Nutrients; Vitamins

1. Introduction

Noodles are staple foods in many Asian countries (Miskelly, 1993). Historically these products originated in northern China, from where they were introduced to other parts of Asia by traders, seafarers and migrants. Noodles gradually became a staple food for many consumers and this was facilitated by the introduction of dried noodles (Huang, 1996). Many styles of Asian noodles are produced with preferences varying on a regional basis. Noodles are produced from different basic ingredients including wheat and rice flours. Asian wheat noodles differ from pasta products as they are typically made from bread wheat flour rather than durum semolina. In addition, a sheeting process is applied rather than extrusion. It can be estimated that, in 1990, at least one eighth of global wheat production was used in the manufacture of Asian noodles (FAO, 2001; Nagao, 1995, chap. 7).

The three main styles of Asian wheat noodles are white salted, yellow alkaline and instant noodles. Flour is the primary ingredient and selection of a suitable flour depends on the type of product as well as the specific preferences of the consumers. Generally, the flour should have fine granularity, low ash, good colour, reasonable degree of extensibility and rapid water absorption in a short mixing time and requirements for specific noodle types have been described (Kruger, Matsuo, & Dick, 1996; Nagao, 1996; Simmonds, 1989). Usually, the amount of water added is limited (less than 35% of flour weight) therefore the mixing stage forms stiff and crumbly spheres. This saves energy by minimising subsequent drying or frying stages, as there is less water to remove (Kruger et al., 1996).

The other main ingredient is salt in the form of NaCl or alkaline salts or a combination of these. The alkaline salts are often referred to as lye water or kan swi and are typically mixtures of sodium and potassium carbonates (Moss, Miskelly, & Moss, 1986). Salts have a variety of important

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functions in the processing of noodles. They not only enhance flavour and strengthen the gluten network but also help in moisture diffusion, inactivate enzymes and inhibit dough fermentation (Nagao, 1996). Furthermore, kan swi enhances starch gel strength (Moss et al., 1986) as well as appearing to confer a distinctive flavour and producing a natural yellow colour in the noodle by detaching flavones from starch.

In recent years considerable research has been undertaken and has resulted in the publication of a monograph reviewing noodle and pasta technology (Kruger et al., 1996). The emphasis has been on the identification of the flour characteristics which should be chosen to give the best quality of noodle products. These studies have included white salted styles of noodles (Oda, Yasuda, Okazaki, Yamauchi, & Yokoyama, 1980) and yellow alkaline noodles (Miskelly & Moss, 1985). Relatively little has been published on the instant types of noodles which are increasingly popular (Kim, 1996). Some research has specifically focussed on the development of procedures which might allow selection of new genotypes for particular noodle end uses (Baik, Czuchajowska, & Pomeranz, 1994a; Crosbie, 1991). Factors influencing noodle colour have also been studied from the perspectives of genotypic influences (Kruger, Matsuo, & Preston, 1992), the role of enzymes (Baik, Czuchajowska, & Pomeranz, 1994b) and the effect of alkaline salts used in yellow alkaline noodles (Miskelly, 1996; Moss et al., 1986).

One area which appears to have received limited attention is that of composition. At this time there is relatively little data available on the nutritional value of noodle products. Throughout the early 20th century, nutrient deficiency represented a major public health problem. The adequacy of vitamin intakes remains a current concern and has continued to be the subject of research and attention in recent years. The B group vitamins have been measured in a wide range of foods including breads and it is known that cereal foods are typically good sources of these nutrients (Ottaway, 1993). However, in the manufacture and storage of food products different vitamins demonstrate varying stability characteristics. The levels may decline significantly in some cases with serious nutritional implications. Among the factors which may be important are light, temperature, pH, water activity and the presence of certain food additives (Bender, 1997; Gubler, 1991, chap. 6).

Another issue is that of fortification where nutrients including vitamins are added during food manufacture. Around the world there are differing views of fortification. In the United States it has been required since 1941 for many foods (Borenstein, Caldwell, Gordon, Johnson, & Labuza, 1990, chap. 10; Iannarone, 1991, chap. 20). In other countries, a more cautious regulatory approach has been adopted (Becker, 1993). As Asian noodles represent a major end-use of wheat globally, it is therefore of interest to better understand the contributions they make to dietary intakes of essential nutrients. In addition, the potential of these products to act as vehicles for fortification requires investigation.

It has previously been shown that the levels of B group vitamins decline during the preparation of durum based products (Dexter, Matsuo, & Morgan, 1982; Watanabe & Ciacco, 1990). However, the different ingredients and processes applied in production of Asian noodles warrant the investigation of these products. Accordingly, the purpose of this study has been to compare white salted, yellow alkaline and instant noodles which have been prepared in the laboratory in order to determine the stability and retention of thiamin during processing. In addition, the influence of pH has been related to product formulation and the loss of thiamin.

2. Materials and methods

2.1. Materials

All chemicals used in this study were of analytical grade. Thiamin used as standard was the purest grade available from Sigma, Missouri. Commercial flours used to make noodles in the laboratory were Maximus strong bakers flour and Continental Farina, from Weston Milling, Melbourne.

2.2. Methods

2.2.1. Noodle formulation

White salted, yellow alkaline and instant noodles were prepared in the laboratory following the procedures of Moss et al. (1987). It is specifically noted here that all steps in the preparation of noodles were carried out in subdued lighting conditions in order to minimise the potential impact of light on vitamin retention. White salted noodles were prepared from Continental Farina. The formulation used for white salted noodles was: 300.0 g flour, 96.0 g water and 9.0 g common salt. The bakers flour was used to make yellow alkaline noodles and instant noodles. The ingredient formulation used for yellow alkaline noodle was: 300.0 g flour, 96.0 g water and 3.0 g sodium carbonate and for instant noodles: 200.0 g flour, 60.0 g water and 0.2 g sodium carbonate with palm oil being used for deep frying.

2.2.2. Noodle preparation

The equipment used was a Kenwood mixer and a small spaghetti maker (Imperia brand, Italy) consisting of two rolls with adjustable gap settings and a cutting roll attachment. For white salted and yellow alkaline noodles, the salt was first dissolved in the water and this solution was added to the flour over a period of 30 s in the mixer set on speed one. Timing of mixing then began when all the liquid had been added. The mixer was set at the lowest setting (speed one) for 1 min. After that, the speed of the mixer was increased smoothly to setting four and allowed to mix for a further 4 min. After a total of 5 min mixing (1 plus

4 min), the resultant dough had a crumbly consistency similar to that of moist breadcrumbs.

The dough was first formed into a dough sheet by a process of folding and passing the crumbly dough through the rollers of the noodle machine several times. Typically three passes were required although up to five passes were used where necessary in order to give a uniform sheet which held together as a single dough piece. Then this combined sheet was allowed to rest in a plastic bag, covered with aluminium foil, at room temperature for 30 min. The thickness of the rested sheet was reduced stepwise by passing between the rollers of the noodle machine. The sheet was cut into strands using the cutting roll attachment of the noodle machine to a width of 2.0 mm. The noodle strands were then cut to 25 cm lengths before drying in a fan forced oven at 40 °C for 24 h. The product was then allowed to cool for 30 min in the ambient conditions of the laboratory prior to being placed in airtight plastic bags or containers for storage.

The procedure for making instant noodles was the same as that for white salted and yellow alkaline noodles at the mixing and rolling steps. However, following these, the resultant sheet was not rested but was immediately passed a further four times between the rollers to reduce the sheet thickness before cutting into noodle strands for further preparation steps of steaming (for 2 min), deep frying in palm oil for forty five seconds at 150 °C, draining and cooling in the air flow created by a fume cupboard for 20 min prior to placing into a sealed bag or container for storage.

2.2.3. Cooking of noodles

Noodle samples were cooked by placing a small amount of noodles into a saucepan of boiling water (at a ratio of 1:10, one part of noodles in 10 parts of water). After every minute, a strand of noodle was removed, immediately placed into cold water and then squeezed between two microscope slides. The noodle was determined to be fully cooked if the uncooked core had disappeared, i.e., a uniform colour and appearance was observed upon squeezing. The optimum cooking time of noodles varied depending upon the type of noodles.

2.2.4. Thiamin analysis

The extraction and assay of thiamin were performed according to the Fluorometric method (Association of Official Analytical Chemists (AOAC) procedure number 953.17). This involved: preparation of samples (ground and cooked noodles), acidification (homogenised with 0.1 M HCl), autoclaving (20 min/109 °C), centrifugation (20 min/3500 rpm), oxidation using $K_3Fe(CN)_6$, extraction (isobutanol) and determination of thiochrome (fluorescence measurements using excitation wavelength set at 365 nm and emission wavelength at 435 nm). Quinine sulfate solution was also used to assess reproducibility. In all cases multiple analyses were performed.

All thiamin values are expressed in units of mg per kg and have been calculated to a dry weight basis. For measurement of the pH of noodle samples and the moisture contents, American Association of Cereal Chemists (AACC) method 02–52 and AOAC method 925.10 respectively were used (AACC, 1994; AOAC, 1990).

3. Results and discussion

3.1. The influence of noodle processing on thiamin losses

The aim of this study has been to investigate the influence of processing and the impact of processing parameters on thiamin losses. Laboratory methods were selected and set up to allow control of individual steps during preparation of white salted, yellow alkaline and instant noodles. The procedures were chosen to reflect as far as possible typical current commercial practice for each of the styles of noodles. For this study, considerable effort was made to control factors which might affect the thiamin content of the noodles. So for example, during preparation, the times were carefully controlled. It is noted that different flours were used for noodle preparation. Previous research has demonstrated that flours having specific protein contents and dough characteristics are required to provide the particular eating qualities expected by consumers of different styles of Asian noodles (Huang, 1996; Miskelly, 1993; Nagao, 1995). Therefore the bakers flour was used for the yellow alkaline and instant noodles as this flour had higher protein levels and the softer flour was chosen for the white salted noodles. The bakers flour had been fortified with thiamin whereas the softer flour had not.

Thiamin levels were analysed at each stage of processing of the noodles and the results are presented in Figs. 1–3. Relatively little loss occurred for white salted noodles (Fig. 1) at each step from flour to dough to the dried noodles. However, more than half of the thiamin was lost during the cooking of the dried prepared noodles. The results

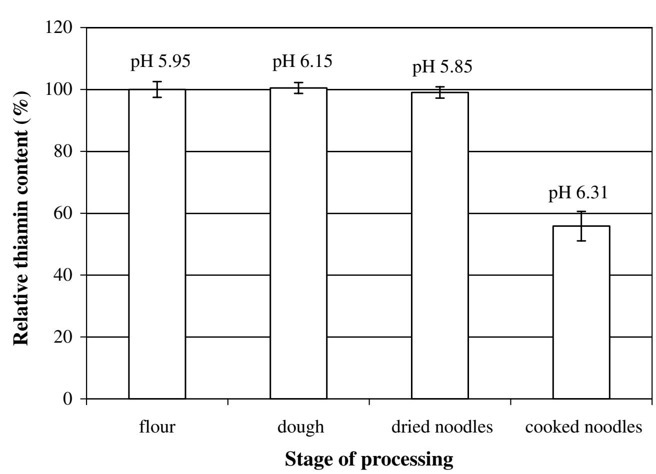

Fig. 1. Relative thiamin contents and corresponding pH values at different stages during processing of white salted noodles (thiamin values are means ± standard deviation, expressed as a percentage of the amount present in the flour, calculated after all values had been adjusted to a dry weight basis).

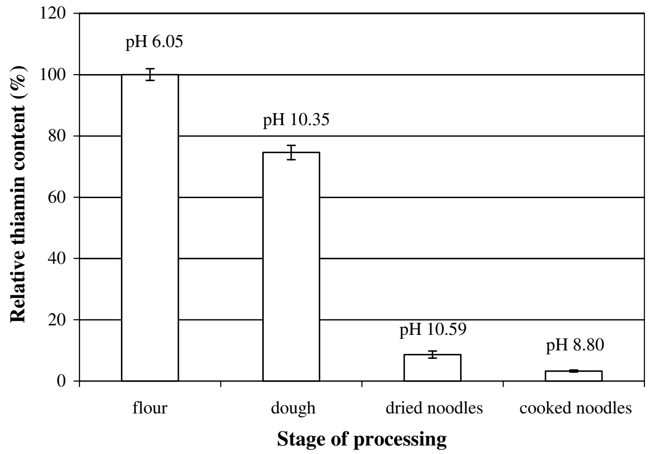

Fig. 2. Relative thiamin contents and corresponding pH values at different stages during processing of yellow alkaline noodles (thiamin values are means ± standard deviation, expressed as a percentage of the amount present in the flour, calculated after all values had been adjusted to a dry weight basis).

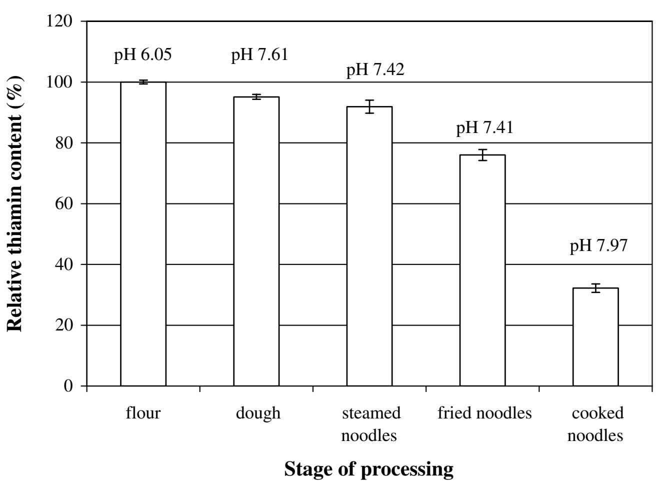

Fig. 3. Relative thiamin contents and corresponding pH values at different stages during processing of instant noodles (thiamin values are means ± standard deviation, expressed as a percentage of the amount present in the flour, calculated after all values had been adjusted to a dry weight basis).

are similar to those of Dexter et al. (1982) who studied the processing of spaghetti. These workers found that thiamin levels did not appear to be reduced during processing but the levels of thiamin in enriched spaghetti samples decreased very rapidly during the initial stages of cooking and continued to decline significantly throughout cooking.

In the case of yellow alkaline style noodles, losses of thiamin clearly occurred at each stage of noodle processing (Fig. 2). Major losses were observed both during the preparation prior to cooking and also during cooking.

Instant noodles were also made in the laboratory and the process included additional steps not required in the preparation of white salted and yellow alkaline styles of noodles. In these steps noodle strands were heated first by steaming and subsequently during a frying stage. The results of thiamin analysis of samples taken during instant noodle preparation are shown in Fig. 3. Relatively little thiamin was lost during dough preparation whereas there were some losses during the deep-frying step. Besides heat damage, losses of thiamin have to be considered through the solubility in water. Leaching into surrounding aqueous media may also be one of the causes contributing to the losses of thiamin during cooking. Significant losses occurred during processing of the instant noodles.

The pH characteristics of the different noodle styles were also measured to identify if there were any major differences which might relate to thiamin losses. These results (Figs. 1–3) show that the typical values were slightly acidic for white salted and relatively alkaline for yellow alkaline noodles. Instant noodles were also alkaline (pH 7.4) consistent with the addition of the alkaline salts but at lower levels (0.1%) than those for yellow alkaline noodles (1.0%). There were some changes in pH during cooking, particularly for yellow alkaline noodles where the pH dropped from 10.6 to 8.8. This may reflect leaching and loss of the salts into the boiling water.

3.2. Effect of cooking time on thiamin contents

The data for white salted, yellow alkaline and instant noodles (Figs. 1–3) indicated that significant losses of thiamin have occurred during cooking for all three styles of noodles. A further series of experiments was designed to study the rate of loss of thiamin during the cooking process. These also provided information on thiamin loss due to overcooking. Samples of three noodle styles were made and cooked for varying periods ranging from 0 to 17 min. It is noted that this time frame was selected to extend well beyond the expected optimum cooking times. The noodle strands were taken out at 1 min intervals. Then, the moisture and thiamin contents of all samples before cooking and at each time during cooking were measured (Figs. 4–6). It should be noted that different vertical scales have been used for each of the types of noodles. In addition, the amounts of thiamin found in the samples before cooking were used as the reference values to compare the relative losses.

During heating and cooking beyond the optimum point thiamin levels in the noodle samples declined significantly. In all three cases, a reduction occurred in the first minute when noodles were first exposed to the boiling temperature. The rate declined until the optimum cooking time and then it slowed down gradually as there were relatively small amounts of thiamin remaining.

At the optimum cooking point, all the samples had lost almost half of their original thiamin. Yellow alkaline noodles had the greatest loss at the optimum cooking time (59.3%) as well as at the 16th minute of cooking (78.0%). Instant noodles behaved in a similar way as yellow alkaline samples but to a lesser degree. This might be due to the affect of the lower amount of alkaline salts in the ingredients that accelerated the loss through leaching. As may be expected, white salted noodles show the lowest rates of loss among the samples tested.

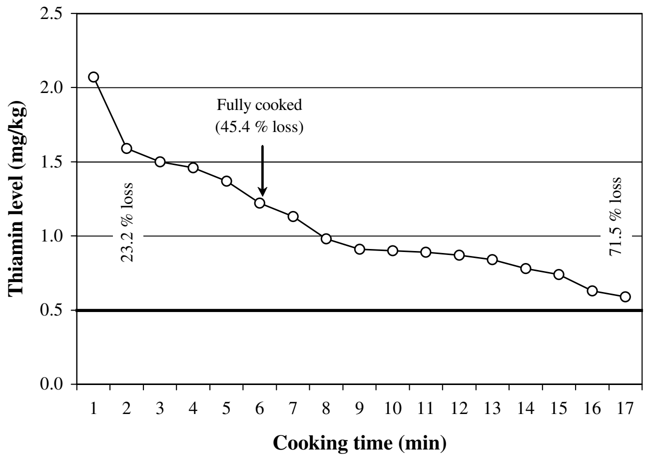

Fig. 4. Thiamin losses during cooking of white salted noodles (thiamin values expressed on a dry weight basis, loss values relate to levels present in dried noodles).

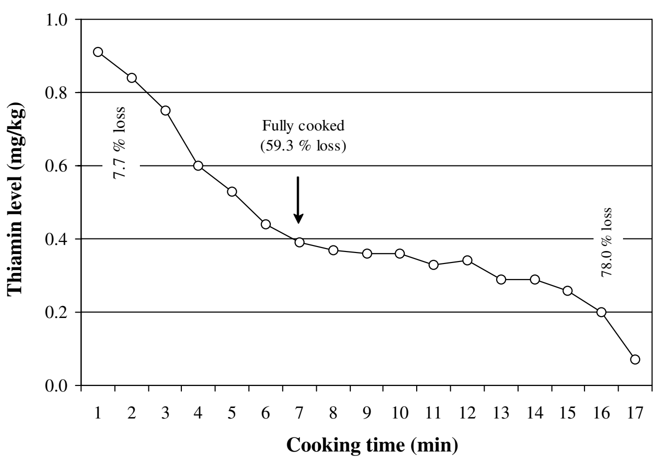

Fig. 5. Thiamin losses during cooking of yellow alkaline noodles (thiamin values expressed on a dry weight basis, loss values relate to levels present in dried noodles).

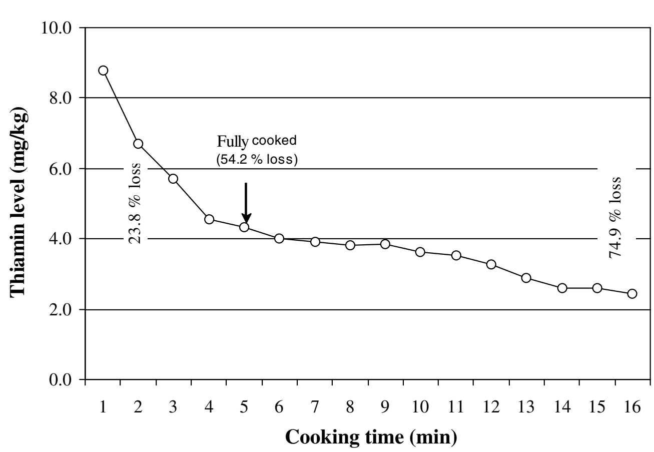

Fig. 6. Thiamin losses during cooking of instant noodles (thiamin values expressed on a dry weight basis, loss values relate to levels present in dried noodles).

Research on thiamin in enriched pasta products which included spaghetti, egg noodles and macaroni (Dexter et al., 1982; Ranhotra, Gelroth, Novak, & Matthew, 1985) showed 30% thiamin was retained in the samples after cooking. Whereas in another study, the loss of thiamin for the pasta products ranged from 41.6% to 54.4% (Ranhotra, Gelroth, Novak, & Bock, 1983) and 57.0–59.0% during cooking (Watanabe & Ciacco, 1990). The results for cooking of Asian noodles found in the current study appear consistent with these published figures.

In the experiments reported here, the optimum cooking time of noodles varied from style to style. The results were also accordant with Moss et al. (1986), who found that alkaline noodles had a longer cooking requirement than those with common salt. In addition, noodles made from high protein flours (yellow alkaline and instant styles) require longer cooking times than soft flours (white salted style). The results here indicated that the yellow alkaline style noodles had a longer cooking time than the white salted style. Instant noodles had a short cooking time as the manufacturing process already included steaming and deep frying which are effectively pre-cooking the product.

Two different flours were used in this study as these provided suitable product quality characteristics. These flours differed in initial thiamin levels as one had been fortified. It has previously been shown that for spaghetti samples, the cooking time was a more significant determinant of final thiamin level than degree of enrichment (Dexter et al., 1982). In a more recent study of spaghetti, the relative losses of B group vitamins including thiamin were found to be independent of level of fortification (Watanabe & Ciacco, 1990).

In the current study, the important issue is that yellow alkaline noodles prepared from a fortified flour (thiamin content of 12 mg/kg) contained less thiamin after cooking than did white salted noodles made from the unfortified flour (containing 2.1 mg/kg).

4. Conclusion

The results of this study show that thiamin contents of noodles are lower than some other foods known to be good sources of this vitamin. Cooking had a major impact for all noodle styles. The losses during boiling appear consistent with published figures for other food products. For example, in the preparation of food composition tables calculations have been based on an expected average loss of 40% during boiling of cereal based foods (Holland et al., 1991). Changes in the thiamin levels during boiling in the current study for white salted and instant noodles (43.2% and 43.8% respectively) were similar to those used by Holland et al. (1991). In the case of yellow alkaline noodles, only 5% was lost in boiling, as very little thiamin remained in the dried noodles, due to losses having occurred during earlier steps of processing.

Throughout these experiments the results indicated that the levels of thiamin loss depended on the amount of alkaline salt used in the formulation which in turn influenced the pH levels during processing. Yellow alkaline noodles were high in pH, thus there was considerable loss of thiamin on processing. Instant noodles also had alkaline pH but much lower than yellow alkaline noodles, therefore, smaller losses. In contrast, the processing method and ingredients for white salted noodles results in thiamin being more stable due to the mildly acidic conditions.

At the optimum cooking times the thiamin contents were reduced by almost half in the final products regardless of the noodle type. The results also demonstrated that even with flour that has been fortified to levels much higher than the Australian minimum legal requirement, the amount of thiamin remaining in the product consumed is quite low. This is the case for both yellow alkaline and instant styles of noodles. Hence fortification may not provide an effective solution to the problem where there is an elevated pH due to the addition of alkaline salts.

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