Grasas y Aceites
Vol. 49. Fasc. 3-4 (1998), 347-351

Vitamins

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SUMMARY

Vitamins

A thermal treatment is an intrinsic part of most food processing procedures and may be employed to inactive enzimes and toxic factors, to change texture and flavour or to preserve. The vitamin degree of transformation or destruction in cooking methods depends on the temperature and on the time of exposure to this temperature. Oxigen, light and transition metals frequently play an active role in accelerating or promoting vitamin losses. Both chemical change and difussion proceed more rapidly as the temperature is raised.

An advantage of deep frying consists of the fact that the temperature within the food does not exceed the temperature of the steam under the crust, and that frying times are in general very short compared to other cooking procedures. Another advantages may be the low content of dissolved oxygen in frying fats, and also in its high tocopherol content. There is no leaching of water-soluble vitamins in deep-frying.

Speaking of vitamin stability we have to keep in mind that the concept of vitamins is a more physiological concept than a chemical one. The stability itself is not a property of the various vitamins but rather of the various chemical compounds sometimes called vitamers, of which a certain vitamin group consists. For practical purposes, vitamin losses should be considered only in foods wich substantially contribute to the vitamin supply of single people or population groups.

There is little data in the literature about vitamin changes in deep-frying of food. However published experimental data on vitamin loses show that deep-frying is one of the most protective cooking procedures. For example, in ours results the vitamin C losses of stewed vegetable foods were twice higher than that of fried ones, (raw potatoes containing 19 mg/100g fresh weight, 13 mg/100g fried in olive oil, and 5 mg/100g stewed in the same oil).

KEY-WORDS: Deep-frying – Thermal processing – Vitamins.

Frying, as well as every thermal process, causes chemical changes in food. As we well know, these changes may have possitive aspects, such as the increase in palatability and the inactivation of enzymes and toxins, as well as negative aspects among which we should include, with some exceptions, the ones which have an effect on the content of vitamins.

Nevertheless, we should not forget that the greatest vitamin losses in industrial or home food processing, either through frying or other cooking methods, are frequently produced not only during cooking but also in the previous preparation of food, such as chopping, defrosting, etc..., and also after the cooking process - warm holding, cooling, preservation and reheating. These losses are common to most cooking methods, and although some of them occur mainly in dining halls they also take place in home preparation. Consequently, issued results of over 90% vitamin C losses in chips are not surprising, if we include the ones ocurring from raw potatoes until the moment immediately previous to their consumption (Brubacher, 1988).

In this sense, let us see what happens to the contents of vitamin C throughout the warm holding and reheating of a vegetable-rich broth such as «caldo gallego» (Galician broth), a typical dish from this Spanish region (Table I) usually cooked, preserved and then reheated for several consumptions.

Table I
Vitamin C content in a raw, cooked and reheated vegetable broth (mg/100g)

	Weight	Vitamin C	Retention (%)
Raw	100	2.36	100
Cooked	66	0.65	28
Reheated	61	0.03	1.3
Reheated (twice)	54	–	0

Ruiz Roso y Belmonte (1988)

Whereas one third of its initial content of vitamin C is retained throughout cooking, the rest is practically destroyed after cooling and reheating. Proportionally, the damage in these last stages is much greater than in its cooking process.

Several authors also find losses of vitamins in catering systems that use warm holding during food distribution. However, recent data regarding dining halls from Williams & col. (1995) point out that vitamin losses are even greater when keeping the dish refrigerated for one day and then reheated rather than through warm holding.

As regards frying, the information available is relatively scarce about vitamin changes throughout this process. The results are frequently different, as so are the conditions in which this process is carried out. Consequently, in the first place we will discuss certain theoretical aspects of the stability of vitamins in relation to the particular conditions of this thermal process. Later, we will discuss some of the results available.

When we speak about the stability of vitamins, we should take into account that the concept of «vitamin» is, as we well know, a physiological rather than a chemical one. For instance: as far as we know, vitamin B6 appears in foods under the form of six different chemical compounds: pyridoxol, pyridoxamine and pyridoxal, and linked to phosphate groups such as pyridoxol-5-phosphate, pyridoxamine-5-phosphate and pyridoxal-5-phosphate.

The stability of each compound is obviously different. For example, pyridoxal can react with the free amino group of amino-acids, thus forming a Schiff base and losing its vitaminic activity. On the other hand, the chemical forms of B6 without the aldehyde group cannot react in the same way.

In general, the stability of molecules with a certain vitaminic activity (either appearing naturally in foods or added for nutritional or technological purposes) depends on a variety of factors (Figure 1):

1. Temperature
2. Moist
3. Oxidizing or reductive agents
4. Light
5. pH
6. Metallic ions
7. Other food components
8. Time

Figure 1
Factors of food vitamin content change during treatment

Temperature: Retinol palmitate, for instance, can be changed by heat into 13-cis-vitamine A palmitate, or colecalcipherol into precolecalcipherol, both molecules of much less vitaminic activity. Also, thiamin chloride and pholates are irreversibly destroyed by heat.

Heat is not the only factor that acts negatively on vitamins throughout cooking. So do water, oxygen and oxidizing agents. Ascorbic acid, for instance, can react with oxygen thus forming dehydroascorbic acid. This compound has the same vitaminic activity as ascorbic acid, but it is very sensitive to oxidizing agents and can be hydrolyzed so as to form dicetogulonic acid, which lacks vitaminic activity. On the contrary, antioxidants, either natural or added, can protect this alteration.

Light, pH and the presence of metallic ions are factors which can increase vitamin loss by beginning or helping degrading reactions.

Interactions during treatment of foods can be also caused by the presence of other vitamins and food components, either natural, added or as a result of the degradation of other nutrients (enzymes, free radicals, sulphur anhydride, etc...). For instance, vitamin C can destroy vitamin B12; also, the reaction mentioned above of pyridoxal with the amino groups not involved in the peptidic bond, and the reaction of vitamin E and free radicals resulting from fat oxidation.

However, certain chemical compounds can be originated exceptionally by similar reactions during food processing, with no vitaminic activity existing in an available form when raw. For instance, niacine can be freed by the cooking of biologically unavailable inactive forms linked to non-amylaceous polysaccharides and glucopeptides, as in maize. Niacine can also be formed from trigoneline, as it occurs in coffee roasting.

Evidently, depending on the type of food and the different combinations of these factors, we can find many ways of possible vitamin damage during manufacturing or cooking processes.

Besides, these factors need some time in order to act. Processing duration is all important in relation to nutrient losses in manufacturing or in cooking. Every vitamin altering reaction has obviously its own kinetic properties, and many of the mentioned factors accelerate the process. Nevertheless, providing there is enough time, significant amounts of vitamin content may be destroyed in foods even in the case of relatively slow reactions, even at temperatures of only 60°, if we recall what has already been discussed regarding warm holding.

For this reason processing duration, in other words, the time nutrient degrading factors are allowed to act is also a decisive factor in vitamin losses. As an example of this, in Table II we find the results of several studies (adapted from Fellows, 1994) about the time/temperature ratio in the stability of certain vitamins and other food components during processing.

Table II

Thermal resistance in certain vitamins compared to enzymes, microorganisms and other food components

	Source	pH	Z (°C)**	D121 (min)*
Thiamin	Peas	Natural	27	247
Thiamin	Carrots	5.9	25	158
Thiamin	Mutton	6.2	25	120
Lysine	Soya flour	–	21	786
Chlorophyl B	Spinach	5.5	79	14
Chlorophyl A	Spinach	Natural	51	13
Betaine	Betroot	5.0	59	47
Peroxidase	Peas	Natural	37	3
C. Botulinum		>4.5	5-10	0.1-0.3
B. Thermophilus		>4.5	7-12	4.0-5.0

* D121 Value: Decimal reduction time to 121°C.
* Z Value: Number of °C required to reduce D value to a tenth.

(Fellows, 1994)

You may notice that the decimal reduction time to 121° in a typically thermolabile vitamin such as thiamin in certain foods is smaller than the most heat-sensitive amino-acids (lysine), but clearly larger than enzymes that should be destroyed by thermal processing, as well as that of microorganism. As we see in Table II, in order to destroy 90% of the thiamin processing at such temperature would be required for over two hours, whereas only a three-minute processing is needed in order to inactivate peroxidases.

In addition to this, if we increase temperature, we will obviously reduce not only the time of cooking, but also the time required to produce an equivalent nutritional alteration, if we look at the «Z» value for these nutrients. As we know, «Z» value measures the increase in degrees Celsius which reduces the time of degradation to a tenth. We notice that this temperature increase is rather high for vitamins, if we compare it with other negative food components such as microorganisms.

Theoretically, this shows that higher temperature processing which allows us to reduce significantly the processing time could be less damaging for vitamins than a moderate but long lasting one, provided that degradation processes are kinetically lineal. This is the basis of UHT or high-temperature time-reduced processing, widely used in food sterilization at present. As we know, this processing allows a greater retention of nutrients and palatable elements than traditional methods.

As it has been previously mentioned, all this is closely related to frying since food inner temperature never exceeds 100° during processing while its water content is evaporating. Also, its processing time is much shorter than that of other cooking methods. According to this, certain vitamins are expected to be more stable to frying than pressure-cooking or boiling.

In the transparency (Table III) we show the results of our group regarding vitamin C content (mg per 100 g) in potatoes and other raw and fried vegetables compared to the same stewed vegetables, in both cases using different cooking fats. Although we notice that there are certain losses of vitamin C in both processings, fried foods retain over twice as much of their vitamin content than stewed ones, the average retention being around 70% after frying and only 25% after stewing.

Table III

Vitamin C content (ascorbic and dehydroascorbic acid) in vegetables raw, oil-dip fried and stewed (mg/100g of raw food)

Foods	Raw	Fried (olive oil)	Fried (margarine)	Stewed (olive oil)	Stewed (margarine)
Potatoes	19.1	13.3 (70%)	11.9 (62%)	4.5 (24%)	4.9 (26%)
Peppers	112.3	82.7 (74%)	85.8 (76%)	9.6 (9%)	36.7 (33%)

Moreiras, Ruiz Roso y col. (1990)

Another additional advantage of frying is probably the low oxygen level dilluted in the oil dip and its tocopherol content, of well-known antioxidizing properties.

We should also take into account that, apart from thermal or oxidative damage produced during processing, vitamin losses can occur due to their solubility in water and lipides. We all know about the substantial losses of water soluble vitamins by washing in the cooking of vegetables, or in meat products by water cooking (Ryley & Kadja, 1994). Such losses might have taken place in this case.

Important amounts of vitamin C and also B1 can be lost in the same way with the gravy released from meat during roasting or baking (Brubacher, 1988).

There are practically no losses of water-soluble vitamins by washing during frying. Theoretically, it could be possible to find similar losses among fat-soluble vitamins, but there are no conclusive data regarding the subject. In addition to this and according to our results, we have found, as have other authors (Fellows, 1994), significant increases of vitamin E in frying foods, possibly due to the absorption of this vitamin existing in the oil deep.

This better behaviour of frying regarding water-soluble vitamins compared to other processings such as boiling or pressure-cooking has also been described by other authors (Ryley & Kadja, 1994).

General results in the influence of frying on vitamin retention ranges in different foods compared to other cooking methods are offered in the data from different countries about nutrient changes in food processing (NLG Project), recently compiled and published by Dr. Bergström (1995), of Eurofoods Project, in which we have taken part (Table IV). Generally, these wide ranges seem to depend more heavily on the type of food and vitamin rather than on cooking methods.

Table IV
Vitamins. Retention ranges (%)

FOOD	Vit. A	Vit. E	Vit. C	B_1	B_2	Niacin	B_6	Folic acid	B_{12}
Potatoes									
Baking	90	100	80-85	75-85	70-100	65-95	60-95	50-90	–
Boling	90	100	60-80	75-85	70-95	70-95	70-95	50-90	–
Frying	90	100	25-80	40-80	70-100	65-95	65-95	35-75	–
Meat, poultry									
Stewing	85-100	60-100	80	30-92	60-70	30-96	40-70	55-70	50-90
Frying	60-100	60-100	80	45-95	70-105	65-95	45-80	50-87	50-90
Roasting	75-100	60-100	80	45-80	70-105	50-90	45-90	60-95	65-90
Fish shellfish									
Steaming	65-95	100	–	55-95	60-100	70-95	70-100	70-100	80-100
Frying	80-95	100	80	55-90	80-95	80-100	55-90	70-100	80-100
In oven	85-95	100	–	70-95	80-100	80-100	90	80-90	75-90

Adaptado de: Report N.° 32/1994. National Food Administration, Sweden.

In relation to other published studies, most research for vitamin losses has been done with potatoes, since chips have been for many years a widely consumed food in all western countries. The importance of these studies is shown not only by the fact that potatoes are the main source of vitamins C and B1 in many countries, but also because these studies give an idea about the influence of this processing on thermolabile nutrients. In these studies (Augustin & col., 1981) results are given of between 65 and 83% water-soluble vitamin retention during home preparation of chips, finding the greater losses in products with a higher surface/volume ratio. This indicates that losses are mainly produced in the dehydrated surface of the food. Fellows (1994) speaks of complete vitamin C destruction in the outer crust produced by frying, as well as of losses of fat-soluble vitamins and gains of vitamin E.

From a nutritional point of view, we should be concerned with vitamin losses by frying, as well as with those produced during any other manufacturing or cooking food treatment, only insofar they affect the intakes of their individual or collective consumers. Obviously, we should not consider dish or meal intakes, not even those of a certain day; on the contrary, we should consider average intakes of at least a fifteen-day period. From a practical point of view, vitamin losses by frying, as well as those of any other processing, should be a matter of our concern only in those foods that contribute significantly to cover the reccommended intakes of individual or collective potential consumers.

In this sense, according to Brubacher (1988), using RDA average values we can classify foods in four categories in relation to their vitamin content (Table V):

Foods that contain less than 1/3 RDA/2500 kcal, as very poor vitamin sources.

Those that contain between 1/3 and 1 RDA/2500 kcal, as poor vitamin sources.

Those that contain between 1 and 2 RDA/2500 kcal, as adequate sources.

Those that contain over 2 RDA/2500 kcal, as very rich sources.

Table V
Foods as vitamin sources according to their nutritional density per 1.000 Kcal

	Source Classification			
	Very poor	Poor	Adequate	Rich
Vitamin A (μg)	133	133-400	400-800	800
Vitamin E (mg)	1.6	1.6-4.8	4.8-9.6	9.6
Vitamin B1 (mg)	0.17	0.17-0.52	0.52-1.04	1.04
Vitamin B2 (mg)	0.21	0.21-0.64	0.64-1.28	1.28
Vitamin B6 (mg)	0.23	0.23-0.68	0.68-1.36	1.36
Vitamin PP* (mg)	1.1	1.1-3.3	3.3-6.6	6.6
Pholates (μg)	53	53-160	160-320	320

* Considering that half of thiamin allowances come from tryptophan

Brubacher (1988)

Vitamin losses in foods that contain less than 1/3 RDA/2500 kcal can be rejected for many reasons since such losses, considered in the diet as a whole, would not cause appreciable modifications in the whole vitamin allowance.

Finally, in Table VI there is a summary of certain contents of water and fat-soluble vitamins in raw animal foods and their retention after oil-dip frying. Among the results available we have only considered those which would have nutritional interest according to what has been mentioned above. These are some of the data from a study belonging to one of the research lines of COST-91 Project, developed by our research group and carried out by our friend Prof. Brubacher in Hoffmann-La Roche Vitamin and Nutrition Research Department, Basel.

Table VI
Raw content and retention (%) of certain vitamins in oil-dip fried animal foods

	Vitamin A µg/1.000 Kcal (retinol)	Vitamin E mg/100 Kcal (α-tocopherol)	Vitamin B1 mg/1.000 Kcal (thiamin chloride)	Vitamin B2 mg/100 Kcal (riboflavin)
Beef	21	Traces	0.42 (64%)	2.1 (76%)
Pork	13	Traces	5.7 (87%)	1.3 (97%)
Mince meet (Beef meat balls)	190 (67%)	Traces	0.63 (45%)	1.1 (94%)
Sardines (Sardines pilchardus)	22	8.3 (79%)*	0.04	1.2 (66%)
Eggs	1.300 (78%)	2.9 (132%)	0.43 (93%)	3.1 (96%)

* Fried sardined were floured previously.

Brubacher (1988)

If we look at retinol, only two of the foods studied, meat balls and eggs, were an appreciable source and their retention was between 67 and 78%.

In the case of vitamin E we find that whereas there were certain losses (retention being of 79%) in sardines, very rich in this vitamin, in other foods (eggs) it was possibly the absortion of this vitamin from the oil dip what made its final content surpass the initial one.

In relation to water soluble vitamins, we found more retentions in the case of riboflavin (between 76 and 97%) than in thiamin (between 45 and 93%), as it was expected. However, high retentions of all vitamins found in fried eggs could be surprising -a very popular food, as well as chips (remember that this is the food shown in the poster of this Congress), although we should bear in mind that this food is prepared in a very short time compared to the other foods studied.

From my point of view, this reasserts the idea of the advantages of frying as opposed to other cooking methods, not only in relation to vitamin retention but also because of the short time required for its preparation.

I believe that the theoretical considerations and tested data commented on this report show that frying is one of the less agressive cooking methods for the most labile nutrients in food, as losses of vitamin content due to this cooking method are equal, and smaller in many cases, to those produced by other thermal processings.

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