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# Assessing nutritional quality of milk-based sport supplements as determined by furosine

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**Abstract**

Milk proteins have a strong position in the sport nutrition markets, such as sport supplements for highly trained athletes, apart from bodybuilders. Furosine, a well-known index for the availability of lysine and subsequently of the extent of the Maillard reaction, was evaluated in different common ingredients used for formulation, as well in commercial sport supplements. Furosine content ranged from 2.8 to 1125.7 mg/100 g protein in commercial sport supplements being usually lower in samples containing mainly whey protein isolates or casein, as compared with whey protein concentrates. It is estimated that 0.1–36.7% of the lysine content is not available in this type of products. The use of high quality ingredients for the manufacture of sport supplements reveals important, since it could be the major source of protein intake of certain group of consumers in high or moderate training regime. Furosine is an appropriate indicator to estimate the nutritional quality of sport supplements. A reference value of 70 mg furosine/100 g protein content in dried sport supplements could be set up for controlling the quality of milk-based ingredients used in the formulation. Samples with higher levels are suspected of use of low quality milk-based ingredients or inappropriate storage conditions.


*Keywords:* Maillard reaction; Sport supplements; Protein quality; Furosine

## 1. Introduction

Sports supplements are usually included in the diet of highly trained athletes, as well as overall population in a moderate and high training regime, apart from bodybuilders in whom muscle mass is particularly high. The main determinants of an athlete's protein needs are their activity level and habitual protein intake; however, there is no consensus in the scientific literature, as to habitual resistance exercises increasing protein requirements (Tipton & Wolfe, 2004). Special sports foods, including some protein supplements and meal replacements, may be useful in some circumstances, but high doses of these must be avoided to prevent harmful organic effects (Maughan, King, & Lea, 2004).

The basic ingredients used in manufacturing the sport supplements are mainly caseinates and milk whey, and in a minor scale soy, wheat or egg proteins, as well as dextrinomaltose as the main carbohydrate source. But whey proteins have a strong position in the sport nutrition market based on the quality of proteins they provide. Whey proteins represent only 10% of the total solids of whey and on drying whey the resulting powders have low protein content (De Wit, 1998). Dried whey could be grouped according to the protein content and technologies applied for the production (Hoch, 1997). Then, whey protein concentrates (WPC) usually contain less than 25% of protein and whey protein isolates (WPI) usually contain more than 70% protein. Then, the addition of whey proteins from whey powders into food products has two goals: one nutritive (as dietary supplements) and the other technological (solubility, foam formation, gel formation, emulsion, water binding, viscosity, etc.). Concentrated whey powders that

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contain more than 70% proteins are used in a wide range of food applications (infant formula, health foods, and drinks) as nutritional and functional ingredients (Fox, 1989). The high nutritive value of the whey proteins is mainly due to their high content of essential amino acids as compared to the wheat, beef, soy bean or eggs (FAO, 1970).

Application of thermal treatments during the purification of different ingredients, or even in the mixture process for formulation to obtain the final product can involve the development of the Maillard reaction (MR). MR occurs between the free amino group of lysine and/or other amino acids and the carbonyl groups of reducing sugars such as glucose and maltose (Camire, Camire, & Krumbar, 1990) and is favoured in systems with intermediate moisture content, temperatures over 50 °C and pH 4–7. Lysine is commonly one of the most reactive amino acids in the early step of the MR (Ashoor & Zent, 1984). Then, loss of available lysine is the most significant consequence of the MR, and it is of great importance in those foods where lysine is the limiting amino acid (Erbersdobler, 1986). Evaluation of the early steps of the MR, as subsequently the protein quality, can be achieved by determination of furosine (ε-*N*-(furoylmethyl)-L-lysine) amino acid formed during acid hydrolysis of the Amadori compounds fructosyllysine and lactulosyllysine (Nursten, 1981).

There is a lack of information on the extent of the MR in sport supplements, and special attention should be paid since it could be the major protein source in a specific group of consumers and an appropriate balance of essential amino acids should be maintained. The aim of this study is to determine the impairment of lysine due to the MR, measured as furosine, in different commercial sport supplements, as well as some of the classical ingredients used in the formulation.

## 2. Materials and methods

### 2.1. Chemicals

All chemicals used were of analytical grade and were obtained from Merck (Darmstadt, Germany), unless mentioned otherwise.

### 2.2. Samples

#### 2.2.1. Ingredients

Nineteen different protein ingredients, present in most formulations for sport supplements, were directly obtained from several international companies for sport supplements. The ingredients were named with letter F followed by a number (Table 1).

#### 2.2.2. Sport supplements

Thirteen commercial sport supplements (dried) with different nutrient compositions were also supplied by international companies. Samples cover most of the types of formulations marketed, and commercial variations (i.e., flavouring) for the same product/trade mark were not considered. The samples were designed with letter S followed by a number (Table 2).

Table 1
Protein and furosine content of representative ingredients used for sport supplements formulation

| Protein source[a] | Code | Protein[b] | Furosine[c] |
|---|---|---|---|
| WPC | F1 | 15.5 | 285.2 ± 2.04 |
| | F2 | 10.8 | 319.9 ± 2.76 |
| | F3 | 16.4 | 862.3 ± 19.59 |
| | F4 | 10.9 | 886.3 ± 20.01 |
| | *Mean* | *13.4 ± 2.97* | *588.4 ± 306.20* |
| WP-hydrolysed | F5 | 69.3* | 266.6 ± 30.48 |
| WPI | F6 | 78.2 | 16.8 ± 1.32 |
| | F7 | 84.5 | 27.2 ± 0.97 |
| | F8 | 85.5 | 27.3 ± 0.61 |
| | F9 | 90.5 | 32.4 ± 1.19 |
| | F10 | 79.6 | 68.7 ± 1.98 |
| | F11 | 87.1 | 142.1 ± 10.62 |
| | F12 | 91.1 | 149.7 ± 6.77 |
| | F13 | 91.7 | 154.9 ± 21.94 |
| | F14 | 93.0 | 261.0 ± 1.61 |
| | *Mean* | *86.8 ± 5.33* | *97.8 ± 81.54* |
| Casein | F15 | 86.5 | 12.2 ± 0.59 |
| | F16 | 82.6 | 20.1 ± 11.89 |
| | F17 | 78.9 | 54.8 ± 7.01 |
| | *Mean* | *82.7 ± 3.80* | *29.1 ± 21.20* |
| Casein-hydrolysed | F18 | 86.6* | 23.6 ± 0.85 |
| Soy | F19 | 90.0 | 3.3 ± 0.19 |

[a] Protein source: WPC, whey protein concentrate; WPI, whey protein isolate.
[b] Data are expressed as g/100 g product, and as net protein*.
[c] Data are expressed as mg/100 g of protein, respectively (means ± SE).

### 2.3. Protein determination

The samples (0.800–1.000 g) were heated to 1050 °C following AOAC 992.15 (AOAC, 1995) in a LECO model FP-2000 (Leco Instruments, Madrid, Spain) protein/nitrogen analyser calibrated with ethylenediaminetetraacetic acid (Dumas method). The nitrogen-to-protein conversion factor considered was 6.38, and results were expressed as grams of protein/100 g of product.

### 2.4. HPLC determination of furosine

Furosine determination was performed following the methods described by Resmini and Pellegrino (1991) with some modifications. Briefly, 50 mg of the sample was hydrolysed with 8 ml of 7.95 M HCl at 110 °C for 23 h in a Pyrex screw-cap vial with PTFE-faced septa. Hydrolysis tubes were sealed under nitrogen. The hydrolysates were aerated and cooled at room temperature and subsequently centrifuged at 14,000*g* for 10 min. A 0.5-ml portion of the supernatant was applied to a Sep-pak $C_{18}$ cartridge (Millipore) pre-wetted with 5 ml of methanol and 10 ml of deion-