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Nutritional evaluation of the full-day diet

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Abstract: Nutrition plays an important role in human life. So far, there have been discussions focusing on the nutritional value of individual foods, separate dishes, or daily meals. However, they have not taken into account the composition of the diet in the longer term. The aim of this work was to evaluate a full-day diet from a currently renowned company that is producing box diets on the Czech market against a full-day diet of twenty randomly selected students. The results showed that the box diet met the required amount of protein, fat, vitamin E, cholesterol, and also the optimal intake of *n*-6 and *n*-3 fatty acids. The amount of saturated fatty acids (SFA) was only slightly increased. Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) content averaged 38 mg day^{-1}, which did not meet the current requirements. The students' full-day diet was variable, the individual differences were large. Protein intake could be assessed as sufficient in most cases. The total fat intake ranged from 21 g day^{-1} to 126 g day^{-1}. Seven out of twenty samples would satisfy the recommendation for SFA. The content of the essential acids EPA and DHA was below the detection limit with the exception of one sample (containing herring fillets).

Keywords: box diet; proteins; fatty acid composition; EPA; DHA

Nowadays, an increasing amount of people are interested in a healthy way of life and nutrition. They look not only at the composition of products, nutritional values, and positive components [polyunsaturated fatty acids (PUFA), fibre content, etc.] but also at what we should consume less of [added sugars, saturated fatty acids (SFA), *trans*-unsaturated fatty acids, salt, etc.] (WHO 2020).

A balanced diet must be designed to ensure appropriate intake of energy, macronutrients, and micronutrients, as well as, for example, fibre. The need for energy and nutrients is completely individual and dependent on many factors, such as age, gender, height, weight, sports activity, load activity, illness, unusual physical conditions such as pregnancy, etc. (EFSA 2017; Kohout et al. 2021).

The average daily energy intake for a normal person is around 2 000 kcal (or 8 400 kJ). The diet should ideally be divided into 5–6 portions (breakfast, brunch, lunch, snack, dinner, and possibly a second, but lighter, dinner). The biggest meal should be, of course, lunch. Fruits and vegetables should be represented in 5 servings [Regulation (EU) No. 1169/2011; EFSA 2017].

Protein should represent approximately 12–15% of energy intake and the proportion of animal and vegetable protein should ideally be around 1 : 1. Significant restriction of animal protein, together with a reduction in dietary diversity is not appropriate and

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can lead to a deficiency of some essential amino acids. Protein intake is sometimes given in absolute units as 0.8–0.9 g protein kg^{-1} body weight (adults and adolescents) (EFSA 2017).

The proportion of fats should be in the range of 20–35% of energy intake (depending mainly on the intensity of physical activity) (EFSA 2017; Kohout et al. 2021). The nutrition guidelines recommend reducing SFA intake, previously recommending a maximum of 10% of total energy intake or 30% of total fat. The current recommendations operate with the term 'as low as possible' (similarly for *trans*-unsaturated fatty acids) (EFSA 2017). Great emphasis is placed on the intake of polyenoic fatty acids. Linoleic acid intake should be 4% and linolenic acid 0.5% of energy intake. The sum of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) intake should be 250 mg day^{-1}. For this reason, it is recommended to consume fatter sea fish, which are their main source. Current dietary guidelines for a healthy population no longer take into account dietary cholesterol intake. It appears only in the opinions of professional medical companies, such as the American Heart Association (SCF 1993; Caballero et al. 2003; Chrpová et al. 2010; Rodwell et al. 2018; Carson et al. 2020; Kohout et al. 2021). Vitamin E intake is important in preventing the oxidation of biomembrane lipids. The recommended daily amount of vitamin E is 11–15 mg (Hamre 2011; Menoyo et al. 2014; Velíšek 2014; EFSA 2017).

Various full-day diets, usually intended for everyday life or for weight reduction, appear on the market increasingly often. We assumed that they would provide a balanced diet, but reliable scientific information mapping the nutrient content and composition of long-term box diets is not yet available. For comparison, we used the students' diets, which, in agreement with published results (Bernardo et al. 2017), we assumed to be unbalanced in some ways. The aim of our research was therefore to determine the content of important nutrients and to evaluate the benefits or risks of consuming a professionally produced boxed diet. Students' diets are the subject of a number of scientific publications. Most of these publications focus on students' eating habits (Zurita-Ortega et al. 2018; Morris et al. 2020), but scientific publications on the nutrient intake in students' usual diets are limited (Khattak et al. 2012; Aidoud et al. 2019). This work focused on the nutritional assessment of a box diet produced for the Czech market. Samples of regular full-day diets of students were used for comparison. The monitored parameters were energy, protein, fat, saturated and polyenoic fatty acids, fibre, tocopherols, and cholesterol. It can be assumed that the composition of the diet and the intake of important nutrients in students will not be in accordance with the requirements for good nutrition. Box diets, produced on a professional basis, could be a suitable alternative for this population group.

MATERIAL AND METHODS

Samples

Ten samples (two-week menu for weekdays) of box diets (Zdravé Stravování s.r.o., Strážnice, Czech Republic) were analysed. The box diets, which were always distributed the morning after production, were processed immediately upon receipt of the boxes. Twenty samples of the full-day diet of university students [University of Chemistry and Technology, Prague (UCT Prague), Czech Republic] were also analysed. These samples were also obtained and processed the morning of the following day. The selection of students was random. Characteristics of the group of these students: 12 men, 8 women; age 23–26 years; in good health; without the need to restrict the intake of certain foods; none of the students followed a reduction diet; all students routinely consumed a mixed diet. This part was realized by the method of duplicate samples (the portion of food consumed was purchased twice). Tables 1 and 2 summarise the composition of the box diet and the students' full-day diet.

Sample preparation

The synthetic antioxidant butylhydroxytoluene (Sigma-Aldrich, Germany) was added to both students' and box diet samples. All samples were homogenised (Grindomix GM 200; Retsch, Germany), then lyophilised (Alpha 2-4 LSCbasic; Christ, Germany), and stored at freezing temperature (–18 °C) (GS 30D410; Siemens, Germany).

Methods of analysis

Three parallel determinations were performed for each sample.

Determination of dry matter. Dry matter determination is based on the drying to a constant weight (AB204-S; Mettler Toledo, Switzerland) according to ISO 1026:1982.

Determination of ash. The sample was mineralised; the ash was then determined gravimetrically according to ISO 2171:2007.

Determination of crude protein content. The procedure for the determination of the 'crude protein'

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Table 1. List of analysed dishes including their weight (box diet)

Sample No. (day)	Meal composition	Total weight of dishes (g)
1 (Monday)		
Breakfast	leek spread, pastry	
Brunch	extruded corn bread with cheese and cherry tomatoes	
Lunch	barley groats with mushrooms and smoked meat	1 445
Snack	blackberry dessert with sweet oat chips	
Dinner	chicken pieces with honey-mustard sauce, salad, roasted potatoes	
2 (Tuesday)		
Breakfast	cottage cheese spread, pastry	
Brunch	tzatziki, textured bread	
Lunch	beef stew on balsamic with peas, potatoes	1 500
Snack	homemade cheesecake dessert	
Dinner	poultry with apricots, oats	
3 (Wednesday)		
Breakfast	baked eggs, pastry	
Brunch	strawberry drink with goji	
Lunch	salad of pasta with mini mozzarella and pumpkin seeds	1 391
Snack	dip with fresh herbs, sticks	
Dinner	cod in curry sauce, couscous	
4 (Thursday)		
Breakfast	three-grain porridge with fruit	
Brunch	crispy peppers with cheese	
Lunch	chicken strips with broccoli, rice	1 662
Snack	carrot spread with tofu, fit bread	
Dinner	pork roast with spinach, sticks	
5 (Friday)		
Breakfast	tuna spread with spring onion, pastry	
Brunch	beet carpaccio, fragile slice	
Lunch	gratinated chicken fillet with ham, bulgur with corn	1 443
Snack	chocolate mousse with wild berries	
Dinner	pasta with lentil ragout	
6 (Monday)		
Breakfast	spread with roasted ham, pastry	
Brunch	dip of red lentils, sticks	
Lunch	meat on pears, flavoured bulgur	1 222
Snack	stracciatella yogurt	
Dinner	tortilla with tuna, egg and vegetables	
7 (Tuesday)		
Breakfast	avocado spread, pastry	
Brunch	drink à la Piña Colada	
Lunch	meatballs with tomato salsa, rice	1 325
Snack	salty italian cream, mini toasts	
Dinner	chicken pieces with lemon sauce, couscous	
8 (Wednesday)		
Breakfast	spread with grated cheese, pastry	1 444
Brunch	mushroom tartare, brittle slice	

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Table 1. To be continued

Sample No. (day)	Meal composition	Total weight of dishes (g)
8 (Wednesday)		
Lunch	bucatini with pea pesto and chorizo	
Snack	baked plums with white yogurt	1 444
Dinner	poultry roulade stuffed with onion mixture, red puree	
9 (Thursday)		
Breakfast	raspberry oatmeal with pudding	
Brunch	cottage with ham, cherry, extruded corn bread	
Lunch	chicken slice with cabbage, potato sticks	1 574
Snack	egg spread, fitness bread	
Dinner	pork with beans, rice	
10 (Friday)		
Breakfast	spread with protein concentrate 'šmakoun', pastry	
Brunch	fresh cheese roll, extruded bread	
Lunch	pasta with vegetables and soybeans	1 536
Snack	dessert with peanut butter and goji	
Dinner	meat with creamy leek, potatoes, carrot salad with tangerine	

content is based on the measurement of the total nitrogen content (KT200 Kjeltec system; FOSS, Denmark) of food by the Kjeldahl method [The Association of Official Analytical Chemists (AOAC) method, 920.105]. A factor of 6.25 was used to convert nitrogen to protein [Regulation (EU) No. 1169/2011].

Determination of fat content. The fat content was determined gravimetrically according to EN ISO 659:2009; adapted for Soxtec apparatus.

Fat extraction for further lipid analysis. To determine the composition and content of fatty acids, tocopherols, and cholesterol, the classical Soxhlet method for fat extraction was used, which reduces the risk of oxidation of PUFA. A relatively polar 1 : 1 mixture of hexane and ethyl acetate (Penta, Czech Republic) was used as the solvent. The extraction lasted for 4 h. The solvent was evaporated on a rotary evaporator (Rotavapor R114; Büchi, Switzerland).

Determination of fibre. The determination of fibre was performed using the American Association for Clinical Chemistry (AACC) 32-05.01 method – a combination of enzymatic-gravimetric method and liquid chromatography (McCleary et al. 2013).

Determination of cholesterol. Cholesterol was determined by gas chromatography with a mass detector (Agilent 6890 GC/5973 MSD; Agilent Technologies, US) using the American Oil Chemists' Society (AOCS) Official Method Ch 6–91 (1997) under the conditions described by Sabolová et al. (2017).

Determination of composition and content of tocopherols. Tocopherols were determined by reverse-phase high-performance liquid chromatography (LCP 4020.31; Ecom, Czech Republic) using an amperometric detector (HP 1049A; Agilent Technologies, US) and a working glass carbon electrode (Agilent Technologies, US) under the conditions described by Fišnar et al. (2014).

Determination of fatty acid composition. Fatty acids were first converted to fatty acid methyl esters according to EN ISO 12966-2:2011 and then analysed by gas chromatography (Agilent 6890; Agilent Technologies, US) with a flame ionisation detector under the conditions described by Sabolová et al. (2020).

Energy intake calculation. Energy intake was calculated according to the formula [Regulation (EU) No. 1169/2011]:

$$E = 17(DM - A - F - DF) + 8DF + 37F \text{ (kJ)} \quad (1)$$

where: E – available energy intake (kJ); DM – dry matter; A – ash; F – fat content; DF – dietary fibre

Statistical analysis. The statistical analysis consisted of one-way analysis of variance (ANOVA) and cluster analysis and was performed in STATISTICA 12.0 (StatSoft, Inc., US). Scheffé's test was performed at the 5% significance level to identify significant differences between tested samples.

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Table 2. List of analysed dishes including their weight (full-day diet of students)

Sample No.	Full-day diet composition	Total weight of dishes (g)
1	apple, rye bread with sunflower, Camembert cheese, Gouda cheese, extruded bread, melted cheese with gouda, tomato, stewed carrots, boiled eggs and potatoes with butter, banana, pasta salad with peppers, spring onions and oil, cucumber	1 330
2	bun, Gouda cheese, ham, steak in beer batter with cheese, potatoes with butter, plum (2 pcs), potato salad, wheat-rye bread	920
3	white yogurt, chocolate baked muesli, apricot, chicken on paprika, pasta, kohlrabi, peeled carrots, herring fillets with onions pickled in vinegar, soy bun	1 285
4	organic muesli mixture, defatted white yogurt, banana, plum, peeled apple, roasted pork with dumplings, sauerkraut, extruded bread, Camembert cheese, Balkan cheese, tomato, peeled cucumber	1 410
5	UHT milk, oat flakes, banana, Caesar wrap, instant noodles, sterilised corn, smoked tofu	940
6	strawberry yogurt, rye bread with sunflower, baked bun with apple, cottage, extruded bread, radish	1 185
7	instant porridge – apple and cinnamon, baguette with cheese and egg, fresh cheese, wheat-rye bread, ham, cucumber, sliced Edam cheese	620
8	UHT milk, chocolate-coated cornflakes, croissant, vanilla-strawberry milk dessert, processed cheese with Gouda, pasta salad with chicken meat	1 020
9	yogurt with apples and cereals, nectarine, beef goulash, 4 dumplings and pepperoni, biscuits, yogurt, mozzarella, tomato (2 pcs), olives, rustic baguette	1 503
10	wheat-rye bread, soft salami, smoked cheese, tomato sauce, laps and 5 bread dumplings, biscuit, grilled chicken, toasted bread	1 090
11	apple bun, peach, fried rice noodles with vegetables, ham, rice sandwiches, semi-fat cottage cheese, cereal bun (2 pcs), tomato	1 260
12	soy yogurt, organic muesli mixture, apricot (2 pcs), apple, banana, couscous with mushrooms and vegetables, crispy corn slices, cabbage salad with dill, lentil salad with onion, pepper, parsley and cucumber, sunflower bun	1 720
13	poppy seed bun, apricot jam, chocolate spread, Szeged goulash and 5 dumplings, vanilla-cherry croissant, bean goulash with sausages, croissant (2 pcs)	1 090
14	fruit wraps, blueberry yogurt, beef Stroganoff with rice, salami pizza	860
15	instant chocolate porridge, banana, spinach burgers with tofu, potatoes with butter, pate, rye bread with sunflower, chickpea salad with peppers and onions, extruded bread	1 195
16	scrambled eggs with onion and parsley, wheat-rye bread, cucumber, croissant, salami, chopped butter steak and mashed potatoes, sausage in batter, chicken strips and French fries	1 155
17	chocolate roll, plum (2 pcs), beef roast, 5 dumplings, white yogurt, puffed rice, sausages, smoked cheese, toasted bread	1 005
18	Greek white yogurt, organic muesli mixture, peeled pear, rye bread with sunflower, Kendo sprouts, ham, baked potatoes with vegetables and mushrooms, crispy corn slices, vegetable spread India, cantaloupe melon, watermelon, nectarine, rice sandwiches	1 700
19	oat flakes, chocolate-coated cornflakes, fresh milk, soy meat with leek, rice, cucumber, white yogurt, extruded bread, bean salad with peppers and spring onions, crispy corn slices	1 460
20	baked chocolate muesli, fresh milk, banana, couscous salad with grilled vegetables, biscuit, apricot (3 pcs), fried Camembert, boiled potatoes and tartar sauce, bread chips barbecue	1 550

pcs – pieces

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RESULTS AND DISCUSSION

Nutritional value – basic parameters

Samples of a two-week (for weekdays) box diet intended for a regular diet of the population with medium energy demands (around 8 000 kJ) were analysed. This diet is designed and implemented on a commercial basis by a specialised professional company. In contrast, a usual daily diet of randomly selected respondents, university students, was used. The values of energy intake and selected nutrients are given in Tables 3 and 4.

The recommended daily energy intake is the sum of energy from fats (20–35% of energy), protein (12–15%, but up to 25% of energy can be tolerated without problems in the long run), and carbohydrates (45–55% of energy) [Trumbo et al. 2002; Regulation (EU) No. 1169/2011; EFSA 2017; Kohout et al. 2021].

Dry matter and ash contents are only auxiliary parameters for the energy intake calculation, therefore, they are not included in the results.

Box diet. In this case, it is useful to evaluate the weekly average nutrient intake, which eliminates daily fluctuations. Energy intake varies in a not very wide range around 8 000 kJ day^{-1}, which exactly corresponds to the concept of the diet which gives some space for very moderate consumption of popular foods (snacks, confectionery, etc.) (Trumbo et al. 2002; EFSA 2017; Kohout et al. 2021). In this study, however, the experimental data are based only on the contents of box diets.

Protein intake ranged from 107.3 to 143.6 g day^{-1}, the part of total usable energy ranges from 19.4% to 35.6%. The weekly average slightly exceeds the upper tolerated limit of 25% of energy. Fat intake ranged from 49.6 g day^{-1} to 89.7 g day^{-1}, the part of total usable energy ranges from 20.7% to 43.1%. Weekly averages (27.5% and 34.0%, respectively) are fully in line with EFSA guidelines and the previously recommended 30% of energy. Some modern, generally accepted dietary trends recommend some restrictions on carbohydrate intake. A comprehensive view of the intake of the main nutrients shows that this box diet respects this trend. The part of carbohydrates in the total usable energy (obtained by up to 100%) ranges from 26% to 58%, with weekly averages of 47% and 38%. It is positive that carbohydrate restrictions in this diet apply almost exclusively to simple sugars (Trumbo et al. 2002; EFSA 2017; Kohout et al. 2021).

The daily fibre intake of this diet often only just exceeds 20 g, which is reasonably compliant with current dietary guidelines. Tocopherol intake ranges from 7.2 mg day^{-1} to 14.3 mg day^{-1}, with weekly averages of 8.5 mg and 11.7 mg. Most dietary guidelines set down the value of 10 mg day^{-1}. The observed values of tocopherol intake are in acceptable agreement with these guidelines. Daily cholesterol intake ranges from 67 mg to 641 mg. Cholesterol, as a lipophilic substance, remains in the body, so it is more appropriate to use weekly averages, which are 149 mg day^{-1} and 408 mg day^{-1}. Cholesterol intake of up to 300 mg day^{-1} has historically been recommended. The values determined are in agreement with this guideline (Trumbo et al. 2002; Hamre 2011; EFSA 2017; Sabolová et al. 2017; Carson et al. 2020; Kohout et al. 2021).

Students' diet. The variability of the composition of students' diet is multifactorial, determined by the in-

Table 3. Nutrition value of the box diet (mean ± SD; n = 3)

Sample No.	Energy (kJ day^{-1})	Protein		Fat		Fiber (g day^{-1})	Tocopherols (sum) (mg day^{-1})	Cholesterol (mg day^{-1})
		(g day^{-1})	(% E)	(g day^{-1})	(% E)			
1	7 622	129.6 ± 1.0^{b}	28.9	59.2 ± 0.6^{d}	28.7	18.9 ± 0.6^{f}	8.9 ± 0.3^{def}	151 ± 8^{e}
2	8 887	111.2 ± 0.9^{de}	21.3	49.6 ± 0.5^{f}	20.7	23.8 ± 0.5^{bcd}	7.2 ± 0.3^{f}	67 ± 5^{f}
3	7 595	141.8 ± 1.1^{a}	31.7	57.0 ± 0.6^{de}	27.8	21.1 ± 0.6^{def}	9.8 ± 0.4^{cd}	201 ± 8^{d}
4	9 419	107.3 ± 0.9^{e}	19.4	83.6 ± 0.8^{b}	32.8	27.6 ± 0.6^{a}	7.5 ± 0.3^{ef}	202 ± 8^{d}
5	7 569	118.7 ± 0.9^{c}	26.7	55.9 ± 0.7^{e}	27.3	24.6 ± 0.7^{bc}	9.3 ± 0.4^{de}	126 ± 6^{e}
6	6 631	119.9 ± 0.9^{c}	30.7	77.3 ± 0.8^{c}	43.1	21.3 ± 0.6^{def}	10.0 ± 0.5^{cd}	222 ± 9^{d}
7	6 866	143.6 ± 1.0^{a}	35.6	51.5 ± 0.6^{f}	27.8	19.8 ± 0.7^{ef}	12.6 ± 0.4^{ab}	458 ± 10^{c}
8	8 366	133.6 ± 1.0^{b}	27.1	89.7 ± 0.8^{a}	39.7	22.6 ± 0.5^{cde}	9.8 ± 0.4^{cd}	507 ± 10^{b}
9	9 144	141.7 ± 1.1^{a}	26.3	59.6 ± 0.6^{d}	24.1	26.2 ± 0.8^{ab}	11.7 ± 0.6^{bc}	641 ± 13^{a}
10	8 845	114.0 ± 0.9^{d}	21.9	84.0 ± 0.7^{b}	35.1	22.1 ± 0.7^{cde}	14.3 ± 0.4^{a}	210 ± 8^{d}

$^{a–f}$Significantly different values within the columns are marked by different letters; SD – standard deviation; % E – percentage of energy of the total available energy

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Table 4. Nutrition value of the student's diet (mean ± SD; n = 3)

Sample No.	Energy (kJ day^{-1})	Protein (g day^{-1})	Protein (% E)	Fat (g day^{-1})	Fat (% E)	Fiber (g day^{-1})	Tocopherols (sum) (mg day^{-1})	Cholesterol (mg day^{-1})
1	6 089	50.1 ± 0.5^{k}	14.0	50.4 ± 1.0^{h}	30.6	28.3 ± 0.8^{a}	15.4 ± 0.3^{c}	422 ± 8^{d}
2	4 675	74.0 ± 0.6^{g}	26.9	58.1 ± 1.2^{efg}	46.0	11.1 ± 0.8^{fgh}	10.0 ± 0.2^{d}	261 ± 5^{ef}
3	7 485	99.9 ± 0.9^{c}	22.7	59.2 ± 1.2^{ef}	29.3	15.9 ± 0.5^{de}	7.7 ± 0.3^{e}	291 ± 6^{e}
4	7 418	76.1 ± 0.7^{fg}	17.4	64.2 ± 1.2^{de}	32.0	29.6 ± 0.9^{a}	15.4 ± 0.3^{c}	246 ± 5^{efg}
5	7 821	76.1 ± 0.8^{fg}	16.5	66.9 ± 1.4^{d}	31.7	14.8 ± 0.7^{def}	17.4 ± 0.4^{b}	118 ± 4^{jk}
6	5 617	57.6 ± 0.6^{ij}	17.4	20.7 ± 0.8^{l}	13.6	12.8 ± 0.7^{efg}	4.5 ± 0.4^{fgh}	79 ± 4^{k}
7	5 846	59.7 ± 0.5^{ij}	17.4	53.5 ± 1.1^{fgh}	33.9	8.1 ± 0.6^{hi}	5.2 ± 0.2^{fg}	148 ± 4^{ij}
8	6 131	58.3 ± 0.6^{ij}	16.2	50.1 ± 1.0^{h}	30.2	6.2 ± 0.5^{ij}	3.1 ± 0.2^{hi}	137 ± 4^{j}
9	8 578	98.0 ± 0.7^{cd}	19.4	55.2 ± 1.1^{fgh}	23.8	9.9 ± 0.6^{ghi}	5.4 ± 0.2^{fg}	455 ± 9^{d}
10	8 603	114.6 ± 0.8^{a}	22.6	81.8 ± 1.4^{c}	35.2	8.3 ± 0.5^{hi}	6.3 ± 0.3^{ef}	546 ± 11^{c}
11	7 707	79.1 ± 0.7^{f}	17.4	51.7 ± 0.9^{gh}	24.8	17.8 ± 0.6^{cd}	2.8 ± 0.2^{hij}	446 ± 9^{d}
12	8 523	61.6 ± 0.7^{i}	12.3	22.9 ± 1.2^{kl}	9.9	29.8 ± 0.6^{a}	4.2 ± 0.3^{ghi}	252 ± 5^{ef}
13	8 999	74.1 ± 0.6^{g}	14.0	68.9 ± 1.3^{d}	28.3	15.9 ± 0.5^{de}	7.5 ± 0.3^{e}	191 ± 6^{hi}
14	6 820	56.4 ± 0.6^{j}	14.1	41.0 ± 0.9^{i}	22.2	2.6 ± 0.3^{j}	2.6 ± 0.2^{ij}	240 ± 5^{fg}
15	8 502	66.7 ± 0.6^{h}	13.3	49.1 ± 1.0^{h}	21.4	19.9 ± 0.6^{bc}	1.1 ± 0.1^{j}	122 ± 4^{jk}
16	9 593	110.3 ± 0.8^{b}	19.5	126.0 ± 1.8^{a}	48.6	3.9 ± 0.4^{j}	2.8 ± 0.2^{hij}	1 531 ± 20^{a}
17	8 887	88.9 ± 0.7^{e}	17.0	80.9 ± 1.3^{c}	33.7	2.9 ± 0.3^{j}	3.7 ± 0.3^{ghi}	733 ± 12^{b}
18	8 625	95.0 ± 1.0^{d}	18.7	28.6 ± 1.1^{jk}	12.3	23.6 ± 0.5^{b}	17.5 ± 0.4^{b}	205 ± 4^{gh}
19	7 346	74.2 ± 0.7^{g}	17.2	31.2 ± 0.9^{j}	15.7	28.1 ± 0.9^{a}	3.0 ± 0.2^{hi}	163 ± 5^{hij}
20	10 938	73.0 ± 0.7^{g}	11.3	98.4 ± 2.0^{b}	33.3	16.3 ± 0.7^{cde}	24.6 ± 0.5^{a}	156 ± 5^{ij}

$^{a-l}$Significantly different values within the columns are marked by different letters; SD – standard deviation; % E – percentage of energy of the total available energy

dividuality of each student, their different eating habits, influenced by regional or financial factors. Some may be more inclined towards a more rational diet and think more about the composition of their meals. Other students have unhealthy eating habits, favouring the intake of fast foods, sweets, snacks, soft drinks and low intake of vegetables, fruits, or fish.

The same parameters as in the previous case were used to assess the nutritional value of the full-day diet of a randomly selected group of students. The results are shown in Table 4.

All the results obtained show a huge variance given the individual's nutritional needs and nutritional habits. Energy intake varies in a wide range from 5 000 kJ day^{-1} to 11 000 kJ day^{-1}. Most values (12 in total) are in the range of 7 000kJ day^{-1} to 9 000 kJ day^{-1}, which can be assessed as relatively common intake due to low physical activity (Trumbo et al. 2002; EFSA 2017; Kohout et al. 2021).

Protein intake ranged from 50 g day^{-1} to 114 g day^{-1}, in terms of energy percentage, the range is 11.3–26.9%. In the range of 11–15% of energy were 6 samples, 11 samples had up to 20% of energy and only 3 samples exceeded the value of 20% of received energy. This distribution can be considered nutritionally positive. Fat intake ranged from 20 g day^{-1} to 126 g day^{-1}, calculated as a percentage of energy in the range of 9.9–49.6%. Fifteen samples met EFSA guidelines: 20–35% of energy. Four samples were below and one above this limit. Long-term fat intake of around 50% could probably be associated with the development of cardiovascular disease in future. On the contrary, too low intake, below 20%, may not ensure a sufficient intake of essential fatty acids and lipophilic vitamins. A comprehensive view of the intake of the main nutrients shows that they are not probably affected by the downward trend in carbohydrate intake discussed in the previous section. The part of carbohydrates in the total usable energy (obtained by up to 100%) ranges from 27% to 69%, the average value is 55% and in 12 samples the carbohydrate intake is between 40% and 60% of energy (Trumbo et al. 2002; EFSA 2017; Kohout et al. 2021).

The daily fibre intake is very variable, ranging between 3 g day^{-1} and 30 g day^{-1}. Half of the respondents receive more than 15 g day^{-1}, which is in line with cur-

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rent dietary guidelines. Tocopherol intake ranges from 1.1 mg day^{-1} to 24.6 mg day^{-1}. Most dietary guidelines set down the value of 10 mg day^{-1}. Only 6 samples met this criterion. This fact points to the need to pay increased attention to this antioxidant vitamin. Cholesterol intake ranges from 79 mg day^{-1} to 1 531 mg day^{-1}. Cholesterol intake was less than 300 mg day^{-1} in 14 respondents. The average value of 337 mg day^{-1} is burdened by two remote results of 733 mg day^{-1} and 1 531 mg day^{-1}, for which cholesterol intake is extreme (Trumbo et al. 2002; Hamre 2011; EFSA 2017; Sabolová et al. 2017; Carson et al. 2020; Kohout et al. 2021).

Fatty acids

The fatty acid composition of the fat content of foods is an important parameter of nutritional value. The full spectrum of fatty acids was determined for all samples, however, only fatty acids that are important from a nutritional and health point of view are listed in Tables 5 and 6.

The total content of SFA in box diets ranged from 33.8% to 56.1% with an average of 43.9%, while student diet samples were in the range of 15.2% to 56.2% with an average of 37.4%. The maximum daily amount of SFA should be within 30% of all fatty acids (Trumbo et al. 2002). Seven samples of student diets complied with this limit (another 5 samples approached the limit) and none of the box diet (3 samples approached the limit). EFSA guidelines (EFSA 2017) aim to minimise SFA intake. With a certain tolerance, the above 7 samples of student diets and only one sample of box diets can be taken as samples that meet this guideline. The intake of SFA in Czech cuisine is traditionally high and most of the monitored samples copy this trend.

The amount of *trans*-unsaturated fatty acids did not exceed 2% of all fatty acids in any sample, therefore they are not listed in the tables. The EFSA guideline (EFSA 2017) 'as low as possible' is of course met in this case.

EFSA guidelines (EFSA 2017) no longer take into account the previously frequently used ratio of *n*-6 and *n*-3 polyenoic fatty acids. This was replaced by a recommendation for total linoleic and linolenic acid intake expressed as % of total energy intake. For linoleic acid, it is 4%, for linolenic acid 0.5%. For box diets, 6 samples meet the criterion for linoleic acid (the others show the values close to the criterion), for linolenic acid, it is 9 samples out of 10 samples (one is just below the limit). For student diet samples, 13 samples out of 20 samples meet the criterion for linoleic acid (in two cases the intake is very low, on the contrary, in one sample the value is over 11%), for linolenic acid, it is 12 samples out of 20 samples (there is a large variance of values again – from 0.1% to 1.5%). Adequate intake of linoleic and linolenic acid is important not only for the subsequent synthesis of arachidonic, EPA and DHA (from which subsequent reactions produce eico-

Table 5. The composition of important fatty acids in the box diet (uncertainty of analytical determination: 0.01%)

Fatty acid	Sample No.									
	1	2	3	4	5	6	7	8	9	10
P (%)	22.4	20.7	22.1	16.7	21.7	21.7	19.1	22.3	19.2	22.8
S (%)	5.4	6.2	5.7	5.5	9.0	7.5	5.8	6.6	5.3	5.7
O (%)	28.7	29.4	25.5	38.4	30.2	33.7	35.3	29.7	32.4	30.5
L (%)	12.8	11.5	10.6	17.6	17.1	16.3	14.3	16.7	19.1	12.4
ALA (%)	3.2	4.7	1.5	4.1	2.2	2.2	2.7	3.1	4.5	2.6
EPA (%)	0.02	0.06	0.11	0.15	0.09	0.06	0.03	0.02	0.02	0.01
DHA (%)	0.01	0.03	0.18	0.03	0.17	0.19	0.02	0.04	0.04	0.01
SFA (%)	48.8	47.7	56.1	33.8	44.0	41.3	39.8	43.2	37.0	47.7
MUFA (%)	33.0	33.6	29.5	42.8	34.2	27.5	40.8	34.5	37.0	34.8
PUFA (%)	16.9	17.3	13.1	22.5	20.4	19.7	18.1	20.9	24.8	15.9
L (% E)	3.6	2.3	2.9	5.6	4.5	6.8	3.8	6.4	4.5	4.2
ALA (% E)	0.9	0.9	0.4	1.3	0.6	0.9	0.7	1.2	1.1	0.9
EPA + DHA* (mg day^{-1})	17.2	43.3	160.3	146.0	141.0	187.5	25.0	52.2	34.7	16.3

*Calculated according to fat content; % – percentage of individual fatty acid of the total amount of fatty acids; % E – percentage of fatty acid energy of the total available energy; P – palmitic; S – stearic; O – oleic; L – linoleic; ALA – linolenic; EPA – eicosapentaenoic; DHA – docosahexaenoic; SFA – saturated; MUFA – monounsaturated; PUFA – polyunsaturated fatty acid

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Table 6. The composition of important fatty acids in the student's diet (uncertainty of analytical determination: 0.01%)

Fatty acid	Sample No.									
	1	2	3	4	5	6	7	8	9	10
P (%)	28.1	20.2	22.8	22.7	21.1	27.2	23.2	25.9	24.1	28.1
S (%)	7.9	5.7	5.2	10.3	4.2	6.8	8.4	10.9	6.0	9.4
O (%)	29.8	33.3	30.5	35.0	38.3	26.5	33.2	28.7	31.0	32.5
L (%)	11.2	25.2	26.2	15.9	26.0	10.2	10.6	5.6	21.7	11.8
ALA (%)	1.5	2.0	2.0	1.1	4.3	2.2	2.5	1.9	0.6	1.1
EPA (%)	nq	nq	0.23	nq	nq	nq	nq	nq	nq	nq
DHA (%)	nq	nq	0.29	nq	nq	nq	nq	nq	nq	nq
SFA (%)	52.2	36.1	33.9	41.6	28.1	56.2	47.3	50.1	42.6	48.6
MUFA (%)	33.4	35.9	36.6	40.1	41.1	29.6	36.7	32.0	33.9	37.4
PUFA (%)	13.1	27.5	29.1	17.4	30.5	12.8	13.3	8.9	22.5	13.4
L (% E)	3.3	11.2	7.4	4.9	8.0	1.3	3.5	1.6	5.0	4.0
ALA (% E)	0.4	0.9	0.6	0.3	1.3	0.3	0.8	0.6	0.1	0.4
EPA + DHA* (mg day^{-1})	nq	nq	298.6	nq	nq	nq	nq	nq	nq	nq

Table 6. To be continued

Fatty acid	Sample No.									
	11	12	13	14	15	16	17	18	19	20
P (%)	14.7	10.6	25.9	15.9	14.1	18.5	28.2	14.5	21.7	23.6
S (%)	5.0	3.5	7.8	6.2	7.1	7.0	8.8	5.2	8.9	5.7
O (%)	34.7	51.9	39.5	40.6	35.5	44.7	28.4	44.4	32.6	38.2
L (%)	32.4	27.3	17.4	19.9	34.9	18.1	12.5	19.2	13.9	19.6
ALA (%)	2.3	2.0	2.0	4.4	1.9	3.1	1.1	3.9	3.6	2.4
EPA (%)	nq	nq	nq	nq	nq	nq	nq	nq	nq	nq
DHA (%)	nq	nq	nq	nq	nq	nq	nq	nq	nq	nq
SFA (%)	26.3	15.2	36.2	29.5	22.7	27.7	52.1	26.6	38.0	36.7
MUFA (%)	38.0	54.4	43.8	45.0	38.9	50.1	32.6	48.9	35.5	40.6
PUFA (%)	35.2	29.9	19.7	24.8	37.2	21.9	13.9	23.8	17.9	22.3
L (% E)	7.8	2.6	4.8	4.3	7.2	8.5	4.1	2.3	2.1	6.3
ALA (% E)	0.6	0.2	0.5	0.9	0.4	1.5	0.4	0.5	0.5	0.8
EPA + DHA* (mg day^{-1})	nq	nq	nq	nq	nq	nq	nq	nq	nq	nq

*Calculated according to fat content; nq – not quantified (content below 0.005%); % – percentage of individual fatty acid of the total amount of fatty acids; % E – percentage of fatty acid energy of the total available energy; P – palmitic; S – stearic; O – oleic; L – linoleic; ALA – linolenic; EPA – eicosapentaenoic; DHA – docosahexaenoic; SFA – saturated; MUFA – monounsaturated; PUFA – polyunsaturated fatty acid

sanoids as important tissue hormones) but also they positively affect the solubility of plasma lipoproteins. From this point of view, the above results sound relatively positive (Trumbo et al. 2002; EFSA 2017; WHO 2020; Kohout et al. 2021).

For box diet samples, the highest EPA and DHA values were found for samples No. 3, 4, 5, and 6. However, all of these samples only approximate the EFSA 250 mg day^{-1} guideline. The time sequence of samples containing EPA and DHA sources can probably be described as not very suitable. For 19 student diet samples, EPA and DHA were below the limit of quantification. Only one sample, which contained herring fillets, had significant amounts of EPA and DHA, reaching a sum of almost 300 mg. It can be said that fatty sea fish (salmon, herring, mackerel, sardines, anchovies) are the only

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good food source of these extremely important fatty acids, but this type of fish is a very marginal commodity in traditional Czech cuisine. It is also possible to use some food supplements, based either on fish oil or krill oil [Trumbo et al. 2002; Souci et al. 2008; EFSA 2017; Commission Implementing Regulation (EU) 2019/108; Kohout et al. 2021].

Statistical analysis

Statistical method ANOVA was used to assess the difference between the two types of diets. Only differences in protein ($P < 0.0001$), fibre ($P = 0.0158$), and linolenic acid ($P = 0.0302$) intake were found to be statistically significant ($P \leq 0.05$) in the 0.95 confidence interval. In all three cases, the average values are higher for box diets. These are parameters that are considered positive in terms of a healthy diet. This fact also suggests that box diets may be a better alternative to regular uncontrolled diets.

The dissimilarity between individual samples of a given type of diet was assessed using hierarchical cluster analysis. For box diet samples, the cluster analysis did not show any significant differences, the composition of nutrients is balanced. Some deviation can be observed only in sample No. 8 in a comprehensive assessment of protein, fat, and fibre intake (Figure 1).

Larger dissimilarity can be observed between the student diet samples. Sample No. 16 (Figure 2) deviated significantly in a comprehensive evaluation of protein, fat, and fibre intake. This sample also has extremely high cholesterol intake, which was also reflected in the cluster analysis evaluating tocopherol and cholesterol intake. The clear separation of sample No. 12 (Figure 3) when evaluating the fatty acid composition is also interesting. In this case, it is a vegan diet, probably applied only once (there was no vegan in the group of respondents).

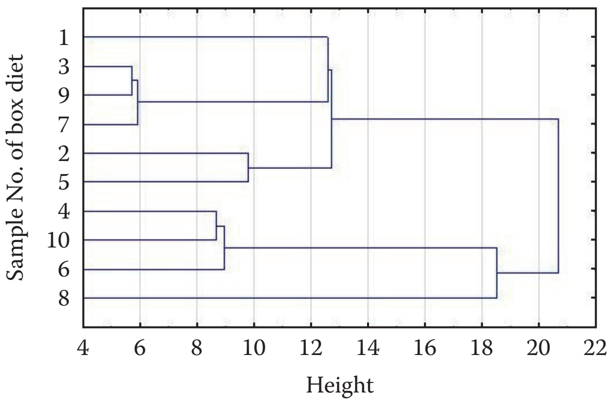

Figure 1. Single linkage cluster dendrogram for box diets (evaluated parameters 'protein', 'fat', and 'fiber')

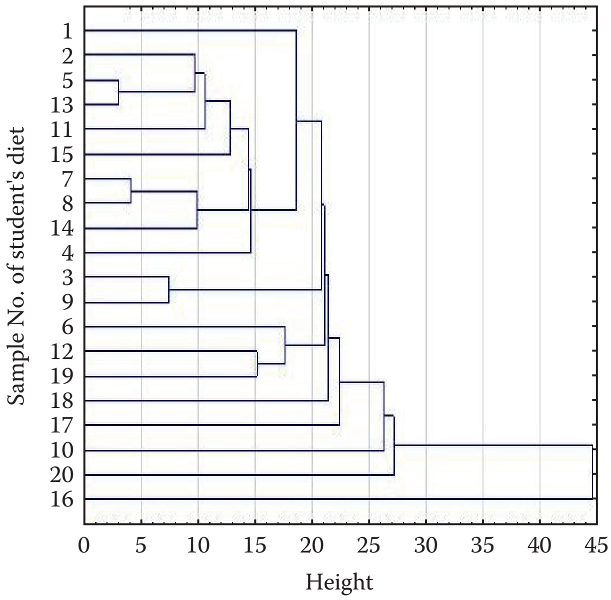

Figure 2. Single linkage cluster dendrogram for student's diet (evaluated parameters 'protein', 'fat', and 'fiber')

The results show that the set of box diets is relatively homogeneous, the variations in nutrient intake on individual days are small. On the contrary, the set of student diets is remarkably variable, and in remote groups (samples No. 16, 12, 17) the intake of certain nutrients is completely inadequate.

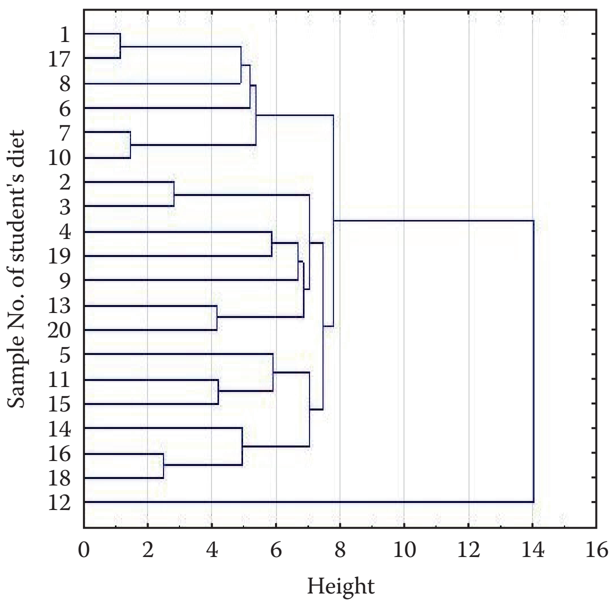

Figure 3. Single linkage cluster dendrogram for student's diet (evaluated parameters 'SFA', 'MUFA' and 'PUFA')

SFA – saturated; MUFA – monounsaturated; PUFA – polyunsaturated fatty acid

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CONCLUSION

The box diet is based on a professional basis. All the main nutrients are contained in the appropriate amount, only a slightly higher protein content and, conversely, a lower carbohydrate content are debatable. Vitamin E intake in this diet is also adequate. However, the fatty acid composition of this diet is not optimal. The diet has a high content of SFA and a lower content of monoenoic acids. The diet ensures a sufficient intake of linoleic and linolenic acid. In contrast, the content of highly unsaturated *n*-3 acids, EPA and DHA is lower than recommended.

The usual diet of the students was very diverse. The intake of the main nutrients is sufficient in most cases and meets the guidelines. The intake of tocopherols is lower, which may pose a problem for the oxidative status of the body in future. The intake of SFA, linoleic and linolenic acid was, on average, comparable to box diets. In only one case was there a significant dietary intake of EPA and DHA. This corresponds to the eating habits of the inhabitants of the Czech Republic, where fatty sea fish are a very marginal food commodity. However, the overall composition of the diet is a bigger problem than meeting the requirements for nutritional value. The poor composition of the diet and the great variability of diets confirm the need for an individual approach to potential nutritional interventions.

The results show that the overall composition of box diets is balanced, and the diet ensures sufficient or almost sufficient intake of important nutrients. In contrast, student diets often have insufficient or excessive nutrient intake. The inclusion of box diets in students' nutrition could have a positive effect on their nutritional status.

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