Original scientific paper
UDC 613.26(497.7)

DEVELOPMENT OF A FOOD FREQUENCY QUESTIONNAIRE TO ASSESS THE DIETARY INTAKE OF A PHYTATE IN THE URBAN MACEDONIAN POPULATION

Daniela Nikolovska Nedelkoska[1*], Sasko Martinovski[1], Aneta Nikolovska[1]

[1]Faculty of Technology and Technical Sciences, St. Kliment Ohridski University, Dimitar Vlahov bb, 1400 Veles, Republic of Macedonia

[*]e-mail: daniela.nedelkoska@uklo.edu.mk

Abstract

Phytate, the salt of phytic acid, is the primary storage compound of phosphorus in seeds. Plant-based foods such as unrefined cereals and legumes, including oil seeds and nuts are the main sources of phytate in the daily diet. Although some studies shown that phytate may have beneficial roles as an antioxidant and anticarcinogen, it is a well-known inhibitor of the absorption of some essential trace elements and minerals, which may lead to calcium, iron, magnesium and zinc deficiencies in the body. Therefore, valid tools for measuring the phytate intake are needed. Food frequency questionnaire (FFQ) is commonly used as an effective, easily administered and inexpensive dietary assessment tool. The aim of this study was to develop a quantitative FFQ for estimating intake of phytate in the urban Macedonian population.

Hence, the main objectives of the study were (a) to generate an appropriate food list, portion size and food frequency options and (b) to pretest the dietary tool with the intent to explore its usability and to identify issues and suggestion for its improvement. The FFQ was developed using 3-day food intake record data from a sample of 100 participants(of both genders, aged 15-65 years and varying dietary patterns) living in Skopje. From the obtained collective food data, 31 single foods were selected and formed the basis for the food list. For each food item, a standard serving was expressed in commonly used portions. The frequency of intake was assessed on an ascending eight-point scale: never, once/month, 2 - 3 times/month, once/week, 2 - 3 times/week, 4 - 6 times/week, once/day, and twice or more/day. Support questions on supplement use, meal practices, demographics, anthropometrics, lifestyle, and health status, were also included.

This study highlights the development of a quantitative FFQ, as a dietary assessment tool for estimating intake of phytate. The next step will involve the verification of the FFQ reproducibility and validity.

***Key words**: Food frequency questionnaire, Dietary assessment tool, Phytate intake.*

1. Introduction

Food consumption habits have changed in recent decades and there is an increasing interest in foods rich in bioactive compounds that may prevent some types of non-communicable chronic diseases [1]. The bioavailability of the bioactive components in the body can be affected by the presence of antinutrients. Phytate (myo-inositol hexaphosphate) is the primary phosphorus storage in plant seeds. For decades phytate has been regarded as an antinutrient. Although some studies shown that phytate may have beneficial roles as an antioxidant and anticarcinogen, it is a well-known inhibitor of the absorption of some essential trace elements and minerals that may lead to calcium, iron, magnesium and zinc deficiencies in the body [2]. Plant-based foods such as unrefined cereals and legumes, including oil seeds and nuts are the main sources of phytate in the daily diet.

Due to evidence showing that plant-based diet has health benefits, modern people started adopting a dietary pattern containing high quantities of plant-based foods. In addition, the food industry has introduced various new products enriched with plant bioactive compounds (e.g., fiber), also rich in phytate. Such dietary patterns led to increased consumption of phytate in modern diet, and an increased risk of reduced mineral absorption in the body. Therefore, a valid tools for measuring the phytate intake are required.

Assessing dietary intakes, especially for a larger population is timely and economically demanding. Apart from clinical or biochemical measures, which are lacking for many nutrients, there are several indirect methods for nutrition assessment. Among them, food frequency questionnaire (FFQ) is commonly used as an effective, easily administered and inexpensive dietary assessment tool [3].

This study aimed to develop and pre-test a quantitative FFQ, as a dietary assessment tool for estimating intake of phytate in the urban Macedonian population.

2. Materials and Methods

2.1 Study sample

One hundred participants of both genders, living in Skopje were recruited via personal contact, by mail messages and by telephone. Sampling was based on a selection matrix stratified by: gender, dietary pattern, place of living and age. Due to higher consumption of a plant-based foods, vegetarians are expected to have superior phytate status to omnivores. Hence, participants with varying dietary patterns (omnivores and vegetarians) were sampled to provide adequate food list.

The study was conducted according to the guidelines laid down in the Declaration of Helsinki and participation was voluntary.

2.2 Data collection

A 3-day dietary record data was used to obtain details of all foods and beverage consumed by the study participants over a 3-day period. Other dietary information collected included description of cooking methods and quantities of food and beverage consumed. Instruction about completing the food record were given to all participants.

2.3 Development of the food frequency questionnaire (FFQ)

A data-driven approach [3], using 3-day dietary record data, was accepted to decide on the foods to be included in the FFQ. The steps involved in the development of the FFQ are illustrated in Figure 1.

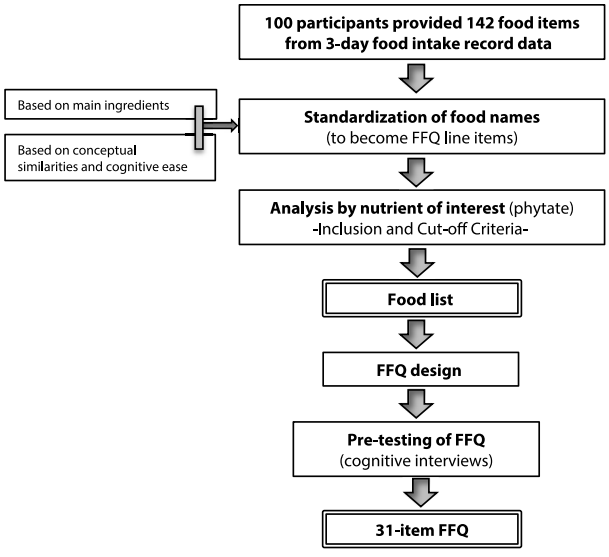

Figure 1. Flowchart of the food frequency questionnaire (FFQ) development study

All individual foods and mixed dishes reported by study participants in the dietary record data were standardized into 142 food items. In order to develop a food list for the FFQ, the amount of phytate contributed by each food item was computed based on phytate content and weight of the food item. Food items that contributed ≥ 1% to daily phytate intake were considered for inclusion in the food list. The inclusion criterion was chosen as achievable criterion considering other FFQ development studies in the literature [4].

2.3.1 FFQ design

After the selection of the food items, it was important to consider the order of the foods in the questionnaire (layout of FFQ). Major contributors to phytate intake were placed near the beginning of the questionnaire. Such layout avoid these items to become subject to participant boredom or fatigue at the end, or errors during initial familiarization at the start of the FFQ [5, 6]. Cognitively similar items were listed consecutively in the food list (e.g., different types of rice). Sub-type questions were asked on the supplementation, cooking/food preparation method (e.g., soaking/boiled/steamed, etc.), refined and whole grains.

2.3.1.1 Frequency of food consumption and portion size

Eight food frequency categories were used, and participants were asked to choose a category that fits the best with their dietary habits. Food portion sizes were determined accordingly data reported in the 3-day dietary record.

2.3.1.2 Pre-testing

The questionnaire was pre-tested for clarity, interpretation and design in individuals who had similar demographic characteristics to the study group. Nutrition experts familiar with food habits of urban Macedonians were checked the appropriateness of food description, portion sizes and frequency of consumption. Cognitive interviews were conducted to identify problems in design and comprehension of the questionnaire. Interviewers were first asked to complete a brief questionnaire. The feedback from interviewers was used to determine issues identified and suggestions for improvement of the FFQ.

2.4 Statistical analysis

Descriptive statistics were used to describe the characteristics of the study participants. Percentage contribution analysis was performed by calculating the contribution of each food item to daily phytate intake. Conventional Windows software was used for statistical computations.

3. Results and Discussion

Table 1 shows descriptive characteristics of the 100 participants who took part in 3-day food record data survey. The mean age was 38.7 (range: 15 - 65) years, 45% were males and 55% females. The mean body mass index (BMI) was 22.9 (range: 18.1 - 35.5) kg/m^2.

Table 1. Descriptive characteristics of the study population (*n=100*)

Parametar	Mean (range)	(% subjects)
Age (years)	38.7 (15 - 65)	
Body mass (kg)	69.8 (48 - 119)	
Body height (m)*	1.7 (1.52 - 1.96)	
BMI (kg/m^2)	22.9 (18.1 - 35.5)	
Males		45%
Females		55%
Omnivores		50%
Vegetarians		30%
Vegans		20%

*BMI - body mass index was calculated as the weight (kg) divided by square of the height (m^2)

Individual foods and mixed dishes reported in the dietary record data were standardized into 142 food items. Several cut-off criteria were used to excluded some food items from the main food list: similar item already in the food list; branded or non-generic food item (e.g., white bread used rather than commercial name of bread); extremely small portion-size (e.g., herbs and spices); or non-standard or uncommon recipe.

Food items that contributed ≥ 1% to daily phytate intake were considered for inclusion in the food list. The amount of phytate contributed by each food item was computed based on phytate content and weight of the food item. In our study, estimates of phytate intake were calculated from the reported values of phytate content in food [3, 7, 8, 9]. An extensive database on the phytate content of foods is essential for food dietary assessments. The development of such a database is difficult because: there is no universally accepted method for phytate determination and second, phytate content in food is highly variable and influenced by many factors such as: growing conditions, type of soil, genetics, maturity, irrigation conditions and fertilizer applications [8]. In addition, the phytate content of food varies as a function of seed treatment (e.g., de-hulling or germ separation) and storage, the part of the seed used, and the method of food processing [2].

The type and number of the food items in the final list largery depend on purpose of the FFQ (assessment of total diet, certain food group or single nutrients) [10] . The review found that the number of food items on a questionnaire ranged from 5 to 350, and the median number is 79 [5].

On the other hand, the number of food items in a questionnare is a critical factor in determing the accuracy of the data and practicability of the FFQ [11]. The risk of over-reporting increases with the unnecessarily elongating the number of the food items. In our survey, 31 food items were selected in the final FFQ list, to enable an accurate estimation of dietary intake. Food items and food serving size, included in the FFQ, are shown in Table 2.

For each food item, a standard serving was expressed in commonly used portions such as grams, tablespoons, slices or pieces. Participants were asked to recall how often, on average, they had consumed each food from the list and how their usual serving size differed from that of standard (medium) serving (i.e., small or large serving was estimated as 50 and 150% of the standard serving, respectively).

The frequency of intake was assessed on an ascending eight-point scale: never, once/month, 2 - 3 times/month, once/week, 2 - 3 times/week, 4 - 6 times/week, once/day, and twice or more/day. According to Cade *et al.*, [5], frequency categories should be continuous, as the sensitivity of the FFQ will be reduced if respondents

Table 2. Food items (serving size) included in the FFQ

Cereals (100 g/200 g/300 g) Corn Wheat Oats White Rice Brown Rice Millet Quinoa Amaranth Buckwheat Cornflakes (1 Tbs; 15 g) Muesli (1 Tbs; 15 g) Wheat Flakes (1 Tbs; 15 g)	***Breads*** (1 slice; 28 g) Whole grain wheat bread White wheat bread Corn bread Rye bread ***Legumes*** (100 g/200 g/300 g) Beans Lentils Peas Chickpeas ***Vegetables*** Potato (100 g/200 g/300 g)	***Nuts*** Almonds (50 g/100 g/150 g) Walnuts (50 g/100 g/150 g) Brazil nuts (1 kernel; 5 g) Cashew nuts (50 g/100 g/150 g) ***Oilseeds*** Soybeans (100 g/200 g/300 g) Tofu (1 slice; 22.5 g) Peanuts (50 g/100 g/150 g) Sesame seed (50 g/100 g/150 g) Linseed (50 g/100 g/150 g) Sunflower seed (50 g/100 g/150 g)

cannot find their response. The authors suggest using 1 to 12 divisions of time in assessing frequency.

Pre-testing was undertaken and the feedback from the interviewers was positive. They liked the length of the food list because it was not dificult to choose food items. There was reaction about exclusion of food groups (e.g., meat and milk products), but the most of them accepted that food list is suitable for the purpose of assessing phytate intake.

Our study was focused on phytate obtained from food intake and did not take into primary account the contribution of supplements that may have been taken by participants. Nevertheless, relevant support questions on supplement use and food preparation were also included. These questions are important for the accuracy of the phytate dietary intake assessment. According to the results, of the 57 study participants who reported on supplement use, 36 reported using mineral supplements on a regular basis, and nobody reported using phytate as a supplement. The phytate content of the food may be decreased during food processing and preparation. For example, soaking and germination are common methods of processing legumes to reduce phytate. 68 participants reported using soaking as a pretreatment during preparation of legumes, while for preparation of cereals, nuts and oilseeds this method is less common and was reported by 33, 37 and 32 participants, respectively.

As mentioned previously, high content of phytate in plant foods-based diets can decrease the bioavailability of crucial micronutrients such as iron, zinc, calcium and magnesium, resulting in mineral deficiencies. Evidence exist that in a well-balanced diet the inhibitory effect of phytate is low, but the situation is different under malnutrition and non-balance diet, low in minerals and high in phytate. To prevent deficiencies of essential elements, two main approaches are possible: by mineral supplementation and by removing phytate from the food [2]. As phytate is heat stable up to ~100 ^{0}C, it cannot be efficiently removed by conventional heat treatment like cooking. Enzymatic degradation of phytate, during food processing and preparation, predominantly during soaking, germination and fermentation, effectively degrades phytate in food. Mechanical separation of the phytate by milling is a common method of phytate removal in cereals, but also lead to a loss of seed nutrients and bioactive compounds.

4. Conclusions

- This study aimed to develop a *de novo* food frequency questionnaire for estimating intake of phytate in urban Macedonians. The food list captures specific foods that are considered high in a nutrient of interest, such as cereals, legumes, nuts and oil seeds.

- We propose that a well-developed FFQ specific to the urban Macedonian population could produce outcomes comparable to other methods of nutrition assessment. Therefore, this FFQ as economic, efficient, and low burden method of dietary assessment, can be effectively used by nutrition professionals in addressing the nutrient-related concerns of the plant based diet patterns among the omnivores and vegetarians.

- While the reproducibility and validity of this FFQ needs to be further determined, an important ongoing program would be the development of the nutrient database of foods commonly consumed in Macedonia.

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