AGRICULTURAL UNIVERSITY OF ATHENS

SCHOOL OF FOOD & NUTRITIONAL SCIENCES

DEPARTMENT OF FOOD SCIENCE & HUMAN NUTRITION

LABORATORY OF MICROBIOLOGY & BIOTECHNOLOGY OF FOODS

PhD Dissertation

Mapping greek “quality cheeses”, compliance to labelling legislation and nutritional profile in relation to greek population’s diet

Evangelia A. Katsouri

Supervisor:

George-John E. Nychas, Professor AUA

Supervising Board:

George-John E. Nychas, Professor AUA

Eleftherios Drosinos, Professor AUA

Antonios Zampelas, Professor AUA

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Χαρτογράφηση των ελληνικών τυριών με ετικέτα ποιότητας, συμμόρφωση ως προς τη νομοθεσία για την επισήμανση των τροφίμων και διατροφικά προφίλ σε σχέση με δεδομένα κατανάλωσης του ελληνικού πληθυσμού

Evangelia A. Katsouri

Evaluation Board:
George-John E. Nychas, Professor AUA
Eleftherios Drosinos, Professor AUA
Antonios Zampelas, Professor AUA
Panagiotis Skandamis, Professor, AUA
Efstathios Panagou, Professor AUA
Emmanouella Magriplis, Associate Professor AUA
Emilia Papakonstantinou, Associate Professor AUA

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Department of Food Science & Human Nutrition
Laboratory of Microbiology & Biotechnology of Foods

ABSTRACT

Labelling information of prepacked foods as it has been formed, during the last decades, in both Europe and the globe, provides an important and trusted tool for monitoring and assessing the food industry and food market, always with regard to each time's contextual food legislation in force. Nutrition labelling, in particular, as an integral part of the general European mandatory labelling provisions currently in force, comprises of both mandatory and voluntary indications. Specifically it comprises of the mandatory nutrition declaration table and of various voluntary front -of -pack labelling schemes (FoPs) and/or other health related information. Nutrition labelling constitutes an additional valuable instrument, which further from delivering information to consumers, can be used for monitoring and assessing the basic nutrients' content and nutritional composition of prepacked foods as well as for the evaluation of their nutritional profile with the utilization of various nutritional profile models or systems (NPMs or NPS). In the context of the above, nutrition labelling stays in the core of the present thesis. In detail two monitoring and dietary assessment studies were conducted in the first place, regarding the main Greek "quality label" cheeses: protected designation of origin (PDO) cheeses feta and gravieras, using food consumption data from the Greek population. Nutrient profiling of all products took place for all products in both two first studies, using various NPMs. An extension of monitoring through the labels of all Greek "quality cheeses", assessment of the nutritional characteristics and evaluation of compliance to European legislation was conducted in the third study. At the same time, all sampled data were structured to create an archival database, initializing the development of a Branded Food Composition Database (BFCD). In particular:

In the first study (Katsouri et al., 2020), Feta (PDO) cheese, a cheese with the highest consumption in Greece and one of the most important Mediterranean food products was used to assess the nutritional characteristics of products available in the market, as well as their contribution to the greek diet. In the study, the basic nutritional content of 81 prepacked feta cheese products available in the Greek market were recorded through their labels. Feta's products' nutrients' content were combined with consumption data from the Hellenic National Nutrition Health Survey (n = 93)to provide an overall picture of feta cheese's contribution to the Greek diet. The nutrient contents per 100 g ranged as follows. Energy: 221–343 kcal, total fat: 20–29 g, saturated fat: 12.8–20.3 g, carbohydrates: 0–3.1 g, sugars: 0–3 g, proteins: 13.1–

21.0 g and salt: 1.2–5.1 g. The median feta daily individual consumption was found to be 39 g, ranging from 20 g to 100 g (fifth and 95th percentiles, respectively). According to the nutritional intake analysis, the daily individual intake as a percentage of the European Reference Intake (RI) showed that saturated fat and salt were ranked on the top of the list, with intakes reaching 101.5% and 85% respectively. The products were also evaluated against five nutrient profile models and their potential use under statutory requirements and nutrition policy recommendations were discussed.

In the second study (Katsouri et al., 2021), Gravieras- 'gruyere' type hard cheeses with a variety of different products and the second highest consumption in Greece, were used. In this study, a dietary intake assessment of prepacked graviera products sold in the Greek market and their nutritional characterization using Nutri-Score Front of Pack Label (FoP), was conducted. The nutrient contents of 92 pre-packed graviera products were combined with daily individual consumption data extracted again from the Hellenic National Nutrition Health Survey (n = 93), attempting to evaluate the contribution of graviera's consumption to the Greek diet. The analysis of nutrients' intake as a European Reference Intake (RI) percentage ranked saturated fat first on the nutrients' intake list, with RI percentage ranging from 36.1 to 109.2% for the 95th percentile of consumption. The respective % RI for energy, total fat, carbohydrates, sugars, proteins and salt ranged from 12.7–20.7%, 21.6–50.4%, 0–3.1%, 0–6.1%, 37–57.1% and 6.3–42%. Nutri-Score classified 1% of the products to C—light orange class, 62% to D—orange and 37% to E—dark orange, while no products were classified to A—dark green or B—green classes. The nutrients' intake assessment, also separately conducted within the classes of the Nutri-Score classification, showed a higher salt intake after the consumption of products classified as D—orange and E—dark orange.

In the third study (Katsouri et al., 2022), a labelling assessment study of greek prepacked "quality label" cheeses was conducted with a view to provide an overview of the whole category. In total, 158 prepacked products belonging to 19 of the 23 greek "quality label" cheeses were identified in the greek market. Among them, Feta had the highest share followed by Kasseri, Graviera Kritis, Kefalograviera and Ladotyri Mitilinis with 81, 16, 15, 11 and 9 products found in the market, respectively. For the rest of the 14 cheeses, the share was limited, ranging from 1 to 4. All labelling indications, nutritional information, claims and other labelling data were recorded and analyzed in relation to their compliance against European food law requirements. The results of the analysis showed that for only 6 of the 19 cheeses, all products fully complied with EU labelling legislation. Among the 14 mandatory labelling requirements, the lowest overall compliance was observed for allergens declaration requirement (65%). The analysis of the nutritional data showed a remarkable variability between cheeses and products. Differences in the nutritional characteristics were more pronounced among soft, semi-hard, hard and

whey cheese. The above data were entered into an archival database. Application of global harmonization and standardization guidelines and tools lead to the initialization of a branded food composition database (BFCD), conceptualizing a specialized database for “quality label” foods.

The present thesis, introduced for the first time in Greece, the study of current labelling applications and tools, implemented in marketed greek prepacked products of “quality label”. Moreover, an overall study of greek “quality cheeses”, in relation to their nutritional profiles as well to the evaluation of compliance to Legislation was conducted for the first time, providing a pilot for the initialization of research monitoring of foods through their labels, in a national level. Numerous uses and perspectives deriving of the above in the field of food nutrition & public health policy are thoroughly discussed. The subject and the results that were generated in the described studies and are presented in the present thesis are expected to be useful in advancing the current national policies, nutrition and regulatory research and science as well as food control and are definitely suggested for further research.

Scientific area: Human nutrition

Key words: label, food labelling, nutrition labelling, nutrition declaration, compliance, nutritional, intake, nutrient profile, nutrient profile model, feta, graviera, cheese, PDO, GI’s, quality label, database, food composition database, FCD, BFCD

Χαρτογράφηση των ελληνικών τυριών με ετικέτα ποιότητας, συμμόρφωση ως προς την νομοθεσία για την επισήμανση των τροφίμων και διατροφικά προφίλ σε σχέση με δεδομένα κατανάλωσης του ελληνικού πληθυσμού

Τμήμα Επιστήμης Τροφίμων & Διατροφής του Ανθρώπου
Εργαστήριο Μικροβιολογίας & Βιοτεχνολογίας Τροφίμων

ΠΕΡΙΛΗΨΗ

Η επισήμανση των προσυσκευασμένων τροφίμων όπως έχει διαμορφωθεί τις τελευταίες δεκαετίες, τόσο στην Ευρώπη όσο και στον κόσμο, παρέχει ένα σημαντικό και αξιόπιστο εργαλείο για την παρακολούθηση και την αξιολόγηση της βιομηχανίας και της αγοράς τροφίμων, πάντα σε συνάρτηση με την εκάστοτε ισχύουσα νομοθεσία. Η διατροφική επισήμανση, ειδικότερα, αναπόσπαστο κομμάτι των γενικών υποχρεωτικών διατάξεων για την επισήμανση, πλέον στην Ευρώπη, αποτελείται τόσο από υποχρεωτικές όσο και προαιρετικές ενδείξεις. Ειδικά περιλαμβάνει: τον υποχρεωτικό πίνακα διαθρεπτικής επισήμανσης (ή διατροφική δήλωση) και διάφορα προαιρετικά σχήματα εμπρόσθιας ετικέτας ή/και άλλες συνδεόμενες με την υγεία πληροφορίες. Η διατροφική δήλωση αποτελεί ένα επιπρόσθετο πολύτιμο εργαλείο, το οποίο επιπλέον της παροχής πληροφοριών προς τους καταναλωτές μπορεί να χρησιμοποιηθεί για την παρακολούθηση και την αξιολόγηση της σύστασης των προσυσκευασμένων τροφίμων και της περιεκτικότητας τους σε θρεπτικά συστατικά, καθώς επίσης και για την εκτίμηση του διατροφικού τους περιγράμματος (προφίλ) μέσω της χρήσης ποικίλων μοντέλων ή συστημάτων διατροφικών Περιγραμμάτων (ΜΔΠ ή ΣΔΠ). Στο πλαίσιο όλων των παραπάνω η διατροφική επισήμανση αποτελεί τον πυρήνα της παρούσας διατριβής. Αναλυτικά, δύο μελέτες παρακολούθησης και διατροφικής αξιολόγησης πραγματοποιήθηκαν κατ' αρχήν, σχετικές με τα κύρια ελληνικά τυριά με «ετικέτα ποιότητας»: συγκεκριμένα την φέτα και γραβιέρα με Προστατευόμενη Ονομασία Προέλευσης (ΠΟΠ) χρησιμοποιώντας διατροφικά δεδομένα κατανάλωσης του ελληνικού πληθυσμού. Πραγματοποιήθηκε κατηγοριοποίηση της διατροφικής σύστασης -θρεπτικών χαρακτηριστικών όλων των προϊόντων με τη βοήθεια διατροφικών περιγραμμάτων και στις δύο μελέτες και την χρήση διαφόρων μοντέλων διατροφικών περιγραμμάτων (ΜΔΠ). Στην τρίτη μελέτη πραγματοποιήθηκε επέκταση της παρακολούθησης μέσω των ετικετών των προϊόντων σε όλα τα ελληνικά τυριά με «ετικέτα ποιότητας», καθώς και η εκτίμηση της συμμόρφωσής τους ως προς τις απαιτήσεις της Ευρωπαϊκής νομοθεσίας για την επισήμανση τροφίμων. Ταυτόχρονα όλα τα δεδομένα που συλλέχθηκαν, δομήθηκαν σε μια βάση δεδομένων με σκοπό να δημιουργηθεί βαθμιαία μια Βάση Δεδομένων Σύνθεσης επώνυμων προσυσκευασμένων τροφίμων. Συγκεκριμένα:

Στην πρώτη μελέτη (Katsouri et al., 2020)το τυρί φέτα ΠΟΠ, το τυρί με την μεγαλύτερη κατανάλωση στην Ελλάδα και ένα από τα πιο σημαντικά μεσογειακά

τρόφιμα, χρησιμοποιήθηκε προκειμένου να αξιολογηθούν τα διατροφικά χαρακτηριστικά του, μέσω των διαθέσιμων προϊόντων στην ελληνική αγορά καθώς και η συνεισφορά του στην διατροφή των Ελλήνων. Στην μελέτη, το βασικό διατροφικό περιεχόμενο 81 προσυσκευασμένων προϊόντων φέτας ΠΟΠ, διαθέσιμων στην ελληνική αγορά, καταγράφηκε μέσω της ετικέτας τους. Το διατροφικό περιεχόμενο των προϊόντων φέτας, συνδυάστηκε με δεδομένα κατανάλωσης από την Ελληνική Μελέτη Υγείας (ν=93), ώστε να συγκροτηθεί μια συνολική εικόνα της διατροφικής συνεισφοράς της φέτας στην ελληνική διατροφή. Το διατροφικό περιεχόμενο ανά θρεπτικό συστατικό και ανά 100g κυμάνθηκε ως ακολούθως:. Ενέργεια: 221–343 kcal, λιπαρά: 20–29 g, κορεσμένα λιπαρά: 12.8–20.3 g, υδατάνθρακες: 0–3.1 g, σάκχαρα: 0–3 g, πρωτεΐνες: 13.1– 21.0 g and αλάτι: 1.2–5.1 g. Η διάμεση τιμή της ατομικής ημερήσιας κατανάλωσης φέτας βρέθηκε να είναι 39 g, με διακύμανση από 20 g έως 100 g (πέμπτο και ενενηκοστό πέμπτο εκατοστημόριο αντίστοιχα). Με βάση την ανάλυση διατροφικής πρόσληψης, η ημερήσια ατομική πρόσληψη που υπολογίστηκε επί τοις εκατό της Ευρωπαϊκής πρόσληψης αναφοράς ανά θρεπτικό συστατικό, έδειξε ότι τα κορεσμένα λιπαρά και το αλάτι κατατάχθηκαν στην κορυφή, με ποσοστά που αγγίζουν τα 101.5% και 85% αντίστοιχα. Τα προϊόντα αξιολογήθηκαν επίσης με χρήση πέντε διαφορετικών μοντέλων διατροφικών περιγραμμάτων και η χρήση αυτών κατόπιν πιθανής θεσμοθέτησης τους ή στα πλαίσια άσκησης διατροφικής πολιτικής συζητήθηκε.

Στην δεύτερη μελέτη (Katsouri et al., 2021), χρησιμοποιήθηκαν οι ελληνικές γραβιέρες, σκληρά τυριά με ποικιλία διαφορετικών προϊόντων και δεύτερα, στο σύνολο τους, σε κατανάλωση στην Ελλάδα. Σε αυτή την μελέτη πραγματοποιήθηκε αξιολόγηση της διαιτητικής πρόσληψης θρεπτικών συστατικών μέσω της γραβιέρας καθώς και διατροφική κατηγοριοποίηση-χαρακτηρισμός των προσυσκευασμένων προϊόντων γραβιέρας που πωλούνται στην ελληνική αγορά, με χρήση του αλγόριθμου εμπρόσθιας ετικέτας Nutri-Score. Το διατροφικό περιεχόμενο από 92 προσυσκευασμένα προϊόντα γραβιέρας συνδυάστηκε με δεδομένα κατανάλωσης από την Ελληνική Μελέτη Υγείας (ν=93), ώστε να συγκροτηθεί μια συνολική εικόνα της διατροφικής συνεισφοράς της γραβιέρας στην ελληνική διατροφή. Η ανάλυση της ημερήσιας ατομικής πρόσληψης που υπολογίστηκε ως επί τοις εκατό της Ευρωπαϊκής πρόσληψης αναφοράς ανά θρεπτικό συστατικό, κατέταξε πρώτα στη λίστα τα κορεσμένα λιπαρά με ποσοστό που κυμάνθηκε από 36.1 έως 109.2% για το 95ο εκατοστημόριο κατανάλωσης γραβιέρας. Τα αντίστοιχα ποσοστά (% της συνιστώμενης πρόσληψης) για την ενέργεια, λιπαρά, υδατάνθρακες, σάκχαρα, πρωτεΐνες και αλάτι κυμάνθηκαν από 12.7–20.7%, 21.6–50.4%, 0–3.1%, 0–6.1%, 37–57.1% και 6.3–42% αντίστοιχα. Το Nutri-Score ταξινόμησε το 1% των προϊόντων γραβιέρας στην κατηγορία C—ανοιχτό πορτοκαλί χρώμα, 62% στην D—πορτοκαλί και 37% στην E—σκούρο πορτοκαλί, ενώ δεν ταξινομήθηκαν καθόλου προϊόντα στις κατηγορίες A—σκούρο πράσινο ή B—ανοιχτό πράσινο. Η σύγκριση των προϊόντων που πραγματοποιήθηκε επιπλέον, με βάση την προηγουμένη κατάταξη και εντός των τάξεων του Nutri-Score, λαμβάνοντας υπόψη και την ανάλυση

διαιτητικής πρόσληψης μέσω των προϊόντων που πραγματοποιήθηκε, έδειξε μεγαλύτερη πρόσληψη αλατιού από την κατανάλωση προϊόντων που ταξινομήθηκαν στις κατηγορίες D-πορτοκαλί και E-σκούρο πορτοκαλί του Nutri-Score.

Στην τρίτη μελέτη (Katsouri et al., 2022), πραγματοποιήθηκε μια μελέτη αξιολόγησης της επισήμανσης των ελληνικών τυριών με «ετικέτα ποιότητας», με σκοπό να παραχθεί μια επισκόπηση της συνολικής κατηγόριας. Συνολικά στην ελληνική αγορά, εντοπίστηκαν 158 προσυσκευασμένα προϊόντα τα οποία ανήκαν σε 19 από τα 23 ελληνικά τυριά με «ετικέτα ποιότητας». Ανάμεσά τους το μεγαλύτερο μερίδιο κατείχε η Φέτα, ακολουθούμενη από το Κασέρι, Γραβιέρα Κρήτης, Κεφαλογραβιέρα και Λαδοτύρι Μυτιλήνης με 81, 16, 15, 11 και 9 προϊόντα αντίστοιχα. Για τα υπόλοιπα 14 τυριά το μερίδιο αγοράς ήταν πολύ περιορισμένο και κυμάνθηκε από 1 έως 4 προϊόντα ανά τυρί. Όλες οι ενδείξεις επισήμανσης , η διατροφική επισήμανση, ισχυρισμοί διατροφής και υγείας και άλλα δεδομένα επισήμανσης για όλα τα προϊόντα καταγράφηκαν και αναλύθηκαν ως προς την συμμόρφωση τους στις απαιτήσεις της Ευρωπαϊκής νομοθεσίας για την επισήμανση τροφίμων. Τα αποτελέσματα της ανάλυσης έδειξαν ότι σε μόνο 6 από τα 19 τυριά, όλα τα προϊόντα ήταν πλήρως συμμορφωμένα. Μεταξύ των 14 υποχρεωτικών ενδείξεων, η χαμηλότερη συμμόρφωση παρατηρήθηκε στην επισήμανση-δήλωση αλλεργιογόνων (65%) Η ανάλυση των διατροφικών δεδομένων έδειξε σημαντική διακύμανση μεταξύ τυριών και προϊόντων. Διαφορές στα διατροφικά χαρακτηριστικά ήταν πιο έκδηλες μεταξύ μαλακών, ημίσκληρων, σκληρών τυριών και τυριών τυρογάλακτος. Τα παραπάνω δεδομένα εισήχθησαν σε μια Βάση Δεδομένων. Η εφαρμογή διεθνών κατευθυντήριων γραμμών εναρμόνισης και τυποποίησης οδήγησε στην έναρξη μιας Βάσης Δεδομένων Σύνθεσης επώνυμων τροφίμων, με όραμα την δημιουργία μιας εξειδικευμένης βάσης δεδομένων για τα τρόφιμα με «ετικέτα ποιότητας».

Η παρούσα διατριβή εισήγαγε για πρώτη φορά στην Ελλάδα την μελέτη σύγχρονων εφαρμογών και εργαλείων επισήμανσης, προσαρμοσμένων σε ελληνικά προσυσκευασμένα προϊόντα με «ετικέτα ποιότητας», που πωλούνται στην ελληνική αγορά. Επιπλέον πραγματοποιήθηκε μια συνολική επισκόπηση των ελληνικών τυριών με «ετικέτα ποιότητας», αναφορικά με τα διατροφικά τους χαρακτηριστικά, αλλά και με την συμμόρφωση τους στις απαιτήσεις της νομοθεσίας, για πρώτη φορά, παρέχοντας ένα πιλοτικό μοντέλο για την ερευνητική επιτήρηση τροφίμων μέσω της ετικέτας τους, σε εθνικό επίπεδο. Πολυάριθμες προοπτικές και χρήσεις που απορρέουν από τα αποτελέσματα συζητούνται εκτενώς. Το αντικείμενο και τα αποτελέσματα των μελετών που περιγράφονται και αναλύονται στην παρούσα διατριβή, αναμένεται να αποβούν χρήσιμα στην εθνική πολιτική για την διατροφή, στην ρυθμιστική και διατροφική έρευνα, στον έλεγχο τροφίμων και συστήνεται σε αυτά η συνέχιση της έρευνας.

Επιστημονική περιοχή: Διατροφή ανθρώπου

Key words: ετικέτα, επισήμανση τροφίμων, διατροφική επισήμανση, πίνακας διαθρεπτικής επισήμανσης (διατροφικός πίνακας), συμμόρφωση, πρόσληψη, διατροφικό περίγραμμα, μοντέλα διατροφικών περιγραμμάτων, φέτα, γραβιέρα, τυρί, ΠΟΠ, γεωγραφική ένδειξη, ετικέτα ποιότητας βάση δεδομένων, βάση δεδομένων σύνθεσης τροφίμων

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Chapter 1

Review of literature and outline of the thesis

FOOD LABELLING & PUBLIC HEALTH

Food Labelling world history, legislation evolution and trends

Food label, according to the internationally accepted definition by FAO/WHO, is any tag, brand, mark, pictorial or other descriptive matter, written, printed, stenciled, marked, embossed or impressed on, or attached to, a container of food. All the information presented on a food product –comprising the food label, is one of the most important and direct means of communicating information to the consumer. In addition, this information, which includes specific items such as ingredients, quality and nutritional value, can accompany the food or be displayed near the food to promote its sale (WHO/FAO, 2007).

Food labels exist from the medieval era (500–1500 AD) as food marking, delivering food identity and properties' information of the food (Food and Agriculture Organization of the United Nations, 2016). In Europe, parchments and plates tied to the neck of champagne bottles around 17th century, were the direct precursors of current food labels. Monochrome labels of alcoholic beverage containers appeared later in the 18th century, bearing the information of manufacturer's name, the quantity and the quality of the content. Later in the early 20th century, color labels were developed among the wine and liquor collectors of Belle Époque Paris, and became collective items since they had been produced by only a limited number of local printers in order to market the product using attractive graphics rather than to protect the consumer (Marcotrigiano et al., 2018). Gradually in the whole world, food labelling became a politically contested space and an indicator for the priority of public health versus the power of vested commercial interests (The Lancet Diabetes & Endocrinology Editorial, 2018) and simple labels evolved from univocal marketing tools in conventional descriptive and informative labels, with various information on the identity, nutritional security, safety, authenticity and quality of the food.

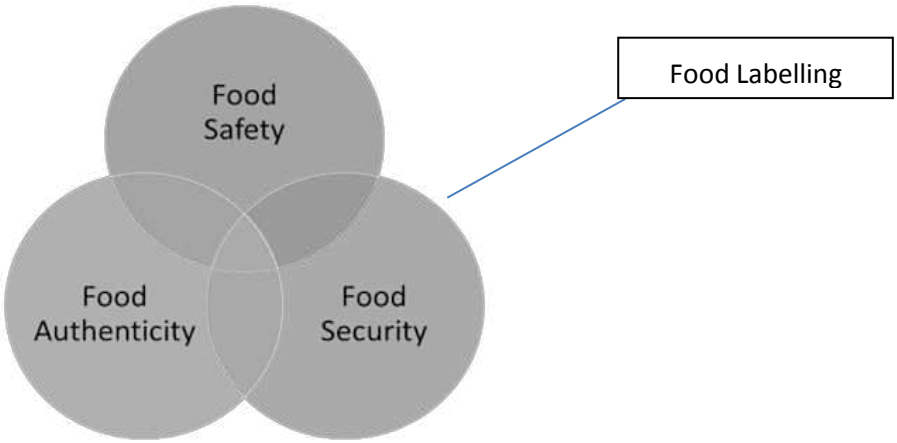


Figure 1.1 Food Labelling among Food Safety, Food Security and Food Authenticity

In Europe, the rise of a 12 nations' of the European Community (EC) single market around 1992, had an enormous impact on food products' composition and on their labels .Many companies had already created and begun advertising several brands for products sold throughout Europe before the issue of any specific legislation (Earl et al., 1990). Of course, a specific directive concerning food labelling, there has been issued by the European Economic Community (EEC) for the first time in 1978 (EC, 1978). However, under the early unified market, the European Community, adopted the Council Directive on Nutrition Labeling for Foodstuffs 90/496/EEC (known as "The Directive") in 1990 (EC, 1990). This Directive, was a common position on nutrition labeling of food products and a precursor to the establishment of a standardized format that would apply in all EC countries (CEC, 1990), later on. In 2000, the European Parliament issued its first specific Directive 2000/13 on the approximation of the laws of the Member States relating to the labelling, presentation and advertising of foodstuffs (EC, 2000) which aimed at aligning the laws of member states on the labelling and presentation of foodstuffs. Finally, to make homogeneous the content of food labels across the member countries (currently 28), Regulation (EU) No. 1169/2011 was adopted in 2011(EC, 2011). This legislation intended to provide information to consumers, to introduce important consumers' protection measures, in order to protect and support informed food choices, with respect to nutritional value and the most common allergenic substances on food labelling obligations and to guarantee uniformity and transparency between member states.

In the US, food labelling emerged as a safety precaution for consumers due to foodborne illness outbreaks in the 1850's. As presented in the University's of Texas website (https://he.utexas.edu/ntr-news-list/food-labels-history, on 29 March 2022), President Zachary Taylor's death after consuming contaminated fruit and milk at a picnic, led to the creation of, the United States Department of Agriculture (USDA) by President Abraham

Lincoln in 1862 and the introduction of strict guidelines for handling and processing of foods.. Criticism of the nutrition content of food labels grew intense in the 1980s and rules governing food labelling considered to be dated in the 1990s. The Nutrition Labeling and Education Act in 1990 was definitely the turning point that forced nutrition labelling as mandatory— which introduced the "Nutrition Facts panel" that we know today, to all foods regulated by the FDA. Until now food labelling, as described, serves further on the implementation of anti-fraud strategies and policies.

Globally, food labels are currently "guided" by Food and Agriculture Organization of the World Health Organization. FAO/WHO in the early 1960s, requested a Joint FAO/WHO Program on Food Standards which led to the creation of the Codex Alimentarius (which here in after can be also referred to as "Codex"). The Codex is a collection of internationally adopted food standards and related texts presented in a uniform manner. These food standards and related texts, aim at protecting consumers' health and ensuring fair practices in the food trade. The publication of the Codex created in order to guide and promote the elaboration and establishment of definitions and requirements for foods to assist in their harmonization and to facilitate international trade. The Codex includes standards for all the principal foods, whether processed, semi-processed or raw, for distribution to the consumer. The Codex includes also provisions in respect of food hygiene, food additives, residues of pesticides and veterinary drugs, contaminants, labelling and presentation, methods of analysis and sampling, and import and export inspection and certification (https://www.fao.org/fao-who-codexalimentarius/about-codex/en , assessed on 29 March 2022). Regarding food labeling guidelines, these are also outlined in the Codex Alimentarius. These guidelines were announced to provide consumers with information so they can make wise food choices, to encourage improved formulation of foods, and to prevent deceptive nutrition labelling. The Codex General Standard for Labelling of Prepackaged Foods/ CXS 1-1985 (FAO, 2018) is the key Codex instrument for delivering information about food to the consumer and the Codex Committee on Food Labelling (CCFL) is the Codex subsidiary body responsible for setting standards and guidelines on labelling that is applicable to all foods. The Codex standard is not a legislative act however it is used by many countries as a guidance for harmonization and as the basis for new food labelling policies. Currently, various food mandatory labelling legislations and policies are in place, serving quite the same labelling objectives, but remarkable differences still exist from country to country and from continent to continent. In terms of confronting this asymmetry and allow consumers safely consume global foods, standardization and harmonization of food labelling are trending globally (Simeone et al., 2015).

Seeing the last decades enormous changes in the way the entire global population eats, drinks, and moves, the new food technologies (regarding food production, food packaging , food marketing) and the increased consumption of processed foods, human diets are changing rapidly and a dramatic rising on overweight and obesity prevalence is observed (GBD, 2017). In response to these rising rates of obesity and diet-related non-communicable diseases (NCDs), such as diabetes and chronic cardiovascular diseases, policies that focus on improving the diets of populations have emerged using strategies such as nutrition and food labelling in combination to specific regulatory and monitoring frameworks. In this context, the consideration of food labelling as a tool for public health strategies and policy makers both in Europe as well as in other parts of the world has been reported in many studies (Storcksdieck et al., 2012; Cecchini and Warin, 2015; Instituto Nacional de Salud Pública de México, 2016).

Particularly, except from the mandatory nutrition information (commonly on the back of pack), supplementary and usually voluntary (Front of Pack labelling schemes (FoPs) have been identified by the Organization for Economic Cooperation and Development (OECD) as the most effective food labelling strategy to tackle obesity and provide strong incentives for agroindustry to improve their nutritional quality by reformulation of its products (OECD. 2019). Additionally, Food and Nutrition Action Plan 2015–2020 of WHO, recommended to governments the implementation of FoPs as part of their policy to address the growing global burden of diet-related NCDs (WHO, 2019). In accordance with all the above, the European Commission as part of its Farm to Fork Strategy, has recently announced that it seems appropriate to introduce a harmonized mandatory FoP nutrition labelling at EU-level in order to help consumers making health-conscious food choices and restrict the the right to make nutrition and health claims (EC, 2020), This fact, stays among others, a main subject of the current year public consultation on Food labelling revision of rules on information provided to consumers.

FoP labelling schemes and systems are simple, interpretive information on the front of packaged food and beverage products, providing at-a glance their nutrition information to consumers and helping them quickly and easily evaluate their healthfulness. An increasing variety of these labelling systems are being implemented internationally, According to the European Commision's report regarding the use of additional forms of expression and presentation of the nutrition declaration (EC, 2020), more than 40 countries in the world currently use a kind of FoP, in order to facilitate consumers' choices. Indicatively FOP labelling systems can broadly be categorized as 'nutrient-specific' systems that provide information on one or more specific nutrients (e.g., Chile's 'high in' nutrient warnings, UK's traffic light labels) or 'summary indicator' systems that provide a score or rating of the

overall nutrient profile of a product (e.g., Australia and New Zealand's Health Star Rating, France's five-colour Nutri-Score). Reviews of the existing evidence suggest that FoP nutrition labels may be an effective approach to help consumers choose healthier products. However, there is no consensus as to which FoP label system may be most effective (Kanter et al., 2018).

Regarding labelling as a part of scientific research, many scientific studies are taking place through out the globe, covering different perspectives of the general subject, deploying in parallel, technology and artificial intelligence tools. As evidence of the research interest that is attracted on food label related scientific issues, numerous studies have been conducted using food labels as a source of research data –both food monitoring and labelling assessment studies. Since 2009, that Lalor et al. published a monitoring study for the Irish food supply chain (Lalor et al. 2009), many studies have been published until now. It is not accidental that very distinct and sophisticated infrastructures are currently occupied with this subject .e.g. George's Institute for Global Health (Australia) 'FoodSwitch' (Dunford et al., 2014), the University of Toronto's (Canada) 'Food Label Information Program (FLIP)' (Mulligan et al., 2020). Food labelling monitoring studies, which are commonly conducted with partial data collection focusing on selected food categories, in selected food shops as well as Cross-sectional studies are increasingly reported. Datasets deriving from the food labels –often through photographs- can be used to assess the nutritional composition of food in the food supply(i.e., salt, fat, sugar content), the use of specific ingredients, (e.g. food additives), for nutrient profiling, for assessment of nutrient intakes in dietary surveys, marketing surveys etc. (Pravst et al., 2022).

Moreover many experiments are also taking place suggesting the introduction of new approaches and innovative applications on food labelling and described whereupon. Narrowly related to labelling the branded food composition databases (BFCDs) –an evolution of the classic food composition data bases of generic foods (FCDBs) and tables (FCTs), as well as personalized nutrition and nutrigenomics, stay further in the core of current trends, together and beyond labels, utilizing both nutritional labelling and FoPs. By way of example:

FoodSwitch –developed by Dunford E. -is a mobile phone app that would provide consumers with easy-to-understand nutrition information and support the selection of healthier choices during shopping, using an approach to rank foods based on nutritional content of products through a branded-food composition database (BFCD), so that healthier alternative products could be recommended (Dunford et al., 2014). The Australian FoodSwitch application for

smartphones was developed to collect branded food composition information and has yielded impressive results.

Food Label Information Program (FLIP) from the University of Toronto, Canada, is a database containing label and nutrition information for prepacked food products from top Canadian retailers. The Health Canada Surveillance Tool (HCST), as a part of the same project is a Canadian nutrient profile model (NPM), which assesses products' adherence to the Canada's recently revised Food Guide (CFG), using thresholds for total fat, saturated fat, sugars and sodium' (Mulligan et al., 2020).

SaltSwitch- developed by Eyles H. et al - is an innovative smartphone application (app) that enables shoppers to scan the barcode on the label of a packaged food and receive an immediate, interpretive, traffic light nutrition label on the screen, along with suggestions for lower salt alternatives (Eyles et al., 2017).

A smartphone app designed to provide tailored digital food labels after scanning a product's barcode, proposed by Klaus Fuchs et al using a tailoring logic developed with dieticians, accounting for gender, age, activity, preferences, diet-related diseases (Fuchs et al., 2019)

Another purchase-related barcode scanning m-Health application utilizing a standardized taxonomy of food allergens, has been also designed by the same research group, for the display of user friendly digital icon-based allergen labels (Fuchs et al., 2020).

Stance4Health (S4H) is a European Commission funded project which aims to develop a complete personalized nutrition service. Information on nutritional composition and other characteristics of foods are sourced by Food composition tables or databases (FCT/FCDB) from different countries and organizations while global standardization and harmonization tools such as FoodEx2 and INFOODS and MySQL and EuroFIR standards are used. S4H's FCDB will be part of the smartphone app which will be used in different personalized nutrition intervention studies with great future perspectives and applications (Hinojosa-Nogueira et al., 2021).

At this point, a figure following could be quite helpful for providing a current overview of the food labelling's possible interconnections, uses and applications.

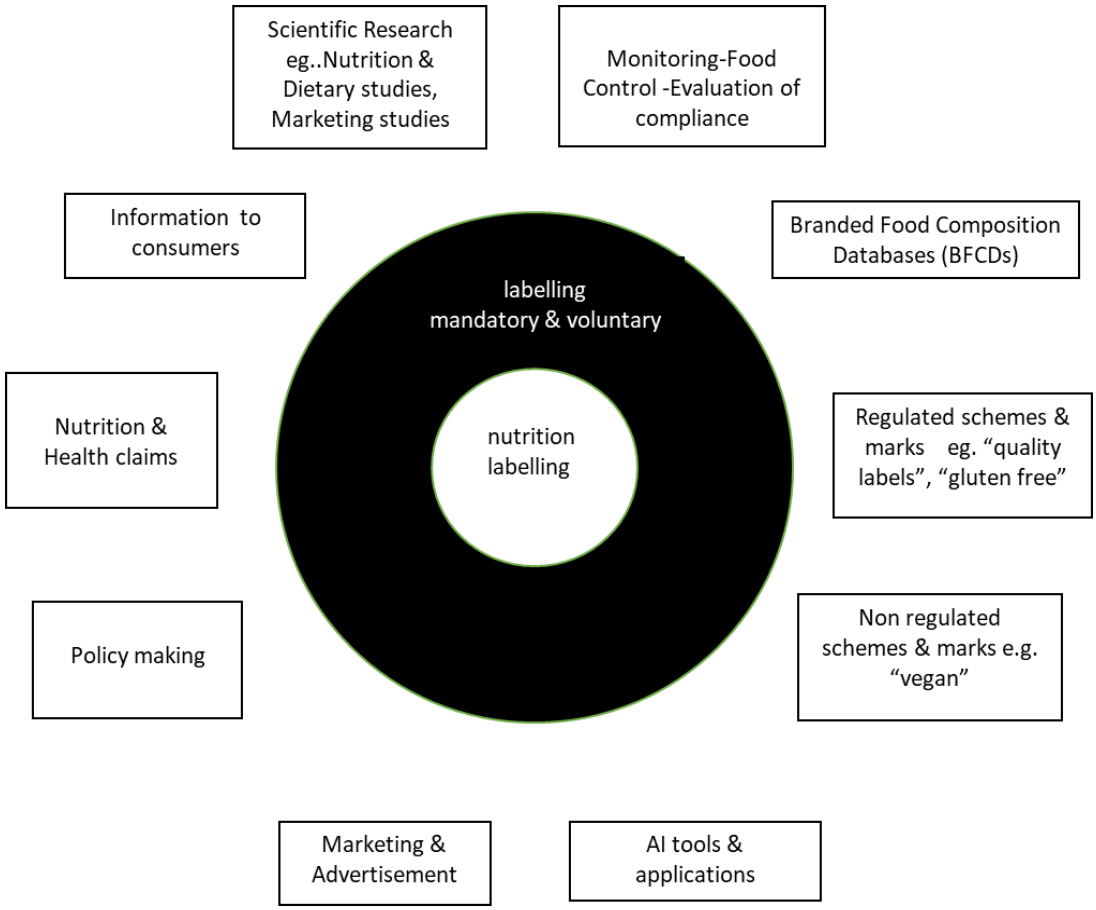


Figure 1.2. Food labelling interconnections, uses and applications

There have been voices, though, supporting that supplementary and especially FoPs and other food labelling marks and claims, especially when under-regulated, may confuse and mislead consumers provoking rather risks than benefits (Nestle and Ludwig, 2010). In the same direction, except from food labeling legislation acts and supplementary labelling tools and applications, additional public health policies interventions and strategies have been brought together on the fight against obesity and premature death and disability due to chronic NCDs worldwide. Special mention has to be given on subsidies and taxes (EUFIC, 2016). International and national health bodies including the World Health Organization and United Nations having called for population health interventions to improve diet, as a means to this direction with propose among others fiscal policy interventions to ensure that healthy foods/beverages are can be more accessible to purchasers and unhealthy ones less accessible , namely taxation and subsidies (Niebylski et al., 2015). Food and beverage taxes usually try to increase the price of less healthy food and beverage products. Although some jurisdictions have applied to foods, health-oriented taxes—such as those high in calories, sugars, sodium, or saturated and trans fats-— have mostly focused on beverages high in sugars, in several countries (Acton et al., 2019).

Moreover, taxes and subsidies have shown to be a likely effective intervention to improve dietary patterns that seem to be associated with obesity and chronic diseases, with evidence showing a consistent effect on consumption levels across a range of tax rates emerging. (Thow, et al., 2014).

Regarding the also trending -omics sciences, there is definitely a connection with all the above and their future perspectives. Nutrigenomics is the science that explains how the nutrients influence or effect the expression of the genes and consists the basis of personalized diets. Personalized diets, can help people to know which is the right nutrient to take or to avoid, to have a specified diet based upon its genotype and to follow effective dietary advice in order to preventing chronic diseases and improving health (Bahinipati et al., 2021). Foodomics complementarily, is the science aiming at studying and developing models that are able to explain how food components, food, diet and lifestyle can influence our pathway towards health=, through the evaluation of different biomarkers (Bordoni and Capozzi, 2014).

Food labelling legislation in Europe

FIC Regulation on the provision of food information to consumers

FIC Regulation (9) consists the current European basic legislation act, on the provision of food information to consumers. This Regulation establishes the general principles, requirements and responsibilities governing food information and in particular food labelling as well as the basis for the assurance of a high level of consumer protection in relation to food information . FIC Regulation put into force in 2011 and introduced a dozen of mandatory indications, following in from the Directive 2000/13, as well as the framework for a set of supplementary non- mandatory provisions. In detail:

Mandatory requirements according art .9 of the FIC Reg. include:

(a) name of the food;

(b) list of ingredients;

(c) any ingredient or processing aid listed in Annex II or derived from a substance or product listed in Annex II causing allergies or intolerances used in the manufacture or preparation of a food and still present in the finished product, even if in an altered form;

(d) quantity of certain ingredients or categories of ingredients;

(e) net quantity of the food;

(f) date of minimum durability or the ‘use by’ date;

(g) any special storage conditions and/or conditions of use;

(h) name or business name and address of the food business operator referred to in Article 8(1);

(i) country of origin or place of provenance where provided for in Article 26;

(j) instructions for use where it would be difficult to make appropriate use of the food in the absence of such instructions;

(k) with respect to beverages containing more than 1,2 % by volume of alcohol, the actual alcoholic strength by volume;

(l) nutrition declaration

In addition to the particulars listed in article 9, additional mandatory particulars for specific types or categories of foods, according to article 10, are laid down in Annex III. Origin declaration allergens declaration, nutrition declaration are the main provisions lately introduced or specified with FIC Regulation.

All the above indications can be said that they are definitely connected at least to one of the special informative labelling objectives which have been described also previously and presented on the following figure.

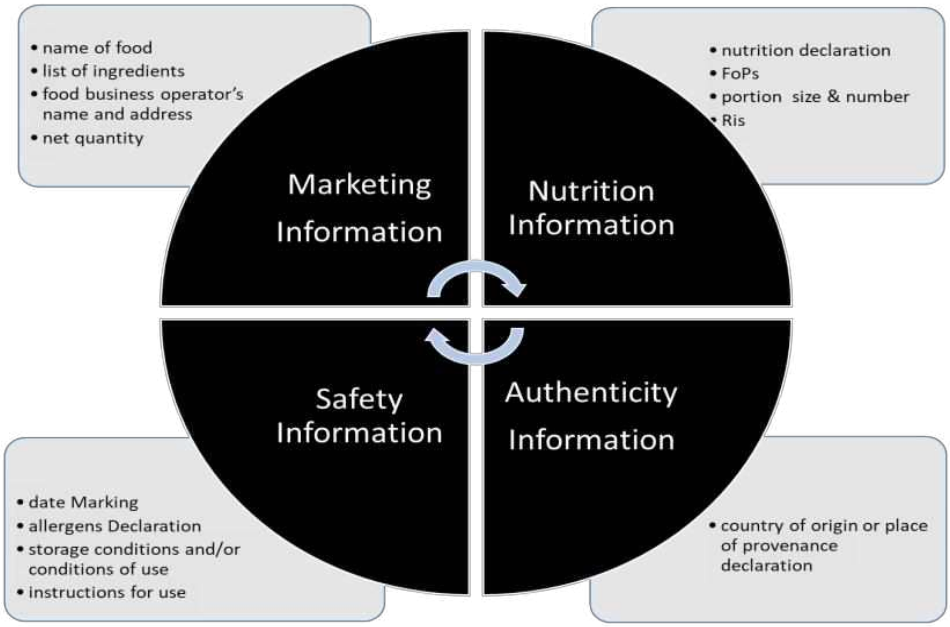


Figure. 1.3. Labelling indications according European FIC Regulation in relation to their informative objective

Nutrition Labelling as a part of FIC and as a necessity

In terms of the present thesis, studies focused on health-related labelling indications and especially on “nutrition declaration” and supplementary nutritional information, which stays in the core of all surveys.

In Europe “Nutrition declaration” responds to nutritional labelling provision, that is the information about the nutritional content of individual food products which emerged as a need for global legislation over the recent decades Regulation .The obligation to provide nutrition information applies since 13 December 2016. According to FIC Regulation nutritional information to consumers is mandatorily provided through the “nutrition declaration” table. “Nutrition declaration” table provisions and format are defined on Annex XV of FIC Regulation. The mandatory “nutrition declaration” must provide the energy value and the amounts of fat, saturated fat, carbohydrates, sugar, protein and salt in the food, expressed per 100g or per 100ml. This information may also, in addition, be expressed per portion or per consumption unit of the product. This mandatory nutrition declaration is often provided on the back of food packaging.

Moreover additional voluntary, non-mandatory nutritional information such as front of pack labelling schemes (FoPs) with specific limitations. According to Article 35 of the FIC Regulation (EC, 2011) “nutrition declaration” can be complemented by a voluntary repetition of the main elements, in order to help consumers to see at a glance the essential nutrition information when purchasing foods. For this repetition, other forms of expression or presentation can be used, in addition to those contained in the nutrition declaration (words and numbers).Moreover, additional forms of expression and/or presentation of the nutrition declaration (e.g. graphical forms or symbols) can be used by food business operators or recommended by Member States, if they comply with the criteria set out in the Regulation. In particular the following criteria are set in Article 35 for these ‘additional forms of expression and presentation’:

- they must be based on sound and scientifically valid consumer research, and not mislead the consumer; Nutrition labelling schemes used in Member States 3

- their development should be the result of consultation with a wide range of stakeholder groups;

- they must be aimed at facilitating consumer understanding of the contribution or importance of the food to the energy and nutrient content of a diet;

-they should be supported by scientific evidence showing that they are understood by the average consumer;

- the forms must be objective and non-discriminatory;

- their application must not create obstacles to the free movement of goods; and

- in the case of other forms of expression, they should be based on harmonized reference intakes (set out in Annex XIII of the Regulation), or on generally accepted scientific advice on intakes for energy or nutrients

EU on a primary attempt indicatively introduced some years before, a voluntary FoP with a specific format, based on the GDA format (FDF, 2021), with the term "reference intakes" having to be used instead of GDAs (EUFIC, 2006). Afterwards additional forms of expression and presentation of the nutrition declaration, such as colors, graphical forms or symbols, were also permitted and continue to exist,, (EUFIC, 2016) with all evaluative FoPs, either nutrient-specific or summary indicators, to be based on nutrient profile models (Storcksdieck et al., 2020)

In this context, many European member states have currently already introduced voluntary FoP schemes to facilitate consumers to identify healthier products. The Commission in its new 'Farm to Fork' strategy, launched in May 2020, announced that intends to propose a mandatory harmonized front-of-pack nutrition labelling system by the end of 2022. Additionally, the European Parliament on the European Green Deal, adopted in January 2020, welcomes the plan for a sustainable food system strategy, including the Commission's intention for improved food labelling (EPRS, 2020).

Around the globe, governmental regulations for nutrition labelling have been in place for many years, in many countries, either as mandatory or not, while also in other countries a statutory framework for the provision of nutrition information has been only recently developed. In both circumstances, thus, the provision of nutrition information as well as of other forms of better information to become an increasingly prominent policy issue.

Meanwhile, voluntary FOP and nutrition labelling initiatives are continuingly proliferating. Nutrition labelling worldwide is also increasingly moving beyond packaged foods, particularly in North & South America and Asia. In detail: legislation requiring mandatory labelling of calories in fast food restaurants (menu labelling) was proposed in Argentina and became mandatory in restaurant chains with over 20 locations, selling substantially the same items and operating under the same name, in the U.S., additional warning labels for food with high salt content were enforced in New York. (EUFIC, 2016)

NHCR Regulation on Nutrition & Health claims

Furthermore, there are additional legislative acts such as Regulation (EC) No 1924/2006 (EC, 2006) on nutrition and health claims, complementing food label health-related non-mandatory requirements such as nutrition and health claims.

Nutrition and health claims, in Europe, have Union rules been established by the specific Regulation which The Regulation started to apply on 1 July 2007 and set the legal framework used by food business operators when they want to highlight the particular beneficial effects of their products, in relation to health and nutrition, on the product label or in its advertising. The rules of the Regulation apply to nutrition claims (e.g. "low fat", "high fibre") and to health claims (e.g. "Vitamin D is needed for the normal growth and development of bone in children"). The objective of Regulation's rules is to ensure that any claim made on a food's labelling, presentation or advertising in the European Union is clear, accurate and based on scientific evidence. Food bearing claims that could mislead consumers are prohibited on the EU market. Consequently, these rules, further to protect consumers, they promote innovation, ensure fair competition and free circulation of foods bearing claims anywhere in the European Union. There are different procedures managed by the Commission for the various types of claims, with regard to their authorization.

A public EU Register of Nutrition and Health Claims (EU Register of Nutrition and Health Claims, 2022), lists all permitted nutrition claims and all authorized and non-authorized health claims, as a source of reference and in order to full transparency for consumers and food business operators is ensured.

Meanwhile there is one requirement of the regulation that has not been enforced yet. This refers to art 9. requirement on nutrient profile as a prerequisite on the setting of nutrition and health claims. According to art. 4 on the Conditions for the use of nutrition and health claims : «By 19 January 2009, the Commission shall, in accordance with the procedure referred to in Article 24(2), establish specific nutrient profiles and the conditions, including exemptions, which shall be respected for the use of nutrition and health claims on foods and/or categories of foods.»

Since its adoption in 2006, the implementation of the Regulation remains incomplete. Nutrient profiles, that had to be set by January 2009, have not been established yet and health claims on plants and their preparations used in foods are not yet fully regulated. This fact lead the Regulation to the refit procedure meaning to evaluations and fitness checks that are used to implement the Regulatory Fitness and Performance program (REFIT). REFIT is a rolling program to keep the entire stock of EU legislation under review and ensure that it

is 'fit for purpose'; that regulatory burdens are minimized and that all simplification options are identified and applied.

On 20 May 2020, the Commission completed the Evaluation of the Regulation on nutrition and health claims, which was announced in its Better Regulation Communication of 19 May 2015. Overall, the evaluation findings showed that the specific objective pursued by the setting of nutrient profiles is still pertinent and necessary to meet the objective of the Claims Regulation, which is a high level of consumer protection. Consequently, the setting of nutrient profiles needs to be further considered and continues to hold a lot of attention (EC, 2020).

This regulation stays in line with the global regulatory taxonomy regarding health related food label claims and serves the same objectives such as food labelling, presentation and advertisement (Rayner and Vandevijvere, 2017).

NUTRITION SCIENCE & PUBLIC HEALTH

Nutrition science and research in relation to foods

As global nutrition and health policies are trying to balance between nutrition, food, environment and health, greek philosopher's Hippocrates axiom "Let food be your medicine, and medicine be your food" stays evergreen after thousands of years, setting the basis of the "food as a medicine" philosophy and lifestyle medicine of current era.

Nutrition and Medicine are reasonably connected disciplines and scientific research focusing on the connection between diet and health remains vivid, in order to confront the rising burden of non-communicable diseases (NCDs) and other challenges, in most countries across the globe.

In Europe, the European Commission's science and knowledge service Science Hub, on its Nutrition page, begins declaring that eating habits may ensure good health and that low consumption of fruits, or fibre, and excess intakes of salt, sugars, and trans and saturated fats are among the top contributors to death and disability caused by non-communicable diseases such as heart disease, diabetes and certain forms of cancer (EC, 2022). Nevertheless from 2007 and on , an integrated EU approach has been designated through the White Paper on A Strategy for Europe on Nutrition, Overweight and Obesity related health issues (EC, 2007), so as to contribute on reduction of ill health due to poor nutrition, overweight and obesity and EU Commission's Directorate on Health is from the beginning responsible also for Food Safety and this specific relative legislation.

In the US, from the 2000s, the Interagency Committee on Human Nutrition Research (ICHNR) in US identified that new scientific insights could change the role of nutrition in public policy among its future developments in Nutrition and Health, future could extend more as the nutritional sciences embrace the tools of molecular biology and genetics and the relationships between nutrition and chronic diseases would begin to allow using diet and dietary tools as an intervention in chronic disease control.(Institute of Medicine (US), 1989)

Along the same lines, - Mozaffarian et al. (Mozaffarian et al., 2021), reported that the U.S. in the 1960s, focused on hunger in order to address major problems of undernutrition after World War II, but in the 1990s, shifted away from hunger towards "food insecurity" to better capture and address the challenges of food access and affordability. Considering the concept of "food security" as the ability to access safe, nutritious, and consistent with personal preferences food, current health and equity challenges call for the U.S. to shift from "food insecurity" to "nutrition insecurity" in order to catalyze access not just to food but to healthy and nutritious food with emphasis to the "nutritious" part of the food that has been overlooked the last decades' with national policies focusing on quantity, rather than quality.

As food and nutrition is proven more and more related to health and especially related to dramatically augmented obesity and chronic NCDs, nutrition related issues constitute a global priority. As for example in 2014, the Second International Conference on Nutrition highlighted the challenges and urgency of transforming food systems to deliver healthy diets in a sustainable manner given the growing double burden of malnutrition (CIHEAM/FAO, 2015). Conceptual frameworks were developed showing the relationship between food systems and nutrition (HLPE, 2017) and calls for transforming food systems to become more sustainable and capable of ensuring healthy diets began to be globally embraced.

The lack of agreement by countries on what constitutes healthy diets and more so on what constitutes healthy diets that are sustainable led the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) to produce the Sustainable Healthy Diets Guiding Principles in 2019(FAO/WHO, 2019). This new definition placed health as a priority, while still underscoring all other aspects. Specifically, "sustainable healthy diets" are defined as, "the dietary patterns that promote all dimensions of individuals' health and wellbeing, have low environmental pressure and impact, are accessible, affordable, safe and equitable, and are culturally acceptable" and includes 16 principles grouped under three aspects of sustainability: health, environmental and sociocultural that must be considered together for achieving sustainable healthy diets.

Therefore, healthy eating, healthy lifestyle and healthy food choices constitute an urgent necessity in consequence.

Food undoubtedly stays in the core of any nutrition, necessary for metabolism, maintenance, growth and repair of tissues, as well as reproduction (Lean, 2015) .Human nutrition deals with the provision of essential nutrients in food that are necessary to support human life and good health (https://www.britannica.com/science/human-nutrition, , assessed 29 March 2022). Nutrition may be linked to socio-economic factors, food security, or understanding of nutritional requirements and nutritional quality of foods. 'Health', according to the Constitution of World Health Organization, beside of the absence of disease or infirmity means also one's state of complete physical, mental and social well-being and is complemented with various dynamic principles, (https://www.who.int/about/governance/constitution , assessed on 29 March 2022). What is though healthy eating and diet? There is no doubt that many clinicians find difficulty to answer their patients this common question. The difficulty to offer simple answer is partly justified due to the overwhelming volume of data generated by food and nutrition researchers with sometimes contradictory findings, and recommendations, as well as due to the flood of misinformation in diet books and the media. Definitely though there are now enough solid strands of evidence from reliable sources to weave clear and true diet recommendations (Skerrett &Willett, 2010).A healthy diet can be defined as the one in which macronutrients are consumed in appropriate proportions to support energetic and physiologic needs without excess intake while also providing sufficient micronutrients and hydration to meet the physiologic needs of the body (Stark C., 2013). . The definition of what constitutes a healthy diet though, is continually shifting to reflect the evolving understanding of the roles that different foods, essential nutrients, and other food components play in health and disease (Cena and Calder, 2020), and thus is so difficult to explain it.

However, as already mentioned the concept of healthy food, diet and eating are multi-dimensional. Healthy diets remain unaffordable for many people in almost every region of the world (FAO, 2020). Nutrient-dense foods are often prohibitively expensive in comparison to foods high in sugar and fat, especially in low-income countries (Headey and Alderman, 2019) while their produced quantities cannot meet minimum global dietary recommendations for the global population (Mason-D'Croz et al., 2019). At the same time, food choices and food-related behaviors are deeply connected to social and economic dimensions of identity, gender, religion, preferences, and culture (Monterrosa et al., 2020) and partly based on the perception of healthiness among the offered products.,thus to on

the nutrient claims, brands, price, labels, and country of origin (Haws et al., 2017; Jo and Lusk, 2018).

Further to the above, guiding consumers towards more healthful food choices may help address the high prevalence of poor dietary quality and diet-related diseases. According to Kelly B. & Jewell J. the use of front-of-package labels (FoPs), usually based upon nutrient profiling systems (NPS) can provide a source of nutrition and health information using focused information and representations easy to understand by consumers and may be able to shift consumers' behavior towards more nutritious and healthful choices (Kelly and Jewell,2018). Consequently, great interest has been developed the last decades, on assessment tools aiming to evaluate the quality and healthiness of diets or foods, such as the science of nutrient profiling (NP) and FoPs –also based on Nutrient Profiling Models (NPMs), as well as several Dietary Quality Indices or Indicators on. Dietary quality indices (DQIs) are algorithms aiming to evaluate the overall diet or individuals according to the overall nutritional quality of their total diet(Gil et al., 2015), while in contrast, nutrient profiling and NPMs are intended to measure the quality of individual foods (Foltran et al., 2010).

Nutrient profiling -Nutrient Profile Models & FOP schemes

Nutrient profiling, also nutritional profiling, is the science of classifying or ranking foods by their nutritional composition in order to promote health and prevent disease. (WHO/IASO, 2010; WHO, 2015; Foltran et al., 2010). A common use of nutrient profiling is in the creation of nutritional rating systems to help consumers identify nutritious food (WHO, 2015)

As already mentioned previously, a variety of nutrient profile models (NPMs), have been developed by academics, health organizations, national governments and the food industry. The development or selection of a model to use in food policy decisions is important, as different models can lead to different classifications of the same foods (Scarborough et al., 2013).

The term nutrient profiling (NP) gained ground following the development of the Ofcom (the regulator for the communications services in UK) model by the UK Food Standards Agency in 2004 to 2005 (Poon et al., 2018) and the mention of nutrient profiles in Regulation (EC) No 1924/2006 on nutrition and health claims by the European Commission in 2006(EC, 2006). In 2010, NP became even more widely known when WHO prepared a set of recommendations on the marketing of foods and beverages to children until now that, NP is globally recognized as scientific method of evaluating the healthfulness of foods, with several governmental marketing and industry applications (e.g. front-of-package food labelling, food taxes, reformulation) (Rayner et al., 2013; Rayner M., 2017).

Several of the earliest forms of nutrient profile models (NPMs) or systems (NPS) were introduced by government bodies in the 1980s and 1990s, such as the US Special Supplemental Nutrition Program for Women, Infants, and Children in 1980(USDA, 2014), Swedish Keyhole in 1989(National Food Agency of Sweden, 2015) and more. Nutrient profile models (NPMs) are based on specific algorithms which take into account the quantity/presence of basic nutrients and/or other ingredients or food components quantity/presence (e.g. fruit and vegetables, whole grain cereals) within a food in order to characterize as "healthy" or "less healthy" through either a numerical score or more qualitative classifications (e.g. eligible/not eligible to carry a logo product) (Labonte', 2018). As latest entry appears the Food Compass, a recently developed and validated NPS in US, which incorporated a broader range of food characteristics, attributes and uniform scoring principles. In particular 54 attributes across 9 health-relevant domains, have been included: nutrient ratios, vitamins, minerals, food ingredients, additives, processing, specific lipids, fibre and protein, and phytochemicals. The final Food Compass Score (FCS) ranging from 1 (least healthy) to 100 (most healthy) applies for all foods and beverages. Content validity was confirmed by various tests, products, and in comparison, to other NPMs including the NOVA food processing classification, the Health Star Rating and the Nutri-Score (Mozaffarian et al., 2021).

Nutritional profile models vary considerably in their design but, fundamentally, they adopt one of two approaches: categorical or continuous (Foltran et l., 2010). Categorical models divide foods into two or more categories, beyond the level of this categorization, foods can no longer be compared. For example, a categorical model may categorize two foods as 'high in saturated fat', but it will not indicate which of the two, contains more sugar. Categorical models are the most common type of nutritional profile model for food labelling purposes, as well as for the setting of criteria for nutrition and health claims, such as 'low in fat',. Also criteria for schemes that have been developed by public health organizations and the food industry "logos" tend to be based on categorical models. Continuous models provide a ranking of foods on a continuous basis. They are in general, more precise, but usually more complex and tend to be impractical for some purposes, in comparison to categorical models. Continuous models can be converted into categorical models simply by setting a score as a threshold Categorical models are also called threshold models and continuous models are also called scoring models due to their "modus operandi".

The scientific field on NPMs, appears dynamic at the moment. NPMs proliferate continuingly, in an attempt of the scientific community to better describe foods' nutritional quality and to better reflect foods' healthiness, while at the same time their validity is also

tested. The number of NPMs according available review studies, varies depending on each study's inclusive criteria (Stockley et al., 2008; Labonte' et al., 2018; Santos et al., 2021).

Nutrient profile models are observed to apply as a possible tool in the attempt to regulate the presentation and advertisement of foods -especially to children, the setting of nutrition and health claims on foods and the creation of Front of Package labelling schemes (FoPs). There are FoPs based on specific NPMs and definitely great interest has been developed on FoPs developed with the aid of the science of nutrient profiling.

In recent years, governmental organizations or food manufacturers have developed a series of FoPs varying in colors and formats to communicate food's nutritional content and relative healthiness. These FoPs, like the Traffic Light System, have proven helpful to evaluate products' healthiness (Acton et al., 2018; Hagmann and Siegrist, 2020; Maubach et al., 2014; Richetin et al., 2022). FoPs are a direct source of nutritional guidance at the point-of-purchase and provide an opportunity for critical information to consumers, on nutrients and ingredients associated with health promotion and/or increased risk of non-communicable diseases.

According to the JRC Executive summary review of 2020 on Front-of-pack nutrition labelling schemes, a variety of FoP schemes–all voluntary as per EU law–have been developed by public institutions, public health Non-Governmental Organizations(NGOs) and the private sector, sometimes collaboratively, and presented analytically in the study. In Europe FoPs vary from purely numerical schemes that repeat some of the information contained in the nutrition declaration (so-called reductive schemes), to summary scoring schemes there of color-coded label versions in which belong graded indicators or dichotomous endorsement logos. Ten approximately public and private FOPs exist and are already implemented in several Member States and the United Kingdom (UK). FoPs developed or endorsed by the public sector are: the Keyhole logo (used in Sweden, Denmark, Lithuania and also in Iceland, Norway, and North Macedonia), the Nutri-Score (used in France and Belgium and adoption announced by Spain, Germany, the Netherlands and Luxembourg), the Finnish Heart Symbol, the Slovenian 'Little Heart' sign, the Croatian 'Healthy Living' logo, and the Multiple Traffic Light combined with Reference Intakes (UK). Italy has developed a scheme based on Reference Intakes, called 'NutrInform Battery'. Some other EU countries are exploring the possibility to recommend a FoP label. Major private-sector FoPs in use are the Reference Intakes label (found throughout the EU) and the Choices logo (Czech Republic, Poland). Additionally, some retailers in Estonia, Portugal and Spain have implemented FoP schemes on their own-brand products based on Multiple-Traffic-Lights color-coding. The Evolved Nutrition Label, (ENL) was a proposal by a group of multinational food manufacturers on a

combination of Multiple Traffic Lights and Reference Intakes that used portions as a reference base for products consumed in small quantities was put on hold in November 2018. Outside of Europe, various nutrition schemes used on the front of pack exist that resemble Reference Intakes, traffic-light coding, or endorsement logos. Additional formats include star-based rating schemes and warning signs (Storcksdieck et al., 2020).

As for example, FoPs have been designed and implemented also in Australia, e.g. the Australian Health Star Rating (HSR), a nutrient-based FOP labelling scheme that rates products on a score of 0.5 to 5 stars for their proportion of 'risk' and 'positive' nutrients which came into effect in June 2014, and in Latin America, e.g. Chile and Mexico's 'black box' warning labels that have been designed to limit marketing aimed at children, and prohibit sales of all products that consist of added sugars, sodium, or saturated fats that surpasses nutrient or calorie cut offs in schools (Singh et al., 2021)

All FoP nutrition labelling schemes, in accordance to NPMs categorization presented above, can be either categorical referred also as numerical or reductive or nutrient-specific or summary, referred also as scoring. .

"QUALITY" PRODUCTS - "QUALITY LABELS"

"Quality" concept and "Quality labels" in the global environment

The "Quality" in general and especially of foods links to various meanings and perceptions depending on the criteria according to which, the subject is examined. Taking into account that "quality" is perceived, evaluated and interpreted by consumers, "quality " ends up to definitely depends on various characteristics and properties related to the food. Consumers used to consider food to be of good quality when it was not adulterated and had no defects (EU, 2020). International Standards Office through ISO 9000:2005 standard defines "quality" as "the degree to which a set of inherent characteristics fulfills requirements" (ISO, 2012). During the last decades, seems that the concept of food "quality" changes. According to another concept, we think of good "quality" linked to certain desirable attributes. These attributes can be intrinsic, meaning that we can assess them using our senses, such as color, appearance, flavor, and smell or extrinsic, that are not tangible but are still a part of the food product, such as environmental impact, place of origin and traditional know-how in their manufacture (Espejel et al., 2007; EUFIC, 2022). According to Grunert, regarding customer-oriented concept of food " quality", is defined to be based on adding value and consequently products with added value are perceived as having higher quality (Grunert, 2005).

"Quality labels" have become a central component of modern consumer policy (Velčovská and Del Chiappa, 2015). They can be identified by a graphic mark, logo or symbol placed on

product's package, intended to inform consumers in relation to product's compliance to specific quality criteria or to the quality manufacturing process, or to special characteristics linked to their geographical area, traditional composition or traditional production method etc. and determined in a corresponding certification system or standard. "Quality labels" can cover many different aspects of the food products such as safety, place of product origin, organic origin, etc. In terms of categorization, there are general labels which address all product quality characteristics, as well as specific labels which focus on particular quality characteristics. Regarding their geographical scope, they can be divided into regional, national, international and global labels. Some of the labels are obligatory (determined by legal rules and compulsory for all products in a given product category), however many of them are voluntary, bringing competitive advantage for a product (Grunert, 2005; Velčovská and DelChiappa, 2015).

"Quality labels" on foods, are designed and determined to promote and protect "quality" food products providing a guarantee of their geographical origin, specific characteristics and/or production methods (Sadílek, 2016). Moreover food "quality labels" can provide a legal protection of a product against imitation- eliminating the misleading of consumers by non-genuine products, can help producers obtain a premium price for their authentic products, and facilitate consumers to identify food products with certified quality (Bagal and Vittori, 2011).

EU Food "Quality labels" or Food Quality Schemes FQS

In EU, the European Commission (EC), in order to help European consumers differentiate certain value food products because of their special qualities, both intrinsic and extrinsic, has laid down certain rules to protect these products, through specific Food Quality Schemes (FQS). According to these rules FQS, have to be protected, products must be recognized, and their distinctive quality can be communicated to consumers. Products protected by quality schemes, national or EU-wide, can be identified by the logos-marks of the respective schemes on their packaging. Next to the above, there are also national and regional quality labels that are applicable in the various Member States. For all FQS, each EU country's competent national authorities are responsible for preventing and stopping the misuse of products using respective names (EUFIC, 2022).

There are currently four EU food "quality label" schemes: Geographical indications (GIs) comprising two quality labels: Protected designation of origin (PDO) and Protected geographical indication (PGI), Traditional speciality guaranteed (TSG) with the following identification marks (EC, 2012b available on website: http://ec.europa.eu/agriculture/quality/schemes/logos/index_en.htm, Assessed on 20 March 2022).

Figure 1.4. GIs logos

Geographical Indications (GIs)

Geographical Indications (GIs) –comprising in particular :PDO, PDP and TGI- is a generic term describing the various legal mechanisms used to protect geographical designators that inform consumers about the geographic origin of a product and the product's quality and characteristics.

Geographical Indications (GIs) –according to Giovannucci et al.-were introduced into international trade treaties by the European Union (EU) during the Uruguay Round trade negotiations but now is an international level topic . , introduced in 1994, with the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement, under the World Trade Organization (WTO), even though strongly resisted by the USA and other New World countries Agreement , The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs), which became effective in 1995, is considered the first multilateral agreement gave an explicit definition of the term "geographical indication", according to which "geographical indications" are "indications, which identify a good as originating in the territory of a Member, or a region or locality in that territory, where a given quality, reputation or other characteristics of the good is essentially attributable to its geographical origin" (TRIPs Article 22.1). Furthermore, TRIPs requires from every signatory to establish minimum standards for the protection of GIs through their national law. Since then, the EU has been a strong advocate for increasingly strict GI regulation and GIs became an essential element in all trade agreements. Even though Gis present surprisingly limited economic importance in both domestic production and international trade by 2009, GI systems were used already in 167 countries and regions. Indicatively China has become recently the country with the largest number of registered GIs, while for many years the majority of registered GIs were found in the EU and, in bilateral trade agreements between the EU and other countries, the number of GIs in the EU far exceeds the number of partner countries(Giovannucci et al., 2009).In the US, USDA's Agricultural Marketing Service (AMS) provides American agriculture with proportional tools and services, such as grading, certification, and verification, that help producers and products to create marketing opportunities. AMS services responsible to guarantee the quality of American food and add

value to American products. Below is a list of the labels and standards AMS verifies (https://www.ams.usda.gov/publications/content/understanding-food-quality-labels.

Within the EU "quality labels" can be actually considered as a type of complex label and are subject to additional regulative provisions according to European Regulations. The EU-wide system for GIs is managed by the Directorate-General, Agriculture and Regional Development, was first introduced in 1992 (EC, 1992) and has been revised twice since then (in 2006 (EC, 2006) and 2012(EC, 2012)).

In 1992 according to the Regulation 2081/92 (EC,1992) the European Union first adopted the system for the PGI and the PDO of agricultural products and foodstuffs and according to the regulation 2082/92 the rules on the certificates of specific character for agricultural products and foodstuffs. Later on, in 2006 the above regulations have been replaced by Regulations (EC) 510/06 (EC, 2006) and (EC) 509/06 (EC, 2006) respectively, without changing their scope and feasibility. By Regulation (EE) 1151/2012 (EC, 2012) of 21 November 2012 on quality schemes for agricultural products and foodstuffs the above-mentioned regulations ((EC) 509/2006 and (EC)510/2006) were merged into a single legal framework, while at the same time, in the same regulation other quality schemes such as optional quality terms "mountain product", "product of island farming" etc. has been also added.

The EU system's has two major types of GIS. Protected Designations of Origin (PDOs) are very similar to the French Appellation d' Origine Contrôlée (AOC) system and Protected Geographical Indications (PGIs) have a German origin with a strong reputational element but a much lower link to the place of origin ,already existing before the EU GI system. Mainly five EU member states (specifically :Italy, France, Spain, Portugal and Greece) are the primary users of the EU's GI system, regarding both the number of registered products and their economic importance (Torok et al., 2020).

The EU geographical indications system, according to EU's website, protects the names of products that originate from specific regions and have specific qualities or enjoy a reputation linked to the production territory. The differences between PDO and PGI are primarily linked to how much of the product's raw materials or the production process must come from the area, or has to take place within the specific region respectively. GI is also specific for spirit drinks and aromatized wines. Protected Designation of Origin (PDO) are those that have the strongest links to the place in which they are made, and every part of the production, processing and preparation process must take place in the specific region. Protected Geographical Indication (PGI) apply also to agricultural products and foodstuffs as well as for wine and spirits and indicate a link with the geographical area in at least one of the stages of production, processing or preparation. For PDO food products, management

conditions are regulated by very strict rules with the aim of obtaining high quality process and the link with the area is stronger, while PGI is a more flexible regulation (Espejal et al., 2008). A Traditional Speciality Guaranteed (TSG) applying to agricultural farm products and foodstuffs highlights a product΄s traditional character, either in the composition or means of production. According to new Regulation on EU quality schemes for agricultural products and foodstuffs entered into force in the beginning of 2013, in order to be "traditional" proven usage on the market during at least 30 years (instead of 25) is now required.

The protection of geographical indications (GIs) -as their name suggests, are labels indicating that a product has a relationship to a particular geographic region (e.g., method of production used in that region or the natural characteristics of the region), fact that comprises an important feature of modern trade agreements. As examples, follow very well-known products: “Champagne” recognized as a GI in Europe corresponds to the sparkling wine produced in the French region of Champagne. Similarly, “Roquefort” identifies a cheese made using milk from a specific breed of sheep and aged in the natural caves of Roquefort-sur-Soulzon in France. Most GIs are known by their geographic location, which usually appears also in their name. As such, “prosciutto” is not a GI but “prosciutto di Parma” is.. However, there are a small number of exceptions, which enjoy GI recognition in Europe even though their specific location of production is not mentioned in the product’s name, , with main examples including the following cheeses: asiago, feta, fontina, gorgonzola, and munster (Slade et al., 2019).

Food and agricultural products, as well as wine, spirits and aromatized wine, registered under the PDO, PGI, and TSG scheme, can be found on the European Commission’s e-Ambrosia portal (EC Quality Products Registers, accessed on 12 January2022), presented also in the following figure.

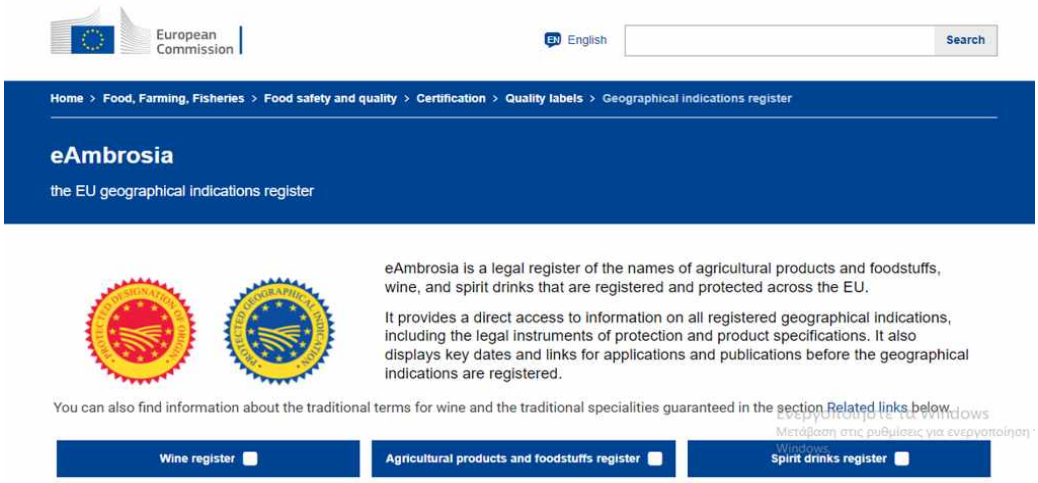


Figure. 1.5. The gate to the EU e-Ambrosia register

"Quality label" products in Greece –the case of "quality cheeses"

In accordance with the aforementioned regulations and under the reorientation of the Common Agricultural Policy (CAP), the farmers in all member-states of the EU, are encouraged to switch to forms of integrated rural development through the diversification of rural production as referred to the greek Ministry of Agriculture website. Furthermore, it is possible the producers (especially in disadvantaged and remote areas) to promote easily their products with special characteristics, achieving better market prices and thereby improving their income and on the other hand consumers to buy quality products with guarantees for the production, processing and geographic origin (http://www.minagric.gr/index.php/en/farmer-menu-2/pdo-pgi-tsgproducts-menu , assessed on 20 March 2022).

In the following figure is presented the greek Ministry of Agriculture website, gate for the greek quality cheeses.

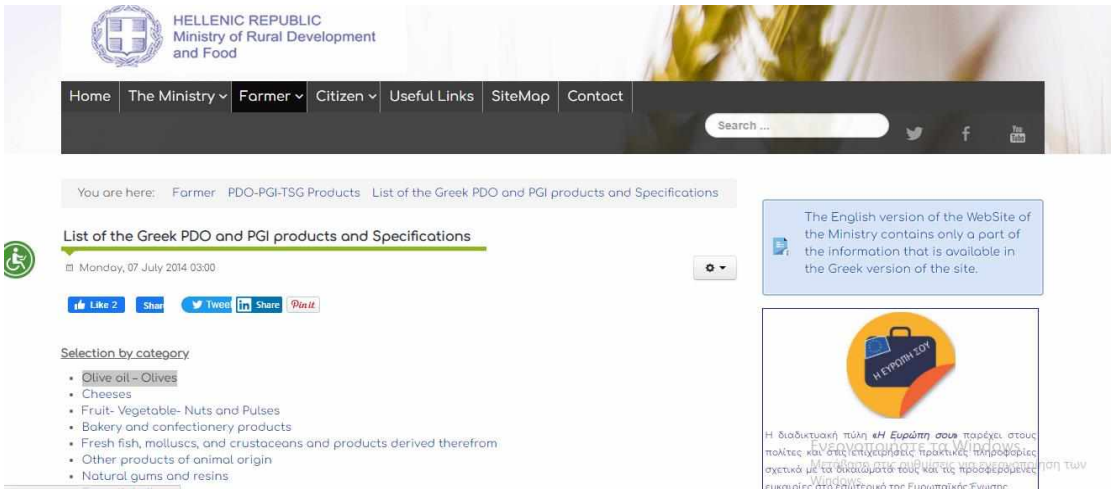


Figure. 1.6. The gate to the greek "quality label products through the greek Ministry of Agriculture website

Greece, as already mentioned before and reported by Torok et al. (Torok et al., 2020), belongs on the five EU countries enjoying the greater penetration of "quality label" products. In detail, according to the analysis made by Katsouri et al. (Katsouri et al, 2022), Greece is the fifth EU country in a" quality label" foods ranking represented by 116 food records in the European GI's register e-Ambrosia (assessed on 20 May 2021), while Italy possesses first place with 339 food records. Regarding "quality label" cheeses is the food category with the third higher share in quality labels of Greece (23 records of total 116 records, 19%). Fruits, vegetables and cereals category (49 records, 43%) stand in the first place and oils and fats category 3 records, 28%) in the second place. Distribution of greek

quality foods registered on EU geographical indications register e-Ambrosia, is presented in Chapter 4 (Katsouri et al.,2022)

Overall 23 greek quality label cheeses are registered in e-Ambrosia Official EU Database for food and agricultural products, wine, spirits and aromatised wine (e-Ambrosia)_, including: Feta PDO (Fe), Kalathaki Limnou PDO (KL), Galotyri PDO (Ga), Katiki Domokou PDO (KD), Kopanisti PDO (Ko), Anevato PDO (An), Pichtogalo Chanion PDO (PC), Xigalo Siteias PDO (XS), Graviera Kritis PDO (GK), Graviera Naxou PDO (GN), Graviera Agrafon PDO (GA), Arseniko PDO (Ar), Kefalograviera PDO (Ke), Ladotyri Mytilinis PDO (LM), Metsovone PDO (Me), Batzos PDO (Ba), Krasotyri of Ko PGI (KK) Kasseri PDO (Ka), Sfela PDO (Sf), San Mihali PDO (SM), Formaella Arachovas Parnassou PDO (FAP), Manouri PDO (Ma), Xinomizithra Kritis PDO (XK). Abbreviations in the parenthesis above are used throughout the study instead of the full names of the cheeses. Of the 23 cheeses, PDO mark is the dominant between Geographical Indications of greek Quality label cheeses. 22 are granted the PDO mark while only one cheese—the recently qualified Krasotyri of Ko—is granted the PGI mark.

According to the national greek Code of Foodstuffs, Beverages and Objects of Common Use (commonly referred to as the "Food Code" (greek Code of Foodstuffs, Beverages and Objects of Common Use "Food and Drinks Code", 1971), "quality label"cheeses belong to four different cheese categories (soft, hard, semi-hard and whey cheeses) based on their firmness.

Table.1.1 List of greek "quality label" cheeses categorized according their firmness-accompanied by the fraction of the % min fat in dry matter /% max moisture (w/w), for each cheese.

number/ category	**Soft Cheeses**	**Hard Cheeses**	**Semi-hard Cheeses**	**Whey Cheeses**
1	Feta PDO (F) (43/56)	Graviera Kritis PDO (GK) (40/38)	Kasseri PDO (Ka) (40/45)	ManouriPDO (Ma) (70/60)
2	Kalathaki Limnou PDO (KL) (43/56)	Graviera Naxou PDO (GN) (40/38)	Sfela PDO (S) (40/45)	Xinomizithra Kritis PDO (XK) (45/55)
3	Galotyri PDO (G)	Graviera Agrafon PDO (GA)	San Mihali PDO (SM)	

	(40/75)	(40/38)	(36/40)	
4	Katiki Domokou PDO (KD) (40/75)	Arseniko PDO (Ar) (40/38)	Formaella Arachovas Parnassou PDO (FAP) (40/50)	
5	Kopanisti PDO (Ko) (43/56)	Ladotyri Mytilinis PDO (LM) (40/38)		
6	Anevato PDO (An) (45/60)	Metsovone PDO (Me) (40/38)		
7	Pichtogalo Chanion PDO (PC) (50/65)	Kefalograviera PDO (Ke) (40/40)		
8	Xigalo Siteias PDO (XS) (33/75)	Batzos PDO (B) (25/45)		
9		Krasotyri of Ko PGI (KK) (43/56)		

Subsequently, the scientific studies of the PhD Thesis are following as published, comprising an original piece of work, providing for the first-time information on greek “quality cheeses”, from the perspective of their nutritional profile and labelling.

OUTLINE OF THE THESIS

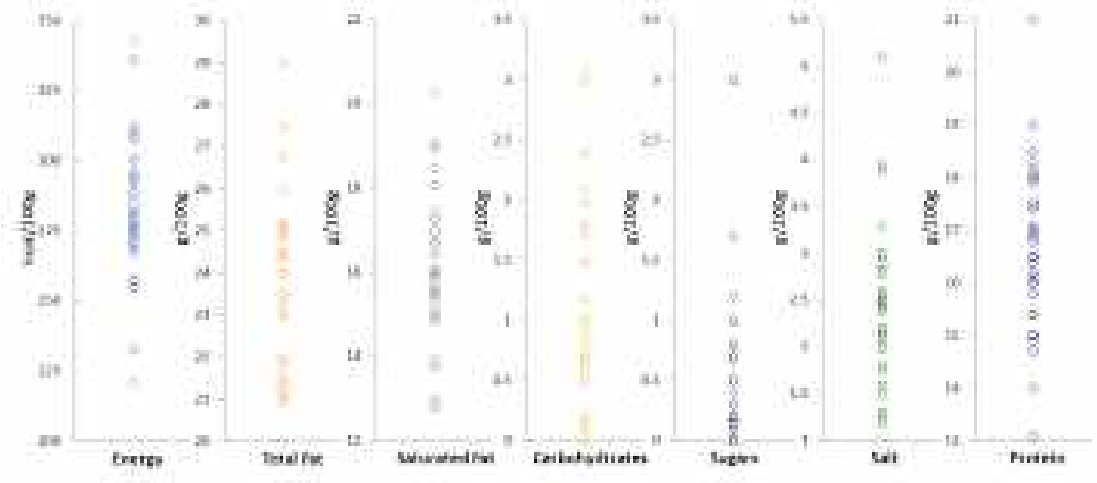
Next to this review of literature on Chapter 1, the thesis consists of three research chapters (Fig.1.7), devoted to applications of new trends of nutrition and foods' labelling regulatory research, applied to "quality label" prepacked cheese products, aiming to provide new evidence and novel directions on the development of nutrition and public health policies in Greece. Specifically:

Feta cheese is the most abundant greek cheese and possesses the biggest share on cheeses' consumption, in the greek population. In Chapter 2, a nutrient intake assessment study, assessing the nutritional characteristics of prepacked Protected Designation of Origin (PDO) feta cheese products available in the greek market and the contribution of feta cheese consumption to the greek diet, was attempted, by combining nutrition labels of the products with consumption data of the greek population. Moreover, monitoring of the nutritional variability of feta cheese products as well as an evaluation of the products using five (5) different Nutrient Profile Models (NPMs), were conducted for the first time, providing evidence on the nutritional profile of feta cheese and the potential setting of nutritional /health claims in their labels.

Chapter 3, subsequently, presents a nutrient intake assessment study assessing the nutritional characteristics of prepacked graviera (PDO and not PDO) products of the greek market and and the contribution of gravieras to the Greek diet. During the assessment, again, the nutritional labelling of gravieras' products were combined with consumption data of the greek population. In this study, variability of Greek gravieras' nutrient profile was also monitored and an evaluation, using the French Nutri-Score front of pack labelling scheme (FoP) attempted for the first time. The discussion was focused on the potential use of the specific FoP labelling scheme for the specific products, as a pilot, considering the globally identified need for the use of FoPs, in order to improve consumers' food choices.

In Chapter 4, Labelling Assessment study of available prepacked greek "quality" cheeses was conducted in order to screen the labelling status and compliance to EU legislation, explore potential problems and perspectives and provide a nutritional syllabus for all greek "quality label" cheeses utilizing their nutrition declaration tables. An archival database with pilot application of a specific data structure as well as the use of standardized guidelines and tools for labelling data was created allowing the conceptualization of its further development to a branded food composition database (BFCD) for "quality label" foods with multiple novel nutritional applications, which are analyzed and discussed.

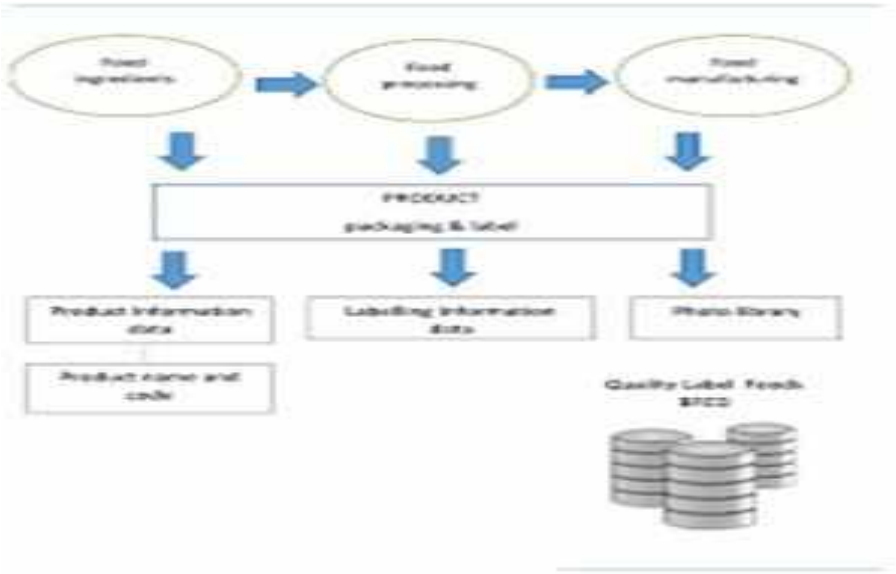
Chapter 5 concludes this thesis providing a summarizing discussion and future perspectives



Chapter 2. Dietary / Nutrient intake assessment of feta PDO cheese in the adult Greek population and nutrient profiling of feta cheese products using 5 available Nutrient Profile Models (NPMs).

Nutri-Score FoP classes	Nutri-Score FoP criteria points for Solid Food	Average scores in products tested	Range of scores in products tested	Classification according to estimated scores, and Percentage of products in each Nutri-Score FoP class
A—dark green	-15 to -1			0%
B—green	0 to 2			0%
C—light orange	3 to10	10	10	1%
D—orange	11 to 18	16	12-18	62%
E—dark orange	19 to 40	19	19-21	37%

Chapter 3. Dietary / Nutrient intake assessment of graviera cheese products in the adult greek population and nutrient profiling of graviera cheese products using Nutri-Score front of pack label scheme (FoP).



Chapter 4. Labelling Assessment of greek “Quality Label” prepacked cheeses as the basis for a Branded Food Composition Database (BFCD) for “quality label” foods.

Fig. 1.7. Graphic overview of the research topics addressed in the thesis’ research chapters.

CHAPTER 2

Nutritional Characteristics of prepacked Feta PDO cheese products in Greece: Assessment of Dietary Intakes and Nutritional Profiles

Evangelia Katsouri, Emmanuella Magriplis, Antonios Zampelas, George-John Nychas and Eleftherios H. Drosinos

Foods 2020, 9, 253, 1 - 15

Abstract

Feta cheese, a protected designation of origin (PDO) food, is one of the most important Mediterranean food products. Although it is the cheese with the highest consumption in Greece, the nutritional characteristics of products available in the market, as well as their contribution to the greek diet, have not been evaluated in detail. In the present study, the basic nutritional content of 81 prepacked feta cheese products available in the greek market were recorded based on their labels. This was combined with consumption data to provide an overall picture of feta cheese's contribution to the greek diet. The nutrient contents per 100 g ranged as follows. Energy: 221–343 kcal, total fat: 20–29 g, saturated fat: 12.8–20.3 g, carbohydrates: 0–3.1 g, sugars: 0–3 g, proteins: 13.1– 21.0 g and salt: 1.2–5.1 g. The median feta daily individual consumption was found to be 39 g, ranging from 20 g to 100 g (fifth and 95th percentiles, respectively). The nutritional intake analysis as a percentage of dietary reference intake (DRI) showed that saturated fat and salt are ranked on the top of the list, with intakes reaching 101.5% and 85% respectively. The products were also evaluated against five nutrient profile models and their potential use under statutory requirements and policy development are discussed.

1. Introduction

Feta cheese has been produced since Homer's time. It is the best known greek cheese, with a prominent place in the greek and international market, and it is ranked first in export sales (ICAP, 2019). Since 2002, feta has been a protected designation of origin (PDO) product in the European Union (EC, 2002). According to the relevant EU legislation, PDO foodstuffs must comply with certain specifications related to name, raw material origin and characteristics, description of production method, definition of the geographical region of origin and production, details for the inspection structures and specific labeling details (EC,

1992). Feta PDO cheese, specifically, must be produced from sheep's milk, or from a mixture of sheep's and up to 30% goat's milk in particular areas of Greece (Macedonia, Thrace, Epirus, Thessaly, mainland Greece, Peloponnesus, Lesvos, Limnos, Agios Efstratios). Most feta cheese is produced from pasteurized milk in organized cheese dairy establishments, using commercial lactic acid cultures (Anifantakis, 1991). Production includes an acidification step aided by the addition of yoghurt starter cultures containing Streptococcus thermophilus and Lactobacillus delbrueckii subspecies Foods 2020, 9, 253 2 of 15 bulgaricus. The fresh cheese is dry-salted for 4–5 days, is then placed in brine with an approximately 8% salt content for ripening for at least 60 days, and is later commercialized (Mauropoulos and Arvanitoyannis, 1999). Feta cheese is traditionally distributed in metal vessels or wooden barrels and sold through the retailers' service counters. Recently, however, prepacked feta cheese products sold at super market shelves have gained a significant share in the greek and international market. The fact that in the latter case consumers have an immediate access to the product label raised the interest of both the dairy industry and the consumers to the nutritional characteristics of the product as well as the potential nutritional claims that could be included in the label.

Composition and nutrient characteristics of feta cheese depend on an increased number of factors including the composition of raw material (milk), microbial ecology of the product, salt content, duration and conditions of ripening and others. For example, the salting method, which can vary among producers, can significantly affect both the salt and the fat content of the final product. On the other hand, ripening conditions and time affects the final cheese composition, since these factors determine the type and extent of lipolysis and proteolysis (Pappas et al., 1996; Katsiari et al., 1997) .

Despite the importance of feta cheese in Greece, data on the nutritional characteristics of the different products marketed in Greece as well as on their contribution to the daily nutrient intake for the greek population are limited. Such data however, are very important for the development of healthy diet strategies. For example, a recent survey on salt intake in Greece (Vasara et al., 2018) showed that only 5.6% of consumers had a salt intake of less than 5 g/day, which is the target intake recommended by the World Health Organization (WHO, 2012), while 50.4% of consumers had a daily salt intake that exceeded 10 g per day. Considering the high consumption of feta in Greece and the fact that it is a product with a high salt concentration an evaluation of its contribution to the daily salt (and other nutrient) intake, is of great importance in order to develop effective salt reduction strategies. The importance of such strategies is supported by actions in the European Union that encompass salt monitoring and evaluation of salt reduction actions, as one of their important pillars (EC, 2012).

Additionally, many consumers around the world are increasingly focused on healthy eating and many actively make dietary choices to reduce risk of various health issues such as obesity, diabetes, high cholesterol and hypertension (The Nielsen Company, 2019). A comparative study of 12 food values between the United States and Norway using the best–worst scaling approach showed that respondents in both countries have similar food values, with safety being scaled as the most important value and nutrition ranked 6th (Bazzani et al., 2018). Moreover, various studies on consumers' "willingness to pay" (WTP) have reported that PDO regional products are highly appreciated (De-Magistris and Gracia, 2015; Likoudis et al., 2016; Aprile et al., 2012) and are perceived by consumers as healthier (Demartini et al., 2018). Other studies have reported that consumers expect that products with nutrition and health claims on the packaging have a better overall nutritional value compared with products without such information (Maschkowski et al., 2014; Soldavini et al., 2012). Taking these reports into account one must also consider that consumers may be biased and confused from labeling information (Angelino et al., 2019), hence providing nutritional and health information to consumers in an effective way, remains a challenge for the food industry.

Food labels are the main method for transferring nutrition and health information of foodstuff to consumers (Angelino et al., 2019). In Europe, information made on food is regulated by specific laws, including (i) the European Regulation (EU) no 1169/2011, which regulates the mandatory information on food including ingredient lists and nutritional declarations (EC, 2011) and (ii) the European Regulation (CE) no 1924/2006, concerning the voluntary nutrition and health claims (NHC) (EC, 2006). According to Reg. (EC) 1924/2006, Article 4, "the Commission shall establish specific nutrient profiles and the conditions, including exemptions, which shall be respected for the use of nutrition and health claims on foods and/or categories of foods". Nutrient profiling involves the classification and ranking of foods according to their nutritional composition for reasons related to preventing disease and promoting health (WHO, 2010). However, the setting of nutrient profiles has been postponed, due to the complexity of the subsequent discussions in relation to scientific issues and potential economic effects. Nevertheless, various optional nutrient profile models (NPMs) have been developed in several countries based on conditions regulated by their particular population and needs (Verhagen and Van den Berg, 2008). The evaluation of feta cheese products against available NPMs would provide the basis for the greek dairy industry to establish the nutrient profile and to prepare future setting of nutrition or health claims in feta cheese.

The present study aimed to evaluate all previously mentioned nutritional aspects of prepacked feta PDO cheese in Greece and assess percent contribution of feta to salt and

saturated fat intake of a representative population sample to recommended intakes. Specifically, the main objectives were (a) to comparatively assess the nutritional characteristics of prepacked PDO feta cheese products available in the greek market, (b) to combine the nutritional characteristics with consumption data in Greece in order to evaluate the contribution of feta cheese consumption to the greek diet compared to the European daily reference intake (RI) values and (c) to evaluate the nutritional characteristics of feta cheese products against available NPMs, providing evidence on nutritional profile and future setting of nutritional or health claims in feta cheese.

2. Materials and Methods

2.1. Sampling, Data Collection and Analysis of Nutritional Characteristics of Prepacked Feta

Cheese Sampling of prepacked feta cheese products took place in supermarkets, discount and cash & carry chain stores of all major retailers (Lidl, AB-Delhaize, Sklavenitis, Masoutis, Elomas, Kritikos, My market, Market In, Discount Markt, Mako Markets, Spar, A/S Agora, Galaxias, Makro, The Mart) in three greek cities (Athens, Thessaloniki, Larisa) during September-December 2018. In total, 81 feta PDO cheese products, produced by 55 feta manufacturers, were identified and sampled. All sampled products were purchased and photographed, and their packages were retained. For each product all nutrients available on the labeling nutrition declaration were retrieved separately. Data, including all labelling information were retrieved from the images of all the sides of each product-package sampled. More specifically, all nutrients available on the labeling nutrition declaration: energy (kcal), protein (g), carbohydrates (g), total sugars (g), fat (g), saturated fat (g), and salt (g) per 100 g were retrieved separately and were analyzed statistically. This information was entered in a specially created database along with a photo of the product. The database was used as a data depot for further statistical analysis.

2.2. Analysis of Nutrient Intake by Feta Cheese Consumption

Nutrient intakes of healthy greek adults from feta cheese consumption were calculated per capita and per day, using the nutrient contents of the 81 sampled products in combination with feta cheese consumption data obtained from the Hellenic National Nutrition and Health Survey (HNNHS). Specific study details have been published (Magriplis et. al, 2019). To evaluate the daily consumption per capita of feta cheese in Greece, consumption data from 1232 adults (46.5% males) from the HNNHS who had declared to consume feta cheese were used. In order to describe nutrient intake variability, feta cheese consumption, median and range were calculated (fifth, 50th and 95th percentiles) based on daily per capita consumption and the mean nutrient content of the 81 tested products. The intake of nutrients was also expressed as percentage of the European daily reference intake (DRI)

values as set by the European legislation (EC, 2011). The RI values used were energy: 2000 kcal, total fat: 70 g, saturated fat: 20 g, carbohydrates: 260 g, sugars: 90 g, proteins: 50 g and salt: 6 g.

2.3. Evaluation of the Nutritional Characteristics of Feta Cheese Products against available Nutritional Profiling Models (NPMs)

The 81 prepacked feta cheese products identified in the greek market were evaluated against the following five NPMs. Model I: The World Health Organization Nutrient Profile Model (WHONPM), model II: The Swedish Keahole (SK-NPM), model III: The United Kingdom Nutrient Profile Model (UK-NPM), model IV: The Food Standards Australia New Zealand Nutrient Profile Scoring Criterion (FSANZ NPSC) and model V: The Choices Programme (CP-NMP).

Models (I), (II), (V) are threshold models while III and IV are scoring models. Model I (WHO, 2015) is a threshold model which sets criteria on two basic nutrients (total fat and salt), aiming to inform product policy development directed to children. Model II (Swedish Food Agency, 2019) is a threshold model which sets criteria on two basic nutrients (total fat and salt) with scope to qualify the products for related health claims. Model III (United Kingdom Government, 2019) is a scoring model developed to regulate food marketed to children and attempts to balance the contribution from "beneficial" nutrients of food alongside the "negative". Model IV (Food Standards Australia New Zealand, 2019) is a scoring model which categorizes food based on specific characteristics (e.g., for cheese: calcium content). Model V (Choices Programme, 2019) is a threshold model which sets criteria on the three basic nutrients (saturated fat, salt and no added sugars) with scope to qualify products for health claim use. All the above NPMs have been developed by government, global, or other agencies and have been used to categorize products according to their nutritional characteristics (Maschkowski et al., 2014; Trichterborn et al., 2011a; Trichterborn et al., 2011b). A detailed description of the selected NPMs is presented in Table 2.1.

Table 2.1. Overview of the five chosen nutrient profile models and their key parameters.

Model Number	Model Name	Calculation approach	Reference quantity	Number of nutrients (negative /positive)	Nutrients to limit (negative)	Nutrients to encourage (positive)	Reference
I	World Health Organization Nutrient Profile Model (WHO-NPM)	THRESHOLD	100g	7	total fat 20g/100g, salt 1.3g/100g	-	[25]
II	Swedish Keahole (SK-NPM)	THRESHOLD	100g	(5/1)	total fat 17g, salt 1.6g/100g	fiber-whole grain	[26]
III	United Kingdom Nutrient Profile Model (UK-NPM(	SCORING	100g	(4/3)	energy, saturated fat, total sugar, sodium,	fruits, vegetables and nuts,	[27]

						fiber, protein	
IV	Food Standards Australia New Zealand Nutrient Profile Scoring Criterion (FSANZ NPSC)	SCORING	one serving	(4/3)	energy, saturated fat, total sugar, sodium,	fruits, vegetables and nuts, fiber, protein	[28]
V	Choices Programme Nutrient Profile Model (CP-NMP)	THRESHOLD	100g	(4/1)	total fat 15g/100g, trans fatty acids 0.1g/100g, sodium 8.3g/100g, salt 2.075g/100g, no added sugars	fiber	[29]

The evaluation of the prepacked feta cheese products against the NPMs was based on their nutrient contents recorded in the first part of the study. For model I, it was not taken into account, that, according to the model's terms, "if the product is a food that has a protected designation of origin or a protected geographical indication or is a guaranteed traditional specialty, marketing (to children) may be permitted according to national context" (WHO, 2015). For model IV, estimations were made with the assumptions of a 39 g serving and an average Ca content of 0.450 g/100 g for all products based on literature data (Jalili, 2016; Hellenic Agricultural Organization (ELGO-DEMETER), 2019). The assumed serving of 39 g for feta cheese corresponds to the median value of feta consumption according to HNNHS data.

3. Results

3.1. Nutritional Characteristics of Prepacked Feta Cheese

In total, 81 products of prepacked feta cheese were identified in the major greek retail chains produced by 55 dairy companies. According to their labeling information and production's establishment approval number the majority of the products (72.9%) were produced in approved production establishments [34] in four of the nine PDO qualified administrative districts [Thessaly (21%), Central Macedonia (19.8%), Epirus (17.3%) and West Greece (14.8%) of PDO. The distributions of the nutrient contents (energy, protein, carbohydrates, total sugars, fat, saturated fat, and salt per 100 g) of the products according to their nutrition declaration are presented in Figure 2.1. Table 2.2 presents the descriptive statistics of the nutrient content of the 81 products.

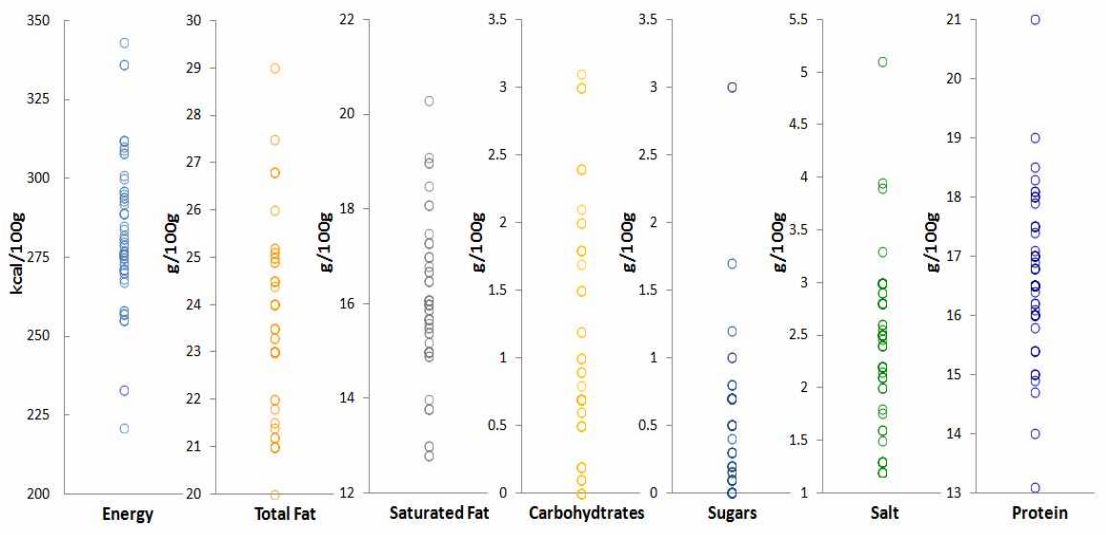


Figure 2.1. Distributions of energy, total fat, saturated fat, carbohydrates, sugars, salt and protein per 100 g, for prepacked feta cheese products available in the greek market.

Table 2.2. Descriptive statistics of nutritional characteristics (per 100 g) of prepacked protected designation of origin (PDO) feta cheese products in the greek market

	energy (kcal)	***total fat (g)***	***sat. fat (g)***	***carbohydrates (g)***	***sugars (g)***	***proteins (g)***	***salt (g)***
Mean	280,5	23,4	15,9	0,9	0,5	16,6	2,4
St. Error	2,3	0,2	0,2	0,1	0,1	0,1	0,1
Median	276,0	23,0	16,0	0,7	0,5	16,5	2,5
Mode	276,0	23,0	15,0	0,7	0,7	16,5	3,0
St. Dev.	20,3	1,6	1,4	0,8	0,6	1,1	0,7
Variance	412,6	2,6	2,1	0,6	0,3	1,2	0,5

The results showed that there is a significant variation in the nutrient content of feta cheese products. In particular, the observed ranges per 100 g were energy: 221–343 kcal, total fat: 20–29 g, saturated fat: 12.8–20.3 g, carbohydrates: 0–3.1 g, sugars: 0–3 g, proteins: 13.1–21.0 g and salt: 1.2–5.1 Foods 2020, 9, 253 7 of 15 g. The coefficient of variation (%CV = SD/mean * 100) for the different nutrients ranged from 6.8% for total fat to 120% for sugar. 3.2. Nutrient Intake by Prepacked Feta Cheese Consumption in Greece and Comparison with the Respective European DRIs Feta cheese consumption data for 1232 healthy adult greek consumers who had declared to consume feta cheese, were obtained from the Hellenic National Nutrition and Health Survey database (Magriplis et al., 2019) and analyzed. The descriptive statistics of the consumption data are shown in Table 2.3.

Table 2.3. Descriptive Statistics of Feta cheese consumption data for adults 20–65 years old according to the Hellenic National Nutrition & Health Survey (HNNHS).

	Consumption per capita per day (g)
Mean	**50,3**
Standard Error	**1,0**
Median	**39,0**
Mode	**39,0**
5th Percentile	**20**
50th Percentile	**39**
95th Percentile	**100**
Standard Deviation	**36,2**

In Figure 2.2, the frequency histogram of greek adults' feta cheese consumption (g) per capita and per day, is shown

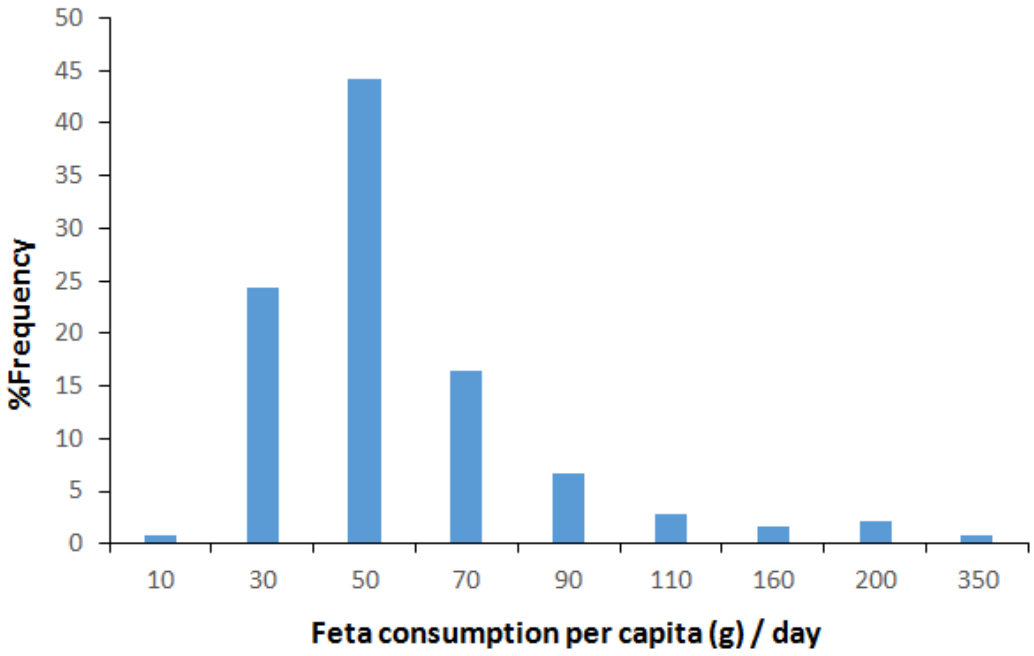


Figure 2.2. Frequency histogram of greek adults' feta cheese consumption (g) per capita and per day based on data 1232 healthy adult greek consumers extracted from the Hellenic National Nutrition & Health Survey (HNNHS) database.

The results from the analysis of the consumption data showed that feta cheese consumption varied significantly among greek consumers. Consumption per capita per day ranged from 5 g to 336 g with an average value of 50.3 g and a median value of 39 g. The estimated %CV was 92.8% and the distance between the fifth percentile (20 g) and the 95th percentile (100 g) was 80 g. The data on feta cheese consumption per capita per day were combined with the data on the basic nutrients' content of the prepacked feta cheese products available in

the greek market in order to provide an overall picture of feta cheese contribution to the greek diet. In order to describe the variability of both daily consumption and nutrient's content among the various products the fifth, 50th and 95th percentiles were used. Table 2.4 presents the daily intake of feta basic nutrients based on the fifth, 50th and 95th percentiles of nutrient contents in the product and daily consumption of feta according to HNNHS data.

Table 2.4. Nutrient daily intake (kcal or g) from prepacked feta cheese consumption marketed in the greek market as affected by product content and daily consumption by greek consumers.

	Feta daily consumption (g)		
Content (g) in pre-packed feta products	**5th Percentile**	**50th Percentile**	**95th Percentile**
	Energy (kcal)		
5th Percentile	51	99	255
50th Percentile	55	108	276
95th Percentile	62	122	312
	Total Fat (g)		
5th Percentile	4,2	8,2	21,0
50th Percentile	4,6	9,0	23,0
95th Percentile	5,4	10,5	26,8
	Saturated Fat (g)		
5th Percentile	2,7	5,2	13,4
50th Percentile	3,2	6,2	16,0
95th Percentile	3,7	7,3	18,7
	Carbohydrates (g)		
5th Percentile	0,0	0,0	0,0
50th Percentile	0,1	0,3	0,7
95th Percentile	0,5	1,0	2,5
	Sugars (g)		
5th Percentile	0,0	0,0	0,0
50th Percentile	0,1	0,2	0,5
95th Percentile	0,2	0,4	1,1
	Salt (g)		
5th Percentile	0,2	0,5	1,2
50th Percentile	0,5	1,0	2,5
95th Percentile	0,7	1,3	3.3
	Protein (g)		
5th Percentile	3,0	5,8	15,0
50th Percentile	3,3	6,4	16,5
95th Percentile	3,6	7,1	18,1

Table 2.4 provides and overall picture of the variability in nutrient intake by consumers of prepacked feta cheese in Greece originated from the differences in nutrient content among products available in the market and the daily consumption quantity among consumers. For example, the salt daily intake for the 50th percentile of feta daily consumption and the 50th percentile of salt content in prepacked feta, representing a scenario of an average consumer eating a product with an average salt concentration, was estimated to 1 g. For an adult consuming prepacked feta cheese at the highest quantity range (95th percentile) of a product with the higher salt concentration among those available in the market (95th

percentile), the salt daily intake increases significantly to 3.3 g, from feta cheese alone. Representative cumulative probability of saturated fat and salt intake per capita and per day, of greek adults' consuming feta cheese marketed in the greek market for the fifth, 50th and 95th percentiles of daily consumption also presented in Figures 2.3 and 2.4.

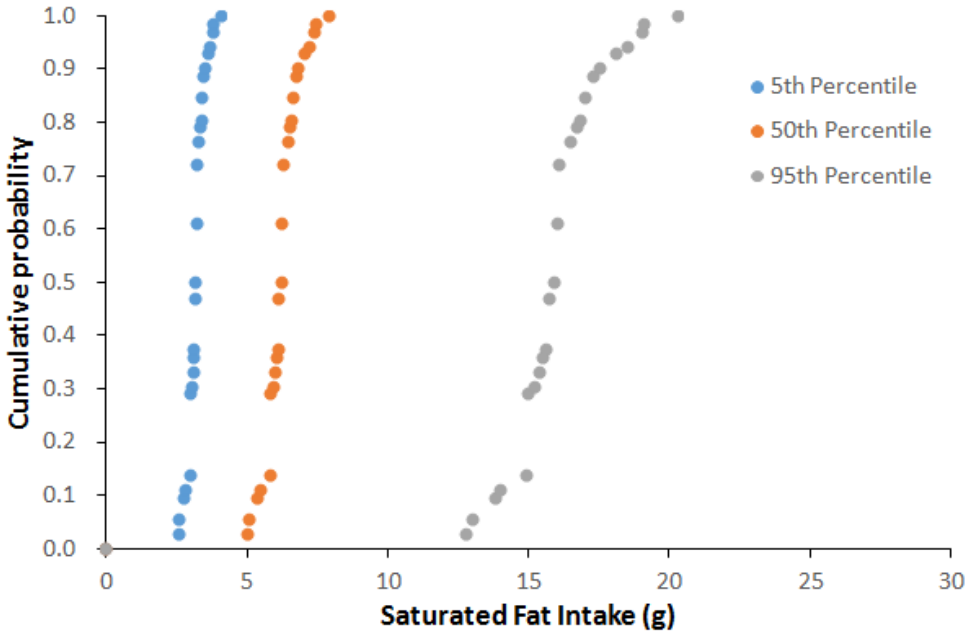


Figure 2.3. Cumulative probability of saturated fat (g) intake per capita and per day of greek adults' consuming feta cheese marketed in the greek market for the fifth, 50th and 95th percentiles of daily consumption.

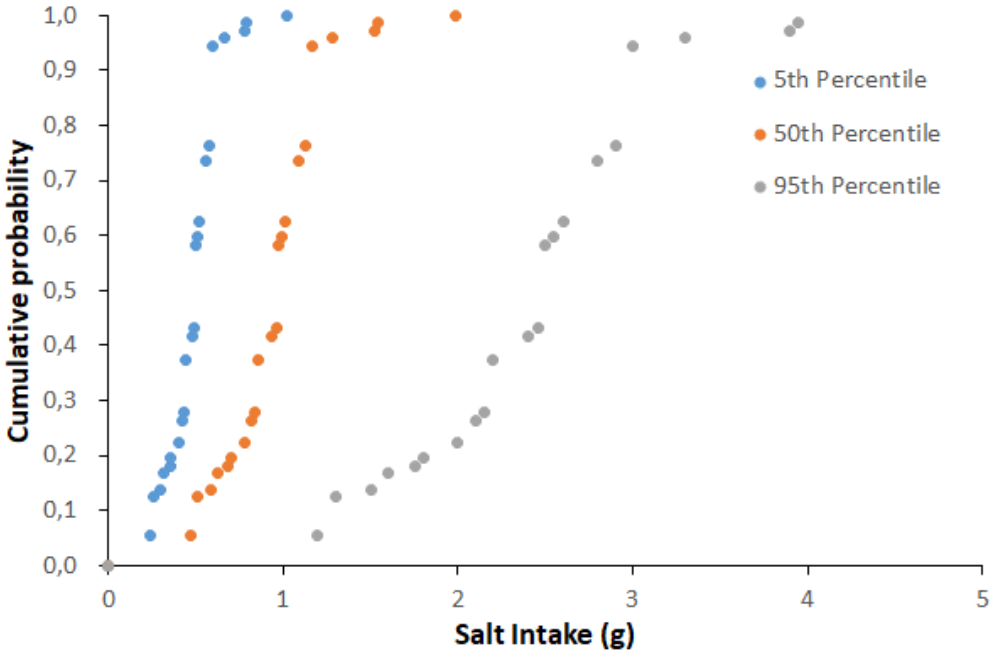


Figure 2.4. Cumulative probability of salt (g) intake per capita and per day of greek adults' consuming feta cheese marketed in the greek market for the fifth, 50th and 95th percentiles of daily consumption.

Nutrient intake was expressed as percentage of the European daily reference intake (DRI) values as set by the European Regulation (EU) 1169/2011 on the provision of food information to consumers, in order to demonstrate the contribution of feta cheese consumption to a healthy adult's diet.

Figures 2.5 and 2.6 present the box plots of the daily nutrient intake as DRI percentage by feta cheese consumption for the 50th and 95th percentiles of daily consumption quantity. For the 50th percentile of daily feta consumption (corresponding to 39 g), the estimated ranges for energy, total fat, saturated fat carbohydrates, sugars, proteins and salt were 4.3–6.7%, 11.1–16.2%, 25–39.6%, 0–0.5%, 0–1.3%, 10.2–16.4% and 7.8–33.2%, respectively. For the 95th percentile of daily feta consumption (corresponding to 100 g), the %RI for energy, total fat, saturated fat carbohydrates, sugars, proteins and salt were 11–17.2%, 28.5–41.4%, 64–101.5%, 0–1.2%, 0–3.3%, 26.2–42% and 20–85%, respectively.

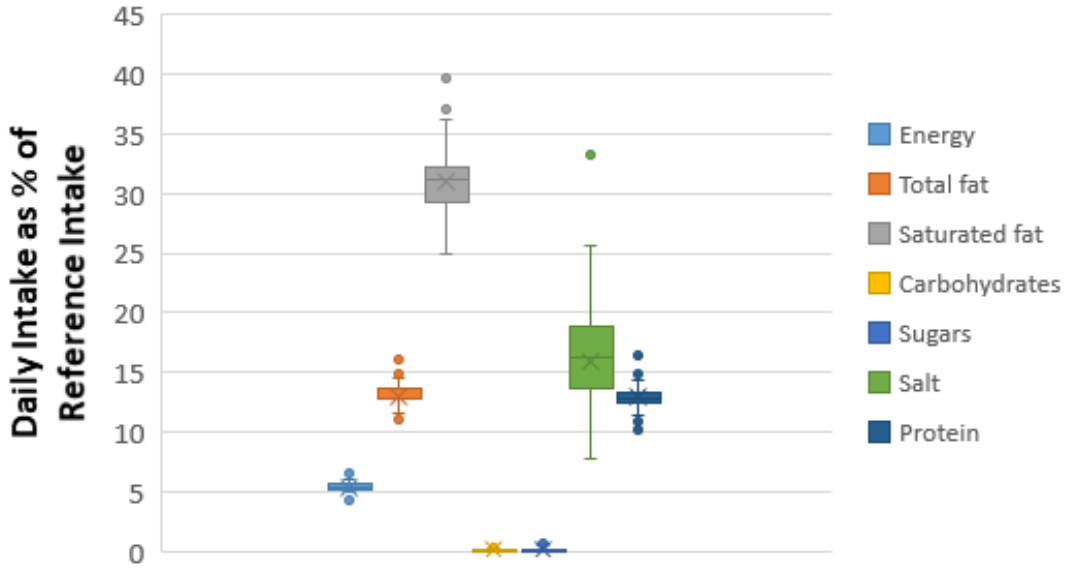


Figure 2.5. Daily intake per capita as a percentage of European daily reference intakes (RIs), for the 50th percentile of the daily consumption of prepacked feta cheese marketed in the

Greek market.

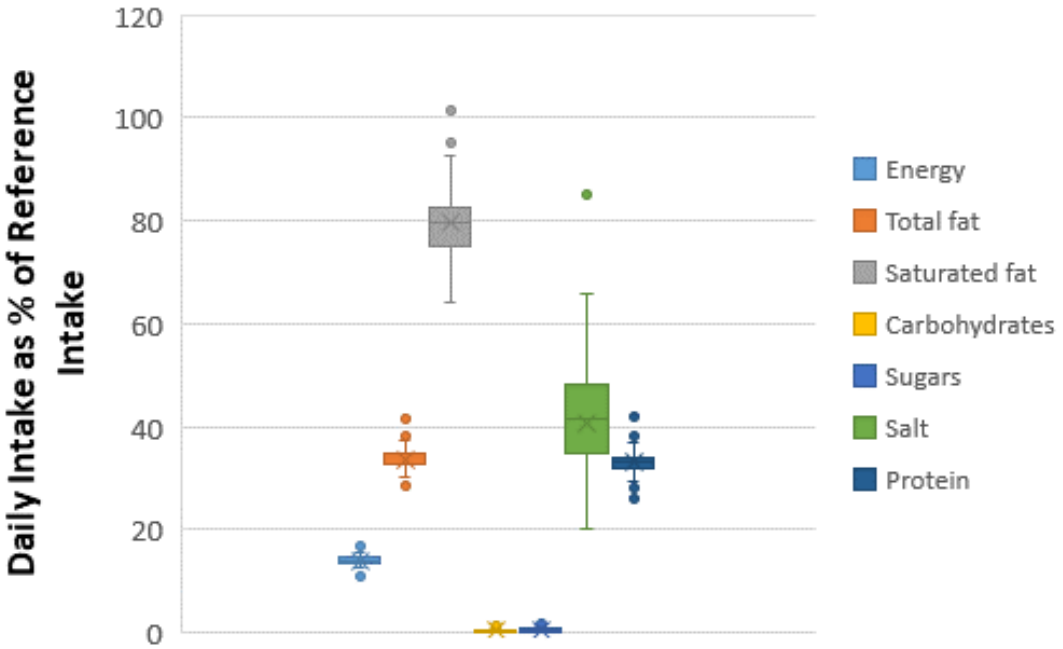


Figure 2.6. Daily intake per capita as a percentage of European daily reference intakes (RIs), for the 95th percentile of the daily consumption of prepacked feta cheese marketed in the Greek Market.

3.3. Evaluation of the Nutritional Profile of Feta Cheese Products against Five NPMs

The 81 prepacked feta cheese products were evaluated against three threshold (I, II, and V) and two scoring (III and IV) nutrient profile models. The results of the evaluation are presented in Table 2.5

Table 2.5. Percentages of feta cheese products that met the respective criteria of five chosen nutrient profile models.

Nutrient Profile Models	(I)	(II)	(III)	(IV)	(V)
Results	% of Products passing or failing model's criteria				
Pass				100 *	5
Fail	100	100	100		84
Not Applicable					11

* The score varied between 17 and 23 points.

The results showed that almost all products failed the criteria of models I, II and III. This can be attributed to the high levels of total fat, saturated fat and salt content. A very low

number of products (5%) that had a favorable combination of saturated fat and salt content was qualified against model V. Regarding the evaluation against model IV, all products (100%) were qualified based on the assumption that Ca content is 450 mg/100 g and the serving unit of 39 g. However, considering the expected variability in the Ca content among products and the serving unit among consumers, the qualification of a product to the latter model may also vary. For example, for Ca content ≤320 mg/100 g and a 39 g serving unit 0% of the products are qualified, while for the same Ca content and a 25 g serving unit, the percentage of qualified products increased to 30%. Thus, to evaluate the prepacked feta cheese products against model IV, further research is required on the variability of Ca content.

4. Discussion

The analysis of the nutritional content of prepacked feta cheese products in the greek market performed in the first part of the present study, showed that the average values are in agreement with previously reported nutrient content of feta cheese (Anifantakis, 1991). However, a significant variability in the nutrient content among the products was observed, which can be attributed to the differences in raw material (milk), production methods and conditions among feta cheese producers. Indeed, Pappas et al. [6] manufactured feta cheese by using five different salting methods and reported significant differences in both salt and fat content of the final products. McMahon et al. (McMahon et al., 2009) reported that the salt concentration in brine and the temperature of brining may significantly affect the moisture of feta and thus all nutrients content per 100 g. Moisture content may also be affected by the final pH of feta cheese as well as the ratio of goat's and sheep's milk used [McMahon et al., 2009; Mallatou et al., 1994). It needs to be noted that this is the first study providing quantitative data on the variability of nutrient content among feta cheese products available in the greek market.

In the second part of the present study, feta cheese consumption data were extracted from the HNNHS database and analyzed. The latter consists in an in-depth analysis which characterizes the variability in feta cheese consumption among greek consumers based on a very large sample (1232 consumers). The results from this analysis showed a high variability of the quantity of feta cheese consumed per capita per day. The estimated median daily consumption of 39 g is nevertheless in accordance with previously published consumption quantities for feta cheese. Specifically Manolopoulou et al. (Manolopoulou et al., 2003), reported that an average annual consumption per capita of this cheese in Greece is approximately 12 kg, which corresponds to a daily consumption of 32.8 g.

Since the available studies connecting nutritional characteristics of food products with contribution to diet and health are very limited (Kaur et al., 2016), the present study attempted to give an overview of the nutritional quality of feta PDO products present on the greek market with a focus on their differences and their contribution to the greek diet by combining feta consumption data from the greek population. The results showed that the estimated daily intake of basic nutrients by feta cheese consumption for a healthy adult varied significantly depending on the consumption quantity and the selection of the product from among these available on the market. The ranking of daily nutrient intake from prepacked feta cheese consumption, estimated as percentage of European RI, was (from higher to lower quantity): 1-saturated fat, 2-salt, 3-total fat, 4-protein, 5-energy, 6-carbohydrates, 7- sugars. Among them, intake of saturated fat and salt may exceed the RI with percentages up to 101.5% and 85% of RI, respectively. These results are supported by recent studies, reporting high salt intakes observed in Greece (Vasara et al., 2018; Magriplis et al., 2011). In particular, 50.4% of the adults in SING study (Vasara et al., 2018) had a daily salt intake which exceeded 10 g per day while WHO recommendations for salt intake limit is 5 g/day, and 23% of children in GRECO study (Magriplis et al., 2011)reached high percentages regarding daily salt intake. Given that greeks consume feta cheese almost on a daily basis, and that its consumption covers the largest part of total domestic consumption (ICAP, 2019), feta, may consequently have a significant contribution on saturated fat and salt intake on the greek population's diet, as this study showed. This is also supported by the study of Athanasatou et al. (Athanasatou et al., 2018) who reported that the main contributors to sodium intake in Greece are dairy products (including cheese, yogurt and milk), breads and snacks, in descending order.

The above results confirm the need for the development of strategies for reducing saturated fat and salt intake in Greece, including policy initiatives, industry interventions and improvement of food label information provided to consumers, regarding the nutritional content and healthiness of food. In the policy field, WHO has published a Guideline on salt reduction (WHO, 2012) and launched a public consultation on draft guidelines for intake of saturated fat and trans-fat. The objective of the latter guideline is the reduction of cardiovascular diseases in adults and children through recommendations about saturated fat and trans-fat intakes (WHO, 2019). Similarly, the European Union encompasses monitoring and evaluation actions as one of their important pillars in reducing salt intake (EC, 2012). To the best of our knowledge, the Hellenic Food Authority has also launched a strategic plan on the reduction on salt (Hellenic Food Authority, 2016). The data provided in the present study could be helpful for the development of such strategies.

Regarding the greek dairy industry, possible intervention strategies to reduce salt intake by feta cheese consumption may include nutritional reformulation such as the partial substitution of NaCl by KCl. Indeed, Katsiari et al. (Katsiari et al., 1997), reported that feta cheeses made with mixtures of NaCl/KCl exhibited no significant ($p > 0.05$) differences in compositional (moisture, fat, protein, salt), physicochemical (pH, aw), sensory (appearance, body and texture, flavor, overall quality) and textural (force and compression to fracture, hardness) properties in comparison with the control cheese. They also showed that the 1:1 NaCl/KCI mixture in the salting of feta cheese effectively brought its Na:K ratio in the final products close to 1 while reducing the sodium content by about 50%. Such a salt reduction can definitely support the use of the comparative nutrition claim “less salt”, which is already being used by industry in feta’s prepacked products, in a small percentage that manages to satisfy the claim’s criteria.

Regarding improvement of food label information provided to consumers, the study supports that the implementation of a selected nutrient profile scheme not only for products bearing NHC but also for products with other type of health-related label information and geographical indications (GI)’s, should be established and be mandatory either in European or national level as also suggested by other studies (Maschkowski et al., 2014). Nutrient profiling could serve as a tool for consumers in order to identify products with a high content of “negative” nutrients such as saturated fat and salt and make healthier choices. Nevertheless, attention is needed on too restrictive NPMs that could lead to exclusion or rejection of products with potentially beneficial effects on human diet, due to specific positive nutrients such as calcium, in dairy products, which may not be taken into account in the NPM. Indeed, Trichterborn et al. (Trichterborn et al., 2012) showed that too restrictive nutrient profile models could help reducing the intake of salt and saturated fat of dairy products but could also negatively impact the intake of calcium and vitamin D. The latter is confirmed by the results of the present study, which showed that feta cheese products could be qualified only against NPM’s which take into account the Ca content. Feta ‘s Ca content in addition, can evidently support the use of “source of calcium ” or “high in calcium” nutrition claims, but analysis is needed on a case-by-case basis.

PDO food products such as feta cheese, already highly appreciated by consumers, need to point out their historical and nutritional quality by complying with legislation and making accurate use of available tools. Future setting of nutrition claims and the possibility of a potential inclusion of minimum nutritional requirements in PDO specifications could possibly be examined. The results of the present study provide feta PDO cheese with useful data on these directions.

CHAPTER 3

Dietary Intake Assessment of Pre-Packed Graviera cheese in Greece and nutritional characterization Using the Nutri-Score Front of Pack Label Scheme

Evangelia Katsouri, Emmanuella Magriplis, Antonis Zampelas, Eleftherios H. Drosinos and George-John Nychas

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Abstract

Gravieras are 'gruyere' type hard cheeses with a variety of different products and the second highest consumption in Greece. In this study, we present a dietary intake assessment and a nutritional characterization of pre-packed graviera products sold in the greek market using Nutri- Score Front of Pack Label (FoPL). The nutrient contents of 92 pre-packed graviera products were combined with daily individual consumption data extracted from the Hellenic National Nutrition Health Survey (n = 93), attempting to evaluate the contribution of graviera's consumption to the greek diet. The analysis of nutrients' intake as a Reference Intake (RI) percentage ranked saturated fat first on the nutrients' intake list, with RI percentage ranging from 36.1 to 109.2% for the 95th percentile of consumption. The respective % RI for energy, total fat, carbohydrates, sugars, proteins and salt ranged from 12.7–20.7%, 21.6–50.4%, 0–3.1%, 0–6.1%, 37–57.1% and 6.3–42%. Nutri-Score classified 1% of the products to C—light orange class, 62% to D—orange and 37% to E—dark or- ange, while no products were classified to A—dark green or B—green classes. The comparison between the Nutri-Score classification and the nutrients' intake assessment, also separately conducted within the classes, showed a higher salt intake after the consumption of products classified as D— orange and E—dark orange

1. Introduction

According to the greek National Code of Foodstuffs, Beverages and Objects of Com- mon Use (commonly referred as the "Food Code"), hard and semi-hard cheeses are officially cheese products with a maximum moisture of 30–46% and a minimum fat content of 20–50% on a dry matter basis (IAPR, 2021). Hard and semi-hard cheeses' category presents a great variety of cheese products with different characteristics, tastes and nutritional values, many of which belong to greek Protected Designation of Origin (PDO) Products (EC, 1992), such as specific Gravieras, Kefalograviera, Ladotiri, San Mihali, Kaseri, Batzos, Sfella, and Formaella (EC, 1996; Hellenic Ministry of Rural Development, 2020). Among the above

cheese products, Graviera is the one with the highest consumption, possessing the second largest market share in the greek market after feta cheese (ICAP, 2019).

Greek graviera is the most abundant hard cheese type category, regarding the variety and the quantity of the products produced and marketed in Greece. Gravieras are hard cheeses with 38% maximum moisture content and 40% minimum fat content on a dry matter basis, manufactured either from sheep's, goat's, cow's or a mixture of these milk types, in various regions in Greece as PDO or non-PDO products. Specifically, most of the gravieras are commercialized with a geographical denomination—under the name of the region where it is produced (graviera of Crete, graviera of Naxos, graviera of Amfilochia, etc.), but only three of them are registered under the Protected Designation of Origin (PDO) EU scheme, including "Graviera Agrafon", "Graviera Kritis" and "Graviera Naxou" (Danezis et al., 2019; Vatavali et al., 2020). The composition and the sensory properties of the different graviera products may vary substantially depending on the milk type used and the cheese production conditions. Factors such as the animal breed, agro climatic conditions, season, type of feeding, time of milking, the flora of the local pasture, types of starter cultures used, as well as traditional cheese-making practices comprise sources of product variation Litopoulou-Tzanetaki and Tzanetakis, 2014; Morand-Fehr et al., 2007). Further- more, many gravieras in Greece are manufactured with the addition of various herbs, spices and other condiments, intentionally used to impart special flavor and color, improve presentation and attractiveness and/or as a source of health-promoting compounds for consumers (Hayaloglu and Farkye, 2011).

Despite the high consumption and market share of graviera cheese in Greece, very limited data are available regarding its nutritional composition and contribution to the individual daily nutrient intake for the greek population. However, it is well known that dietary intake assessments in nutrition research are crucial in order to correctly reveal the relation between consumption and health, promote consumers' healthier dietary choices and formulate effective health strategies. Healthy dietary choices have become a priority both for consumers and regulatory authorities. This is mainly due to the fact that the in- creasing trend of obesity and diet-related non-communicable diseases (NCDs), such as cardiovascular diseases, forms a major cause of premature mortality in Europe. Indeed, in the period 2010–2016, overweight and obesity rates on the continent increased by 2.9% and 2.5%, respectively (WHO, 2018). Furthermore, NCDs, which are indissolubly related to dietary risk factors, are also leading causes of mortality and disability globally (GBD 2017, 2018; GBD 2017, 2018). Therefore, curbing the adverse effects of unhealthy diet is a major challenge in developing public health strategies (Julia et al., 2018).

With regard to the fact that pre-packed foods increasingly comprise the majority of contemporary consumer's food supplies, food labels' nutrition declaration, which became mandatory under the Food Information to Consumers (FIC) Regulation (EC, 2011), constitutes a great tool providing information to consumers and reliable food nutrition data to scientists. In evidence, there is an increasing number of food labelling research studies dealing with nutritional characteristics assessments using food label data (Angelino et al., 2019; Katsouri et al., 2020; Dall' Asta et al., 2020). Regardless of its advantages, however, recent studies have shown that the classic textual information of nutrition labelling has a limited impact on consumers' dietary choices and is unlikely to lead to any meaningful result from a public policy perspective (Delhomme, 2020a). In reaction, governments and operators have been experimenting with more effective tools, such as front-of- pack labels (FoP labels or FoPLs) that convey information in a simplified and more salient manner (Delhomme, 2020b). FoPL has been identified by the Organization for Economic Co-operation and Development (OECD) as the most effective option of food labelling strategy to tackle obesity and provide strong incentives to the agroindustry to reformulate its products in order to improve their nutritional quality (Organization for Economic Co-operation and Development, 2019). Additionally, the Food and Nutrition Action Plan 2015–2020 of WHO recommends governments to implement FoPLs as part of a policy to address the growing global burden of diet-related NCDs (WHO, 2019). In accordance with the above potential use of FoPL schemes to help consumers making health-conscious food choices, the European Commission has recently announced that it seems appropriate to introduce a harmonized mandatory FoP nutrition labelling at EU-level, as part of its Farm to Fork Strategy (EC, 2020). However, there is still great concern regarding whether an EU-wide nutritional labelling system with a broad food labelling mechanism including nutritional aspects is capable of reflecting the nutritional quality of foods in whole (Council of the European Union, 2020). At the same time, the application of FoPLs in greek pre-packed foods appears extremely limited and no FoPL has ever been adopted by the greek Authorities or industry.

Considering all the above, the aim of the present study was to perform an analysis of the nutritional characteristics and dietary intakes of pre-packed graviera cheese in Greece. The objectives of this study were: (a) to comparatively assess the nutritional content of pre-packed graviera products in Greece, (b) to attempt a combination of the nutritional content with consumption data of the greek population in order to conduct a dietary in- take assessment for graviera consumers and evaluate graviera's contribution to the greek diet and (c) to evaluate greek gravieras using Nutri-Score FoPL and discuss its potential use by the greek Authorities or industry.

2. Materials and Methods

2.1. Sampling, Labelling Data Collection and Nutritional Content Analysis of Pre-Packed Graviera Products

Sample selection was made after taking into consideration a sufficient geographical representation of the products and their markets, as well as all types of available greek gravieras' and brands' variety. The sample collection of pre-packed cheese products took place in supermarkets, discount and cash and carry chain stores of all major retailers in major greek cities as well as in online shops, from January 2020 until June 2020.

In total, 92 graviera pre-packed products were identified and collected, 16 of which carried a PDO Geographical Indication mark, including 14 Graviera Kritis PDO and 2 Graviera Naxou PDO products. Regarding non-PDO gravieras (76 products in total), 46 originated from the country's mainland (Thessaly, Amphilochia, Drama, Macedonia, Peloponnese), 21 from the island of Crete, 5 from the island of Lesvos-Mytilene and 3 from different islands of the Cyclades (Ios, Syros, Paros). Twenty-one of the total 92 products were manufactured with the addition of herbs, spices and other condiments.

All sampled products were purchased and photographed. Data from all the images of all the sides of the package were collected for all products. For each product, all labelling information was retrieved. A photo and labeling information database was created and used for statistical analysis. For each product, all nutrients available on the labeling nutrition declaration table, specifically: energy (kcal/100 g), protein (g), carbohydrates (g), total sugars (g), fat (g), saturated fat (g), and salt (g) per 100 g, were analyzed. Products without a nutritional declaration table were excluded from the analysis.

2.2. Statistical Analysis

The data on nutrient contents of graviera products and daily individual consumption extracted from the Hellenic National Nutrition and Health Survey were analyzed using the descriptive statistics option of Microsoft Excel 2003 (Microsoft Corp. Redmond, WA, USA). The 5th, 50th and 95th percentiles were calculated and used to assess the nutrient intakes, which were presented as cumulative distributions or boxplots graphs.

2.3. Nutrients Intake Assessment by Graviera Consumption

Individual daily nutrient intakes of healthy adult graviera consumers in Greece were calculated by combining the nutrient contents of the sampled products with graviera cheese consumption data obtained from the Hellenic National Nutrition and Health Survey (HNNHS) database (Magriplis et al., 2019). According to the HNNHS database, 93 adults (43% males) had reported graviera cheese consumption in at least one of the two 24 h recalls conducted. Details on 24 h recall methods have been previously described (Magriplis et al.,

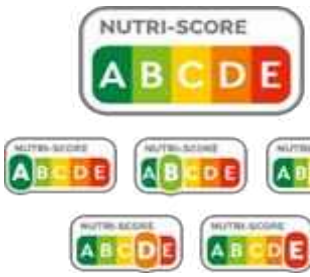
2019). The data of graviera's daily individual consumption were combined with the data of the basic nutrient concentrations of the pre-packed graviera cheese products so as to provide an overall assessment of graviera cheese contribution to the intake of nutrients. As a way to portray variability, the intake of nutrients by the consumption of graviera cheese was calculated using the 5th, 50th and 95th percentiles of both the individual daily consumption and the nutrient content of the 92 tested products. To demonstrate the contribution of graviera cheese consumption to an adult's diet, the intake of nutrients was also expressed as a percentage of the European Daily Reference Intake (RI) values as set by the European Regulation (EU) 1169/2011 on the provision of food information to consumers (EC, 2011). The RI values used were: 2000 kcal, 70 g, 20 g, 260 g, 90 g, 50 g and 6 g for energy, total fat, saturated fat, carbohydrates, sugars, proteins and salt, respectively.

2.4. Evaluation of the Nutritional Content of Graviera Products Using the Nutri-Score FoP Label Scheme

The 92 pre-packed graviera products were classified based on their nutritional profile using the Nutri-Score FoP label scheme (Julia and Hercberg, 2017). A detailed description of the selected FoPL system and its graphical format is presented in Table 1.

Nutri-Score is a color-coded label that provides a summary interpretive indication of the nutritional quality of the food. Based on the content of the product per 100 g, its underlying nutrient profiling system includes both unfavorable-negative nutrients (energy, saturated fat, sugars, and sodium) and favorable-positive elements (fiber, protein, and percentage of fruit, vegetables, legumes, nuts, rapeseed, walnut and olive oil) to yield a summary score (ranging between −15 and 40). The score is finally calculated as the difference (N−P) between negative total (N) and positive total (P) points, and represented in a five-class color-coded scale (with each class expressed by a color and a letter). Products with higher nutritional quality are rated as A (dark green), and products with lower nutritional quality are rated as E (dark orange). The underlying algorithm for Nutri-Score was adapted from the 2005 Food Standards Agency nutrient profiling system (Food Standards Agency, 2020). Regarding calcium content, according to Nutri-Score's modified criteria for cheeses, the protein content is counted. This ensures that their relative calcium content is accounted for, although calcium is not one of the nutrients subject to mandatory declaration (Sante Publique France, 2015).

Table 3.1. Presentation of the Nutri-Score Front of Pack (FoP) label scheme parameters.

Nutri-Score parameters	
categories	solid foods / beverages
sub-categories	cheeses / fats, oils
type	summary-interpretative -colour coded- 5 classes scaled from A to E (from healthy to unhealthy)
calculation approach	scoring algorithm
reference quantity	100g/100ml
unfavorable elements	energy, saturated fat, sugars, sodium
favorable elements	fiber, protein, fruit, vegetables, legumes, nuts, rapeseed oil, walnut oil, olive oil
purpose of current use	FoPL (non mandatory)
developer	Public
countries adopted Nutri-Score	FR, BE, GE, ES, DE, NL, LU
logo	

FR: France, BE: Belgium, GE: Germany, ES: Spain, DE: Denmark, NL: Netherlands, LU: Luxembourg.

The classification of pre-packed graviera cheese products against Nutri-Score was based on their nutrient contents recorded from labels' nutrition declaration tables. Nutri-Score estimations were made using the model's calculation criteria and supportively con- firmed randomly through the Open Food Facts project database, which is an international collaborative web project based on a wiki-like interface gathering food composition data based on the available back-of-pack labelling of products (Open Food Facts World, 2020). As suggested by other studies (Szabo de Edelenyi, 2019), the ability of the FoPL to discriminate the nutritional quality of foods is based on the number of available color classes within a group of foods. The more color classes avail- able among the products of a food group-subgroup, the better the discriminating ability of Nutri-Score FoPL was considered.

3. Results

3.1. Analysis of Nutritional Content of Graviera Products

In total, 92 products of pre-packed graviera cheese were identified in the major greek retail chains and online shops. According to their labeling information, all products were produced in approved dairy production establishments (Hellenic Agricultural Organization (ELGO-DEMETER), 2020), mainly in five wide regions throughout the country (West Greece and other mainland districts (49%) Crete (40%), North Aegean Islands and basically Lesvos-Mytilene (6%), and South Aegean Islands and basically Cyclades (5%)). Regarding PDO gravieras, Kritis PDO dominates the pre-packed gravieras market with a 16% percentage of abundance, Naxou PDO follows with 2%, while no pre-packed graviera Agrafon PDO products were found in the greek market (Figure 3.1).

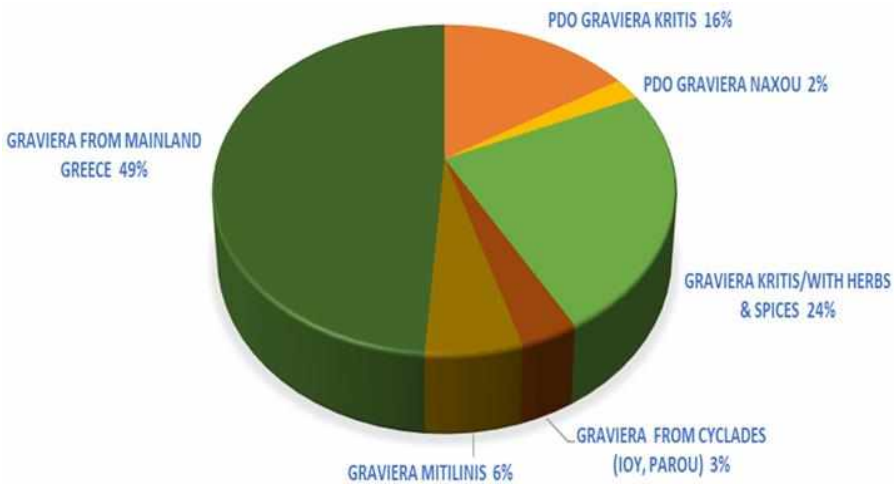


Figure 3.1. Pie-chart of the origin of all pre-packed gravieras' with or without a Protected Designa- tion of Origin (PDO) mark, as a percentage of the sum of the products tested in the Greek market.

From the total 92 pre-packed graviera products identified in the market, 83 had a full nutrition declaration on their labels. Two products had an incomplete nutrition declaration and seven products had no nutrition declaration on their labels. Table 3.2 presents the descriptive statistics of the nutritional content (energy, protein, carbohydrates, total sugars, fat, saturated fat, and salt per 100 g) of the products according to their nutrition declaration on the label

Table 3.2. Descriptive Statistics of nutrients' concentrations (per 100 g) of pre-packed graviera cheese products in the greek market.

	Energy (kJ)	***Energy (kcal)***	***Fat (g)***	***Saturated Fat (g)***	***Carbohydrates (g)***	***Sugars (g)***	***Protein (g)***	***Salt (g)***	***Calcium (mg)***

Mean	1620.7	389.4	30.8	20.9	1.2	0.5	26.2	1.9	648.9
Standard Error	13.9	3.4	0.4	0.3	0.2	0.1	0.2	0.1	63.5
Median	1610.0	388.0	31.0	21.0	0.6	0.2	25.9	2.0	600.0
Mode	1537.0	370.0	30.0	21.0	0.1	0.1	25.0	2.0	600.0
Standard Deviation	126.8	31.3	3.6	2.6	1.6	0.9	2.2	0.6	179.5
Kurtosis	2.1	2.0	3.2	5.1	10.1	31.3	2.1	0.0	0.1
Skewness	0.5	0.5	-0.2	-1.5	2.8	4.9	1.2	-0.6	0.4
Range	778.0	190.0	24.0	17.4	9.5	6.5	12.0	2.6	539.0
Minimum	1259.0	302.0	18.0	8.6	0.0	0.0	22.0	0.5	371.0
Maximum	2037.0	492.0	42.0	26.0	9.5	6.5	34.0	3.0	910.0
% CV	7.8	8.0	11.8	12.7	131.0	185.4	8.5	30.6	27.7
Count	83	85	85	84	84	83	84	84	8

%CV= (Standard Deviation/Mean) ∗ 100.

Overall, the results of the survey showed that the nutritional contents of pre-packed graviera cheese products vary significantly. Specifically, the estimated ranges per 100 g were—energy: 302–492 kcal, total fat: 18–42 g, saturated fat: 8.6–26.0 g, carbohydrates: 0–9.5 g, sugars: 0–6.5 g, proteins: 22–34 g and salt: 0.5–3.0 g. The coefficient of variation (%CV = (Standard Deviation/Mean) ∗ 100) for the different nutrients ranged from almost 8% for energy and protein to 185.4% for sugars. Calcium content ranged between 371 and 910 mg/per 100 g with a median of 600 mg/100 g. It needs to be noted, however, that due to the fact that calcium is not subject to mandatory declaration, only 8 out of 92 products with nutritional tables declared its content in their labelling.

3.2. Nutrients' Intake Assessment by Pre-Packed Graviera Consumption and Comparison with the Respective European RIs

Graviera cheese consumption data for 93 healthy adult greek consumers, from the HNNHS database (Magriplis et al., 2019), were extracted and analyzed. The descriptive statistics of the con- sumption are presented in Table 3.3.

Table 3.3. Descriptive Statistics of graviera cheese consumption data for adults 20–65 years old according to the Hellenic National Nutrition and Health Survey (HNNHS)

Graviera daily consumption (g)	
Mean	38.9
Standard Error	3.3
Median	39.0
Mode	39.0
Percentile 5	13.0
Percentile 50	39.0
Percentile 95	84.0
Standard Deviation	31.4
Sample Variance	983.9
Kurtosis	22.9
Asymmetry	3.9
Range	247.0
Minimum	5.0
Maximum	252.0
%CV	80.6
Count	93.0

The cumulative frequency chart of greek adults consuming graviera cheese (g) per capita and per day is presented in Figure 3.2.

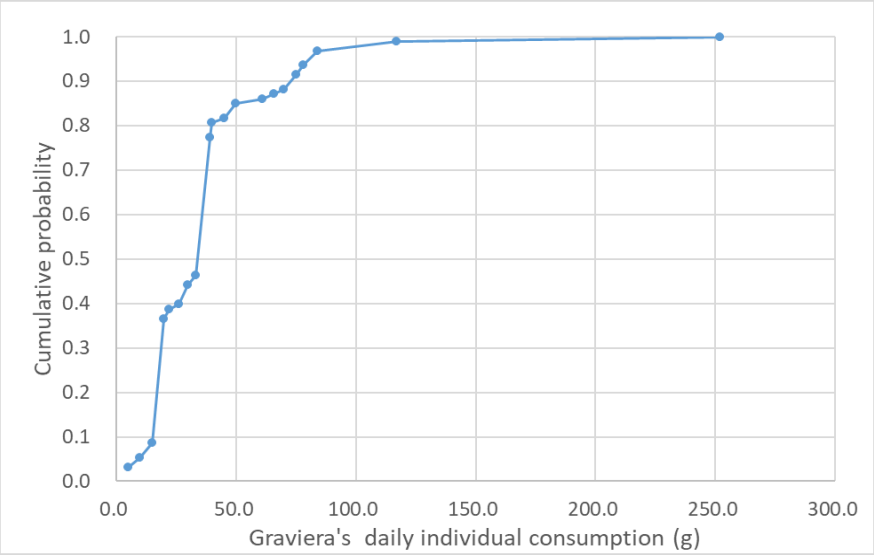


Figure 3.2. Cumulative frequency graph of greek adults' daily individual consumption of graviera (g) based on data of 93 healthy adult greek consumers extracted from the Hellenic National Nutrition and Health Survey (HNNHS) database.

The results from consumption analysis showed that the consumption of gravieras presents a significant variation—an average value of 38.9 g and a median value of 39.0 g, while consumption per capita and per day ranged from 5 g to 252 g. The estimated % CV was 80.6% and the 5th percentile and 95th percentile were 13 g and 84 g, respectively.

The data of graviera's daily individual consumption were combined with the data of the basic nutrient concentrations of the pre-packed graviera cheese products. In the dietary intake assessment, as a part of a nutrition risk analysis, taking into account variability of intake is of great importance (Food Standards Australia New Zealand, 2013). Thus, with a view to assess the variability of both daily consumption and nutrient content among the various products in the present study, the 5th, 50th and 95th percentiles were used. The output of the assessment gives a detailed overview of the variability in the nutrient intake of pre-packed graviera cheese consumers in Greece, which derives from the differences in nutritional content among products sold in the market and the daily consumption quantity among consumers. Denotative cumulative probability graphs of the saturated fat and salt intake per capita and per day of greek adults consuming graviera cheese marketed in the greek Market for the 5th, 50th and 95th percentiles of daily consumption are presented in Figures 3.3 and 3.4.

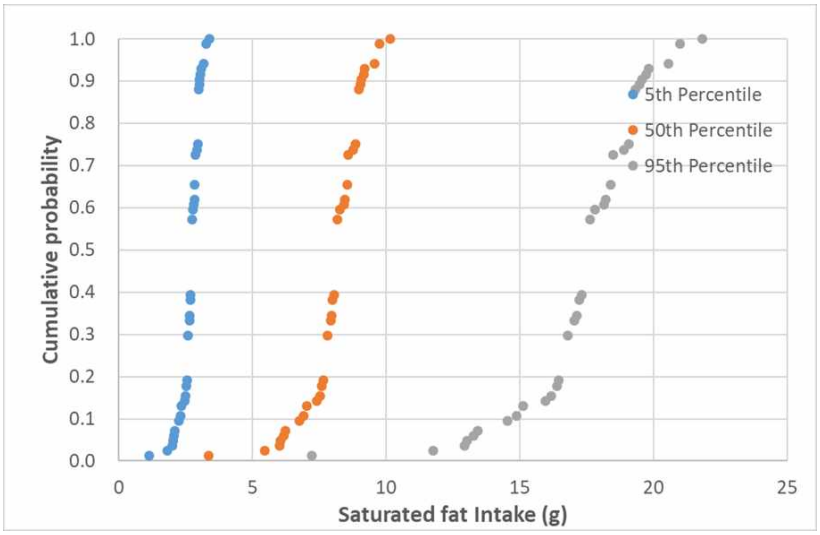


Figure 3.3. Cumulative probability of saturated fat (g) intake per capita and per day of greek adults consuming graviera cheese marketed in the greek market for the 5th, 50th and 95th percentiles of daily consumption

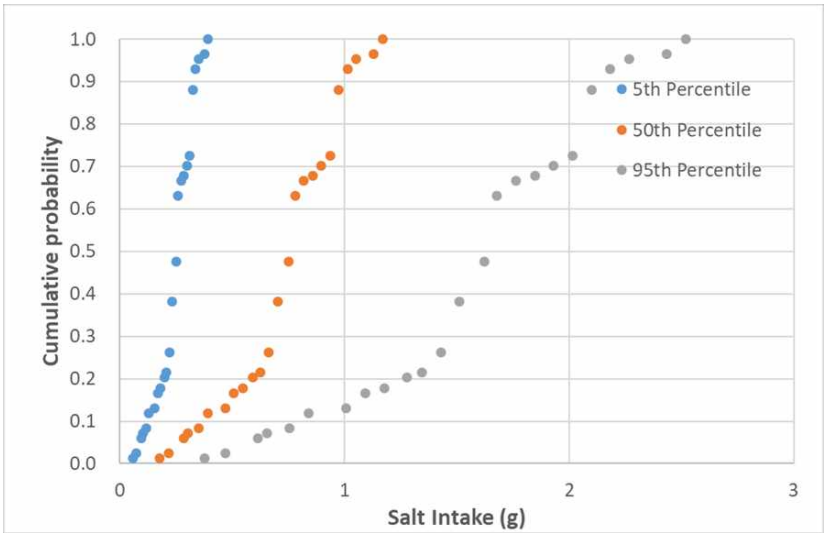


Figure 3.4. Cumulative probability of salt (g) intake per capita and per day of greek adults consuming graviera cheese marketed in the greek market for the 5th, 50th and 95th percentiles of daily consumption.

The intake of nutrients expressed as a percentage of the European Daily Reference Intake (RI) values is shown in Figures 3.5 and 3.6, presenting the boxplots of the daily nutrient intake as an RI percentage by graviera cheese consumption for the 50th and 95th percentiles of daily consumption quantity

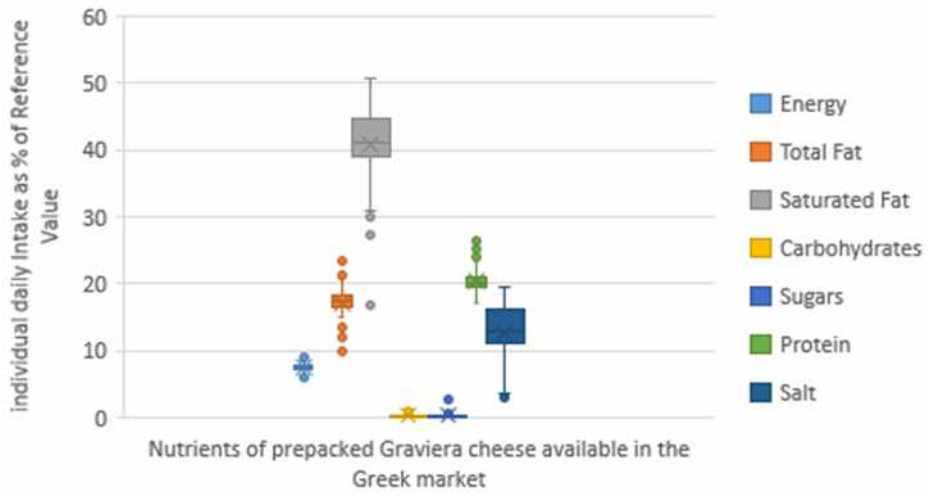


Figure 3.5. Daily intake per capita as a percentage of European Daily Reference Intakes (RIs) for the 50th percentile of the daily consumption of pre-packed graviera cheese marketed in the greek market

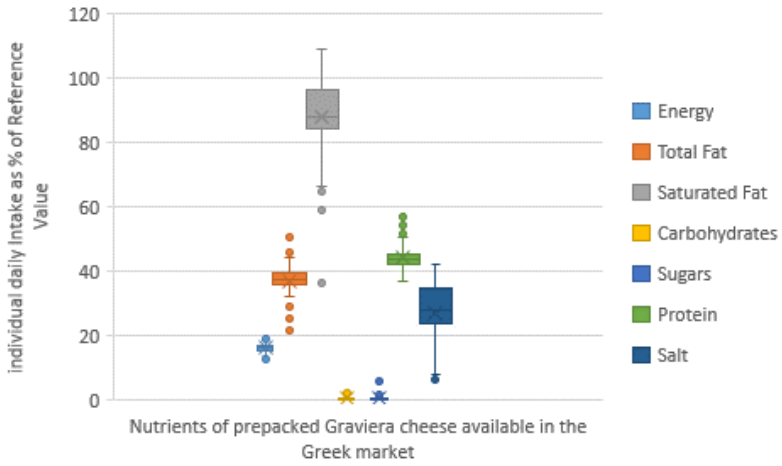


Figure 3.6. Daily intake per capita as a percentage of European Daily Reference Intakes (RIs) for the 95th percentile of the daily consumption of pre-packed graviera cheese marketed in the greek market.

For the 50th percentile of daily individual graviera consumption (corresponding to 39 g), the estimated ranges for energy, total fat, saturated fat, carbohydrates, sugars, proteins and salt were 5.9–9.6%, 10.0–23.4%, 16.8–50.7%, 0.0–1.4%, 0.0–2.8%, 17.2–26.5% and 2.9–19.5%, respectively. For the 95th percentile of daily individual graviera consumption (corresponding to 84 g), the %RI for energy, total fat, saturated fat, carbohydrates, sugars, proteins and salt were 12.7–20.7%, 21.6–50.4%, 36.1–109.2%, 0.0–3.1%, 0.0–6.1%, 37.0– 57.1% and 6.3–42.0%, respectively.

3.3. Nutrient Profile Evaluation Using Nutri-Score FoP Label Scheme

The 92 pre-packed graviera cheese products were evaluated against the Nutri-Score FoP label scheme. The distribution of graviera cheese products in the different Nutri-Score classes is shown in Table 3.4.

Table 3.4. Distribution of graviera cheese products in the different Nutri-Score classes

Nutri-Score **FoP classes**	**Nutri-Score** **FoP criteria points for Solid Food**	**Average scores in products tested**	**Range of scores in products tested**	**Classification according to estimated scores, and Percentage of products in each** **Nutri-Score FoP class**
A—dark green	-15 to -1			0%
B—green	0 to 2			0%
C—light orange	3 to10	10	10	1%
D—orange	11 to 18	16	12-18	62%
E—dark orange	19 to 40	19	19-21	37%

The results showed that 62% were classified in the D—orange class, 37% of the products were classified as E—dark orange, while only one product (1%) was classified as C— light orange, according to the Nutri-Score classification scale. None of the products were classified as A—dark green or B—green. Overall, three color classes of the Nutri-Score FoPL were found to be available among the products of graviera's group-subgroup of cheeses.

In order to evaluate the relation between the Nutri-Score output and the nutrients' intake, the daily intakes of graviera's nutrients were estimated separately for each group of products classified in the different Nutri-Score classes, for the 5th, 50th and 95th per-centiles of daily consumption (Table 3.5).

Table 3.5. Daily individual intakes of nutrients from the consumption of graviera cheese products classified in different Nutri-Score classes. Intakes are estimated based on the median values of nutrient contents for each class

Nutrient	**Nutri-Score Class**								
	C			**D**			**E**		
	Consumption Percentile								
	5th	**50th**	**95th**	**5th**	**50th**	**95th**	**5th**	**50th**	**95th**
	Daily Nutrient Intake (kcal or g)								
Energy (kcal)	51.5	154.4	332.6	50.6	151.9	327.2	50.1	150.2	323.4
Total Fat (g)	4.1	12.4	26.8	4.0	12.1	26.0	3.9	11.7	25.2
Saturated Fat (g)	2.8	8.3	17.8	2.7	8.2	17.6	2.7	8.0	17.2
Carbohydrate (g)	0.1	0.3	0.6	0.1	0.3	0.6	0.1	0.2	0.4

Sugars (g)	0.1	0.3	0.6	0.0	0.1	0.1	0.0	0.1	0.1
Protein (g)	3.4	10.3	22.1	3.3	10.0	21.6	3.5	10.5	22.7
Salt (g)	0.1	0.2	0.4	0.2	0.7	1.5	0.3	1.0	2.1

The above assessment showed significant differences in the salt intake among the Nutri-Score classes. For example, in the 95th percentile of daily consumption, the salt in- take was 0.4 g, 1.5 g and 2.1 g for cheeses classified as C, D and E, respectively. In contrast to salt, the differences in the daily intake of the rest of the nutrients were small among the Nutri-Score classes. The above conclusions can be seen more clearly in Figure 3.7, where the daily intakes for each Nutri-Score class are presented as percentages of the European Daily Reference Intake (RI) values as set by the European Regulation (EU) 1169/2011 for the 95th percentile of daily consumption.

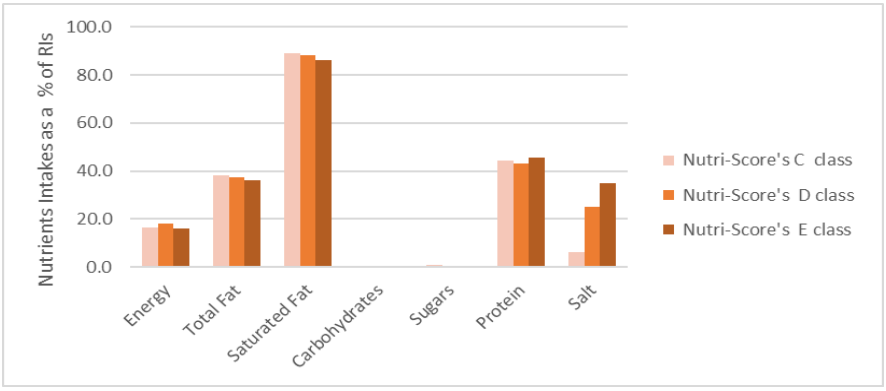


Figure 3.7. Daily individual nutrient intake as a percentage of European Daily Reference Intakes (RIs) for the 95th percentile of daily consumption of pre-packed graviera cheeses classified by Nutri-Score as C, D and E.

Indeed, as shown in the latter figure, while the intake of energy, fat, saturated fat, carbohydrates and protein does not present significant differences among the Nutri-Score classes, the salt intake increases from 6.3% of RI for class C to 35% of RI for class E.

4. Discussion

The nutrient content analysis of greek pre-packed graviera cheese products carried out in the first part of the present study showed a high variability in the nutrient concentrations among products available on the market. This can be ascribed to the differences in the raw material (milk), the predominant microflora of the dairy plants and the cheese- making practices (Vatavali et al., 2020). Despite the above variability, however, average values of nutrient concentrations recorded in the present study were in agreement with previously reported nutrient contents of hard cheeses (Popovic Vranjes et al., 2018).

In the second part of the study, the nutritional content of graviera cheese was combined with consumption data so as to evaluate the contribution of graviera to the greek diet. The results showed that the estimated daily intakes of basic nutrients from graviera consumption by a healthy adult can vary significantly, conditional on the consumption quantity and the nutrient content of the consumed product. Comparing the results of the different nutrients, the ranking of daily intakes from pre-packed graviera cheese consumption estimated as a percentage of European RI was (from higher to lower intake): 1—saturated fat, 2—protein, 3—total fat, 4—salt, 5—energy, 6—sugars, 7—carbohydrates. Among them, the highest intake was observed for saturated fat, which may exceed the RI, with percentages up to 109.2% of the RI. The latter indicated that graviera cheese is an important contributor to the saturated fat intake in the greek diet. This information, better explained in the next paragraph, is important in terms of nutrients' intake assessment and stays in line with the initial aims of this study.

Graviera and feta are the most highly consumed cheeses in Greece. A comparison of the nutrient intakes from the consumption of the two cheeses shows significant differences. In a previous study, Katsouri et al. (Katsouri et al. 2020) reported that for the 95th percentile of daily feta consumption, the %RI for energy, total fat, saturated fat, carbohydrates, sugars, proteins and salt were 11.0–17.2%, 28.5–41.4%, 64.0–101.5%, 0.0–1.2%, 0.0–3.3%, 26.2–42.0% and 20–85%, respectively. Although saturated fat presents the highest intake for both cheeses, graviera consumption results in much lower salt intake and higher protein intake compared to feta cheese. The above comparison indicates that health-associated events related to dairy consumption may differ among product types (Johansson et al., 2018) and stresses the need for nutrient intake analysis of foods as the basis for the development of strategies for nutrition and health. More studies like the present one for a wide range of food products would lead to the development of a complete nutritional database and support the identification and effective selection of strategies and interventions for improved health. Such strategies and interventions may include food reformulation, possible revision of national dietary guidelines, marketing restrictions, industry interventions, the improvement of food label information, and educational campaigns, and some are already in place in several countries of the EU or at EU-level (EU Science Hub, 2020).

In the last part of this study, the pre-packed graviera products sold in the greek market were classified using the Nutri-Score Front of Pack Label (FoPL) scheme. The selection of Nutri-Score FoPL was based on previous studies reporting a very good performance of the scheme regarding increasing consumers' awareness of food's nutritional quality, the perception of FoPL and encouraging healthier choices, in different countries and for various food products (Szabo de Edelenyi et al., 2019; Van Tongeren and Jansen, 2020; Egnell et al., 2018; Dréano-

Trécant et al., 2020). More in detail, Nutri-Score was found to perform best com- pared to other FoPLs—specifically the Health Star Rating system (HSR), Multiple Traffic Lights (MTL), Reference Intakes (RIs), SENS (supported by retailers) and Warning Symbol—as shown in one of the scarce comparative experimental studies (Szabo de Edelenyi et al., 2019; Julia et al., 2017). Additionally, Nutri-Score has already been adopted in several European countries (France, Belgium, Luxembourg, Netherlands, Denmark, Spain, Germany) as an appropriate tool to facilitate consumers' understanding of food's nutritional quality and advance healthier food choices, while several review articles have concluded that FoPLs, in general, are favorably perceived by consumers and can increase their awareness about the healthiness of various food products (Szabo de Edelenyi et al., 2019; Dréano-Trécant et al., 2020). The results of the present study confirmed the ability of Nutri-Score's FoPL to scan nutritional variability within a food category and identify nutritional quality (Szabo de Edelenyi et al., 2019; Egnell et al., 2018). The majority of graviera cheese products were classified to the D—orange and E—dark orange classes. The latter classification can be credited to the rel- atively high levels of saturated fat and salt in graviera cheese, which are evaluated as "negative" in Nutri-Score as well as in all other nutrient profile models due to their association with NCDs. Only one product was classified to the C—light orange class, mainly due to its low salt and high protein concentration (a "positive" factor in Nutri-Score), indicating that this product represents a healthier choice among other graviera cheeses. The analysis of the daily intakes of graviera's nutrients for each group of products classified in the different Nutri-Score classes confirmed the classification of Nutri-Score, especially in relation to the salt content. Indeed, salt was identified as the most important factor de termining the Nutri-Score classification of graviera cheese.

Apart from the advantages of Nutri-Score, though, the above results also impose some skepticism on a potential univocal characterization of the health status of cheeses by an FoPL. Based on the classification performed in the present study, traditional PDO dairy products, such as graviera cheese, which are important components of the European diet and a valuable source of nutrients for humans (Zheng et al., 2015), are classified by the Nutri-Score as "less healthy". The latter is not consistent with the (greek food-based Dietary Guidelines Food-Based Dietary guidelines-Greece, 2020), which suggest that "dairy products are basic food, encouraged to be consumed in up to 2 portions daily, preferably". Moreover, several studies report a null or inverse relationship between cardiovascular disease risk and mortality and dairy consumption, although there is no clear dose response relationship (Vivek et al., 2020). These concerns stress the need for further research in order to improve the applicability of nutritional tools such as the Nutri- Score. For example, the inclusion of the daily consumption–portion size and/or the con- tent of other nutrients, such as vitamins

D and B12 (for cheeses), could improve the ability of Nutri-Score to characterize the health status of dairy products, including PDO cheeses.

In conclusion, this study follows the concept of dietary exposure assessment as a part of a scientific risk assessment process to support decision-making in the development of nutritional and health mitigation strategies (Food Standards Australia New Zealand, 2020). In the nutritional field, it is generally accepted that food is recognized as having both beneficial and adverse effects on health. Nutrition declaration tables are definitely considered to be an important tool for the presentation and evaluation of food's nutritional value. However, other complementary schemes and methodologies, such as nutritional FoPL, Nutrient Profile Models and schemes, nutrients' intake assessments, the nutrient density concept (Lockyer et al., 2020) and even the concept of integrated risk-benefit assessments (Boué et al., 2015), should be further applied in conjunction with regulatory guidance (Jones et al., 2019) to ensure the promotion of genuinely healthier choices for consumers (Townsend, 2010).

CHAPTER 4

Labelling Assessment of greek “Quality Label” prepacked cheeses as the basis for a Branded Food Composition Database

Evangelia Katsouri, Antonios Zampelas, Eleftherios H. Drosinos and George-John E. Nychas

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Abstract

A labelling assessment study of greek prepacked “quality label” cheeses was conducted with a view to provide an overview of the whole category. In total, 158 prepacked products belonging to 19 “quality label” cheeses were identified in the greek market. Among them, Feta had the highest share followed by Kasseri, Graviera Kritis, Kefalograviera and Ladotyri Mitilinis with 81, 16, 15, 11 and 9 products found in the market, respectively. For the rest of the 14 cheeses, the share was limited, ranging from 1 to 4. All labelling indications, nutritional information, claims and other labelling data were recorded and analyzed in relation to their compliance against European food law requirements. The results of the analysis showed that for only 6 of the 19 cheeses, all products fully complied with EU labelling legislation. Among the 14 mandatory labelling requirements, the lowest overall compliance was observed for allergens declaration (65%). The analysis of the nutritional data showed a remarkable variability between cheeses and products. Differences in the nutritional characteristics were more pronounced among soft, semi-hard, hard and whey cheese. The above data were entered into an archival database. Application of global harmonization and standardization guidelines and tools lead to the initialization of a branded food composition database (BFCD), conceptualizing a specialized database for “quality label” foods.

1. Introduction

Labelling laws for food and drink in Europe can be traced back to the Middle Ages (5th–14th centuries) as food marking was adopted to deliver food identity and basic properties information of the food (Food and Agriculture Organization of the United Nations FAO, 2016). Over time, however, under the industrialization of food production, the domination of the retail market by packaged foods and the need for global free movement of foodstuffs, food labels evolved from simple product identity labels to complex information labels that include the food’s generic basis, nutritional composition, ingredients list, production and packaging methods, reflecting the constantly changing labelling regulatory framework, as

well as the competitive global food-marketing environment. Currently, food labels constitute a multifunctional communication and marketing tool (Martini and Menozzi, 2021) delivering basic information to consumers but also intended to build an interaction between authorities, the food industry and consumers, to raise awareness on food, as well as to manage difficult public health objectives and assure the accomplishment of high marketing goals. In particular, food labels in Europe began taking their present form, with Directive 2000/13 EC (EC, 2000), on purpose to enact Community rules of a general nature with detailed labelling, applicable horizontally to all foodstuffs put on the market, and are currently governed by Food Information to Consumers (FIC) Regulation (EC)1169/2011 (EC, 2011).

In practice, FIC Regulation's, labelling requirements are complemented by a number of mandatory provisions applicable to all foods, such as generic and identity information food and category name, production and packaging information, ingredients list, allergens declaration, nutritional composition either with the basic or an extended interface, date marking, etc. in order to ensure consumers' protection. In order to help consumers suffering from allergies identify allergenic foods, allergens as ingredients have been regulated in the EU since 2003 but in view of scientific developments became an obligation under article 21 of FIC Regulation (European Food Safety Authority (EFSA), 2004). Moreover, voluntary information according to FIC or other legislative acts and policies (EC, 2006; EC, 2012) are also provided by the food labels. Under this context, FIC Regulation determined interpretive front-of-pack nutrition labels (FoP) schemes as a voluntary additional form of providing information in an easy-to-use way and facilitating informed consumers' food choices (Santos et al., 2020). Voluntary information may also include claims, specifications, schemes or marks, additional information about taste, history, origin, production methods, sustainability and quality parameters. All previous information promotes health, quality, environmental and economic goals and reduces information asymmetry between the food industry and consumers, through guiding their choices, towards quality diets and more sustainable food systems, as shown by various studies (Miller et al., 2015; Asioli et al., 2020).

The EU quality labels, introduced with Regulation (EU) No 1151/2012 constitute a paradigm of such multifunctional food labels engaging with several of the previous parameters (EC, 2012). "Quality labels" include products either having a specific link to the place of manufacture and committed to satisfying certain conditions of production or products highlighting traditional aspects of production or composition, without being linked to a specific geographical area. "Quality label" products are granted either with a "geographical indication" (GI) mark, a Traditional Specialty Indication (TSG) mark or others, such as Mountain product's, or EU's outermost regions' mark. They are also obliged, after passing

through a specific legal procedure of approval (EC, 2014), to be listed in certain quality product registers like E-Ambrosia and GI view (eAmbrosia (europa.eu)). The European Commission (EC), as part of its policy on food quality (EC, 2021), has adopted the scheme of quality labels, with a view to encourage diverse agricultural production, protect product names from misuse and imitation and help consumers in their decision-making (Quality schemes explained | European Commission (europa.eu); Grunert and Aachmann, 2016).

Geographical Indication (GIs), for foods and wine, listed in the EU geographical indications register e-Ambrosia (Official EU Database for food and agricultural products, wine, spirits and aromatized wine (eAmbrosia (europa.eu)), is the most abundant category of quality labels, and comprises the following schemes.

• Protected Designation of Origin (PDO): includes agricultural products and foodstuffs (food and wine) produced, processed and prepared in a given geographical area, having the strongest link with the place of manufacturing, using recognized know-how.

• Protected Geographical Indication (PGI): includes agricultural products and foodstuffs (food and wine) closely linked to the geographical area, with one at least of the stages of production, processing or preparation taking place in the area, emphasizing the relationship between the specific geographic region and the name of the product.

Their related indication marks are shown in Figure 4.1:

Figure 4.1. Geographical Indication (GI) marks: Protected Designation of Origin (PDO) mark and Protected Geographical Indication (PGI) mark

Furthermore, these constantly evolving multifunctional food labels seem to interact in many and various ways with science, economy, consumers, academia, industry and policymakers utilizing new technologies and reflecting constant skepticism about food. Branded Food Composition Databases (BFCDs) belong in the field of food labelling interaction with nutrition science (Kapsokefalou et al., 2019). BFCDs, form an evolution of food composition tables and Food Composition Databases (FCDs), adapted to processed foods with multifunctional labels. BFCDs serve the augmented need for using nutritional and other label data for diverse governmental and non-governmental activities: such as research,

assessment of national health status, new product development, agricultural and food policy actions like reformulation, advertising and labelling (Kretser et al., 2017 Katidi et al., 2021).

Cheeses is the food category with the third higher share in quality labels of Greece (23 records of total 116 records, 19%). Fruits, vegetables and cereals category (49 records, 43%) stand in the first place and oils and fats category 3 records, 28%) in the second place. Figure 4.2 shows the distribution of greek quality foods registered on EU geographical indications register e-Ambrosia (eAmbrosia (europa.eu)).

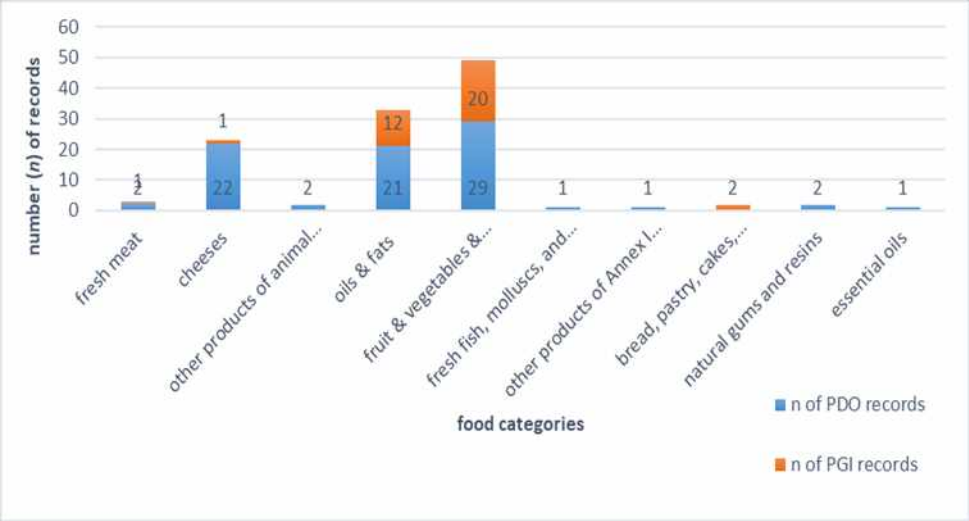


Figure 4.2. Number of records per food category, for Greece on e-Ambrosia, the EU geographical indications food register. PDO: Protected Designation of Origin, PGI: Protected Geographical Indication (PGI) mark.

Moreover, Greece is the fifth EU country in a quality label foods ranking represented by 116 food records in the European GI's register e-Ambrosia (assessed on 20 May 2021), while Italy possesses first place with 339 food records.

Finally, cheeses comprise one of the most abundant food categories of processed food, with great variability and great importance for the domestic economy.

Based on the above, the main objective of the present study was to conduct a Labelling Assessment of prepacked greek "quality" cheeses in order to screen their labelling status and compliance to EU legislation and explore potential problems on their labels. A second objective was to provide a nutritional syllabus for greek cheeses utilizing their nutrition declaration tables. Pilot application of a specific data structure as well as the use of standardized guidelines and tools for labelling data, during the study's progress, allowed the creation of an archival database and the conceptualization of its further development to a branded food composition database (BFCD) for "quality label" foods.

2. Materials and Methods

2.1. Food Category Selection and Description

The present study is focused on prepacked greek quality cheeses. Overall 23 greek quality label cheeses are registered in e-Ambrosia Official EU Database for food and agricultural products, wine, spirits and aromatised wine (eAmbrosia (europa.eu)), including: Feta PDO (Fe), Kalathaki Limnou PDO (KL), Galotyri PDO (Ga), Katiki Domokou PDO (KD), Kopanisti PDO (Ko), Anevato PDO (An), Pichtogalo Chanion PDO (PC), Xigalo Siteias PDO (XS), Graviera Kritis PDO (GK), Graviera Naxou PDO (GN), Graviera Agrafon PDO (GA), Arseniko PDO (Ar), Kefalograviera PDO (Ke), Ladotyri Mytilinis PDO (LM), Metsovone PDO (Me), Batzos PDO (Ba), Krasotyri of Ko PGI (KK) Kasseri PDO (Ka), Sfela PDO (Sf), San Mihali PDO (SM), Formaella Arachovas Parnassou PDO (FAP), Manouri PDO (Ma), Xinomizithra Kritis PDO (XK). All cheeses belong to four different cheese categories (soft, hard, semi-hard and whey cheeses) based on their firmness according to the national Code of Foodstuffs, Beverages and Objects of Common Use (commonly referred to as the "Food Code" (greek Code of Foodstuffs, Beverages and Objects of Common Use "Food and Drinks Code", 1987). Abbreviations in the parenthesis above are used throughout the study instead of the full names of the cheeses. PDO mark is the dominant between Geographical Indications of greek Quality label cheeses. Of the 23 cheeses, 22 are granted the PDO mark while only one cheese—the recently qualified Krasotyri of Ko—is granted the PGI mark.

2.2. Data Source (Products' Sampling)

Original data for the analysis were sourced from all the available selected commercial prepacked "quality" cheese products' labels and packages. Sampling was conducted from both physical retail stores and internet spots (corporate websites, online supermarkets and shops). To enhance sufficient representativeness, physical product sampling took place from stores of all major retailers of three cities in Greece (Athens, Thessaloniki, Larisa). All sampled products from physical stores were purchased and photographed through smartphones, whereas for the e-products all available information was extracted through relevant websites and saved. All photographs constituted a photo library.

The product sampling procedure took place from July 2018 until December 2020. Data from previous studies of our research team (Katsouri et al., 2020; Katsouri et al., 2021) were also used for the labelling assessment.

2.3. Data Collection, Data Structure Data Check and Missing Data

All information and on-pack communication of all sides for each product's package were recorded as data in physical records (photographs and electronic files). Excel sheets including all product data and metadata were created.

During data collection, a methodology was designed in order to structure the labelling information into categories for easier recording and analyzing of data in time. In this regard, data collection and data structuring were conducted considering the approach of International Network for Food and Obesity/NCD Research, Monitoring and Action Support (INFORMAS) recommendations and Food Labelling Protocol Rayner and Vandevijvere,2017; Rayner et al., 2013) and EuroFIR AISBL SOPs Technical Manual Version 2019–01 (EuroFIR, 2019). In order to incorporate all mandatory and voluntary information as enforced by European Legislation and existing in current food labels, an analogous procedure was formed. This procedure is shown schematically in Figure 4.3 and is described in detail further on.

First of all, a product single identity number (ID) was created. For each ID, the product's respective information was reported in an excel sheet. In particular, this sheet contained the products' sampling information (country, place, market, date of sampling, etc.), identity information, (brand name, name in own language English food name, barcode, QR code,) and packaging information (package type, packaging material, quantity-weight). In addition, the identification and description of each cheese (code and names of food category, subcategory, group, etc.) using FoodEx2, Exposure Hierarchy version Matrix 9.0 dated 26 January 2018 (downloaded 7 February 2018) (European Food Safety Authority, 2015) was attempted.

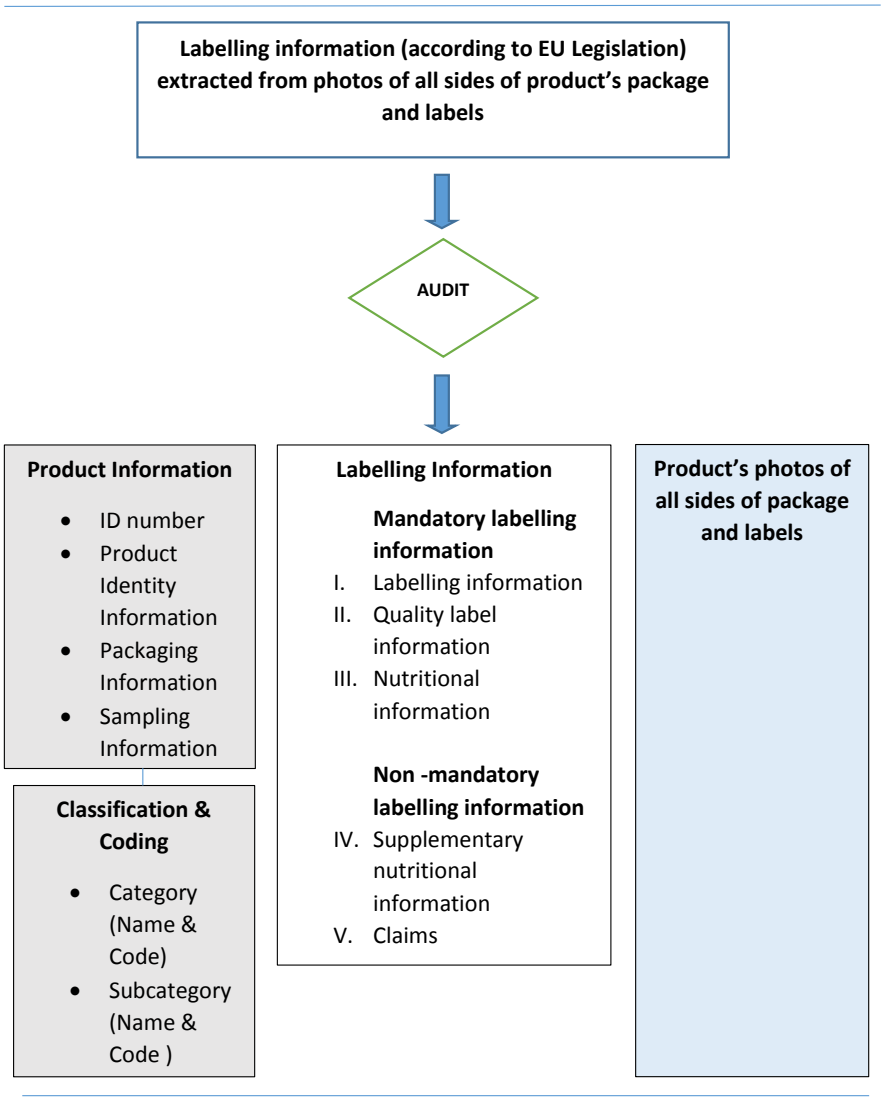


Figure 4.3. Flow-diagram presenting methodology for label data collection and structure.

First of all, a product single identity number (ID) was created. For each ID, the product's respective information was reported in an excel sheet. In particular, this sheet contained the products' sampling information (country, place, market, date of sampling, etc.), identity information, (brand name, name in own language English food name, barcode, QR code,) and packaging information (package type, packaging material, quantity-weight). In addition, the identification and description of each cheese (code and names of food category, subcategory, group, etc.) using FoodEx2, Exposure Hierarchy version Matrix 9.0 dated 26 January 2018 (downloaded 7 February 2018) (European Food Safety Authority, 2015) was attempted.

FoodEx2 is a standardised food classification and description system developed by EFSA to better describe the characteristics of foods and dietary supplements in exposure assessment

studies; this system, the revised version 2, consists of flexible combinations of classifications and descriptions based on a hierarchical system for different food safety-related purposes (i.e., food consumption, chemical contaminants, pesticide residues, zoonoses and food composition). FoodEx2 system consists of 21 clearly defined food groups. Detailed food groups represent the basis of the systems; a food only fits in one group and a parent–child structure is present within the food groups. Facet descriptors, of which there are 28 in total, can be viewed as characteristics of foods from different points of view; the facets give additional information for a particular aspect of food, that is, part nature, ingredient, packaging material, production method, qualitative information, process, target consumer.

Whereupon all labelling information of each selected product was systematically arranged, per product ID number and information category. At the same time, an evaluation of compliance against EU labelling legislation mandatory requirements under the legislation was conducted. Specifically, EU Food Labelling Information System (FLIS) IT Tool for the category of cheeses (EU Food Labelling Information System (FLIS), 2021) entailing (Reg (EU) 1169/2011(FIC) (EC, 2011) and Reg (EC) 854/2005 (EC, 2004) requirements, as well as European/national Legislation for GI's (EC, 2012; greek Code of Foodstuffs, Beverages and Objects of Common Use "Food and Drinks Code", 1987) and non-mandatory requirements under Reg (EU)1924/2006 (NHCR) (EC, 2006), were used. Indications required according to the EU labelling legislation and not presented on the labels (omissions or mistakes) were recorded as missing values and considered non-compliances to legislation. On the other hand, specific indications that were not obvious on corporate sites labels were considered present for the respective indication's assessment.

In detail, all label information was firstly distinguished on mandatory and non-mandatory (voluntary) information and afterwards in further categories within the first two.

Mandatory labelling information contains:

Labelling information. This category includes: all indications required in product's label, evaluated according to Reg (EU) 1169/2011 (FIC), art.9, mandatory requirements and are presented also to EU Food Labelling Information System (FLIS) IT Tool for the category of cheeses (EU Food Labelling Information System (FLIS, 2021)). Specifically, indications required for cheeses are: food name, list of ingredients, allergens declaration, quantitative ingredient declaration QUID, net quantity, date of minimum durability, storage conditions/conditions of use, food business operator's name and address, country of origin/place of provenance, instructions for use, nutritional declaration, lot indication, declaration of term "milk", declaration of the animal species from the milk originates.

“Quality label” information. This category includes: all data related to European “quality label” requirements according to the GI legislation, (quality mark, GI name, production establishment’s address) and national legislation mandatory requirements (category, type of milk, pasteurized or row, % min fat in dry matter and % max moisture (w/w), production date, packaging date, national authority’s mark with relative approval number) as well as production’s establishment’s location with production’s establishment’s approval code according to Reg (EC) 854/2005 (EC, 2004).

Nutritional information. This category includes: all mandatory nutritional information required and presented in the nutrition declaration table presenting food’s composition data per 100 g/mL edible portion. According to FIC Regulation, nutrition declaration table must present at minimum: energy (kJ-kcal/100 g), fat (g), saturated fat (g), carbohydrates (g), sugars (g) protein (g) and salt (g) per 100 g, in this specific order. Sometimes calculations were needed for salt estimation whenever declared as sodium, by mistake. In addition, nutrition declaration is possible to be completed by the declaration of one or more from the following components: monounsaturated, polyunsaturated, polyols, starch, fibre, vitamins and/or minerals mentioned at the Annex XIII of the FIC Regulation, components which are possible to be checked and recorded (detailed-extended nutrition declaration). Whenever information about a specific nutrient was not declared, it was recorded as missing value and non-compliance to legislation. Following the EU labelling legislation, nutrients labelled as “trace” were recorded as 0 g/100 g. Similarly, nutrient content expressed as, for example, <0.3 g, was recorded as 0.3 g.

Non-mandatory labelling information contains:

(IV) Non-mandatory supplementary nutritional information. This category includes: non-mandatory nutritional indications such as front or back of pack labelling schemes (FoPs or BoPs), information per portion (portion-size, number of portion), Reference Intake (RI) percentage on the nutrition declaration table. Thus, this category’s information is not mandatory, presence of information was recorded and evaluated. Metadata regarding FoPs, portion size were also derived and recorded.

(V) Claims, Information This category includes all claims, statements, images or any type of on-pack communication on the product. The Reg (EU) 1924/2006 (NHCR) (EC, 2006) and INFORMAS protocol and taxonomy (Rayner and Vandevijvere, 2017; Rayner et al.,2013) were used for the classification of different types of claims and their presentation. According to the INFORMAS taxonomy, claims are divided into three major categories: (i) nutrition claims, (ii) health claims-compatible also to EU regulation and (iii) other claims, in which health-related claims, for example, suitable for vegans, halal, gluten-free and environment-

related claims, origin and more, were included. “Organic” certification was included also in other claims. In the context of Labelling Assessment, all nutrition or/and health claims, and their conditions of use were checked according NHCR Regulation and the “Guidance on the implementation of Regulation No 1924/2006 nutrition and health claims on foods” (EC, 2021) and recorded.

An Annex of the mandatory and non-mandatory labelling indications for cheeses, linked to respective Legislation, as structured data categories, is presented in Table 4.1.

Table 4.1. Annex of labelling indications–data categories’ structure, used for label data collection accompanied with relative EU legislation.

ANNEX			
	Label	**Labelling Indication/Data**	**EU Legislation**
Mandatory information	**I. Labelling information**	Food name	Reg. 1169/2011
		Ingredient list	Reg. 1169/2011
		Ingredients (extensively)	Reg. 1169/2011
		Allergen declaration	Reg. 1169/2011
		Quantitative ingredient declaration (QUID)	Reg. 1169/2011
		QUID list	Reg. 1169/2011
		Net quantity	Reg. 1169/2011
		Date of minimum durability	Reg. 1169/2011
		Durability date type	Reg. 1169/2011
		Durability date time	Reg. 1169/2011
		Storage conditions/conditions of use	Reg. 1169/2011
		Food business operator’s name and address	Reg. 1169/2011
		Country of origin or place of provenance	Reg. 1169/2011
		Instructions for use	Reg. 1169/2011
		Nutrition declaration table presence	Reg. 1169/2011
		Lot indication	Reg. 1308/2013
		Use of term “milk”	Reg. 1308/2013
		Animal species from which the milk originates	Reg. 1308/2013
	II. Quality label information	Type of milk	National Code, art.83, general requirements
		% min fat on dry matter	National Code, art.83, general requirements
		% max humidity *w/w*	National Code, art.83, general requirements
		Production date	National Code, art.83, general requirements
		Packaging date	National Code, art.83, general requirements
		Packaging identification number	National Code, art.83, general requirements
		Quality label mark	National Code, art.83, Traditional cheeses

		Food name as registered	National Code, art.83, Traditional cheeses
		Production establishment's address	National Code, art.83, Traditional cheeses
		National authority's approval number and mark	National Code, art.83, Traditional cheeses
		Production establishment's approval code number	Reg. 854/2004
	III. Nutritional information	Energy/Energy unit Protein/Protein unit Total fat/Total fat unit Saturated fat/Saturated fat unit Trans fat/Trans fat unit Carbohydrates/Carbohydrates unit Sugar/Sugar unit Fibre/Fibre unit Salt/Salt unit (insert extra row for each extra nutrient if any)	Reg. 1169/2011
		Nutrition declaration mandatory particulars	Reg. 1169/2011
Non-mandatory information	**IV. Nutritional supplementary information**	Portion particulars	Reg. 1169/2011
		Portion size	Reg. 1169/2011
		RI's particulars	Reg. 1169/2011
		Front of Pack Label schemes (FoPs)	Reg. 1169/2011
		Type of FoP	Reg. 1169/2011
	V. Claims information	Type of claim for each claim	Reg. 1924/2006 - INFORMAS taxonomy
		Wording of claim for each claim	Reg. 1924/2006
		Placement of claim for each claim	Reg. 1924/2006
		Format of claim for each claim	
		Total number of claims for each product	
		Nutrition claims' total number	
		Health claims' total number	
		Other claims' total number	
		Other marks-symbols type	

The above structure provides the methodology for collecting label data, adapted to EU labels, and linked to relative EU legislation.

During data collection, a researcher specialized in auditing implementation of EU Legislation recorded in Excel sheets checked all data, initializing an archival database. Afterwards, all entries were cross-checked against the original source through the photo library.

2.4. Labelling Data Assessment

Structured data derived by arranging all label data from all products, according to Table 4.1, were considered as variables for the Labelling Assessment. In detail, we evaluated the compliance/presence of all mandatory and non-mandatory indications, respectively. The

level of compliance for mandatory indications was evaluated through auditing original label data for each product and each indication against respective legislation. Absence of indications was considered non-compliance. A percentage of compliance was estimated per each indication for all products of each PDO cheese. Furthermore, an overall percentage of compliance was estimated per each indication, for all products in total.

Non-mandatory indications were evaluated in a quite similar way, by auditing the type and status of indications present on original data against respective legislation requirements, if any, and/or respective guidance documents. Regarding nutritional declaration tables, a percentage of compliance was similarly estimated for each and all cheeses. Descriptive statistics were performed for each cheese's nutrients' dataset, derived from all cheese products. An overview of the nutritional characteristics of each and all available PDO cheeses was provided. All statistical analysis were conducted with Excel MS Office 2010.

Table 4.2. Percentage (%) of compliance for each mandatory labelling indication according to FIC Regulation's, art. 9, for 158 pre-packed cheese products belonging to 19 cheeses identified in the greek market

Cheese Category	Soft								Hard					Semi hard			Whey			
Cheese	Fe	KL	Ga	KD	Ko	An	PC	XS	GK	GN	Ke	LM	Ba	Ka	Sf	SM	FAP	Ma	XK	Overall
Count of products	81	3	4	2	1	1	1	1	15	2	11	9	1	16	3	1	1	3	2	158
Food name	95	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	97
Ingredients list	73	100	100	100	100	100	100	0	93	50	82	89	100	75	67	100	100	100	100	79
Allergens declaration	65	67	25	0	0	0	100	0	80	0	64	56	100	81	33	100	100	100	100	65
Quantitative ingredient declaration (QUID)	100	67	100	100	100	100	100	100	60	50	73	89	100	75	100	100	100	100	100	90
Net quantity	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Date of minimum durability	100	100	100	100	100	100	100	100	80	100	100	100	100	100	100	100	100	100	100	98
Storage conditions/conditions of use	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99
Food business operator's name and address	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99
Country of origin or place of provenance	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Instructions for use	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Nutrition declaration table	96	67	100	100	100	100	100	100	80	100	82	89	100	88	100	100	100	100	100	92

Colors assigned for overall compliance: 0–70% red, 70–90% orange, 90–100% yellow, 100% green. Fe: Feta PDO, KL: Kalathaki Limnou PDO, Ga: Galotyri PDO, KD: Katiki Domokou PDO, Ko: Kopanisti PDO, An: Anevato PDO, PC: Pichtogalo Chanion PDO, XS: Xigalo Siteias PDO, GK: Graviera Kritis PDO, GN: Graviera Naxou PDO, Ke: Kefalograviera PDO, LM: Ladotyri Mytilinis PDO, Ba: Batzos PDO, Ka: Kasseri PDO, Sf: Sfela PDO, SM: San Mihali PDO, FAP: Formaella Ara-chovas Parnassou PDO, Ma: Manouri PDO, XK: Xinomizithra Kritis PDO

3. Results

3.1. Marketing Findings, Availability and Distribution of Products

In total 158 “quality label” prepacked cheese products were identified in the greek market. All products belonged in 19 of the 23 cheese records of the greek “quality cheeses” list (PDO-PGI-TSG Products (minagric.gr)). In detail, the number of products collected per cheese were: Feta PDO (n = 81), Kalathaki Limnou PDO (n = 3), Galotyri PDO (n = 4), Katiki Domokou PDO (n = 2), Kopanisti PDO (n = 1), Anevato PDO (n = 1), Pichtogalo Chanion PDO (n = 1), Xigalo Siteias PDO (n = 1), Graviera Kritis PDO (n = 15), Graviera Naxou PDO (n = 2), Kefalograviera PDO (n = 11), Ladotyri Mytilinis PDO (n = 8), Batzos PDO (n = 1), Kasseri PDO (n = 16), Sfela PDO (n = 3), San Mihali PDO (n = 1), Formaella Arachovas Parnassou PDO (n = 1), Manouri PDO (n = 3), Xinomizithra Kritis PDO (n = 2). No products of Graviera Agrafon PDO, Arseniko PDO, Krasotyri of Ko PGI, Metsovone PDO were found to be marketed as prepacked. The product distribution among the different cheeses available in the Greek retail market is presented in Figure 4.4.

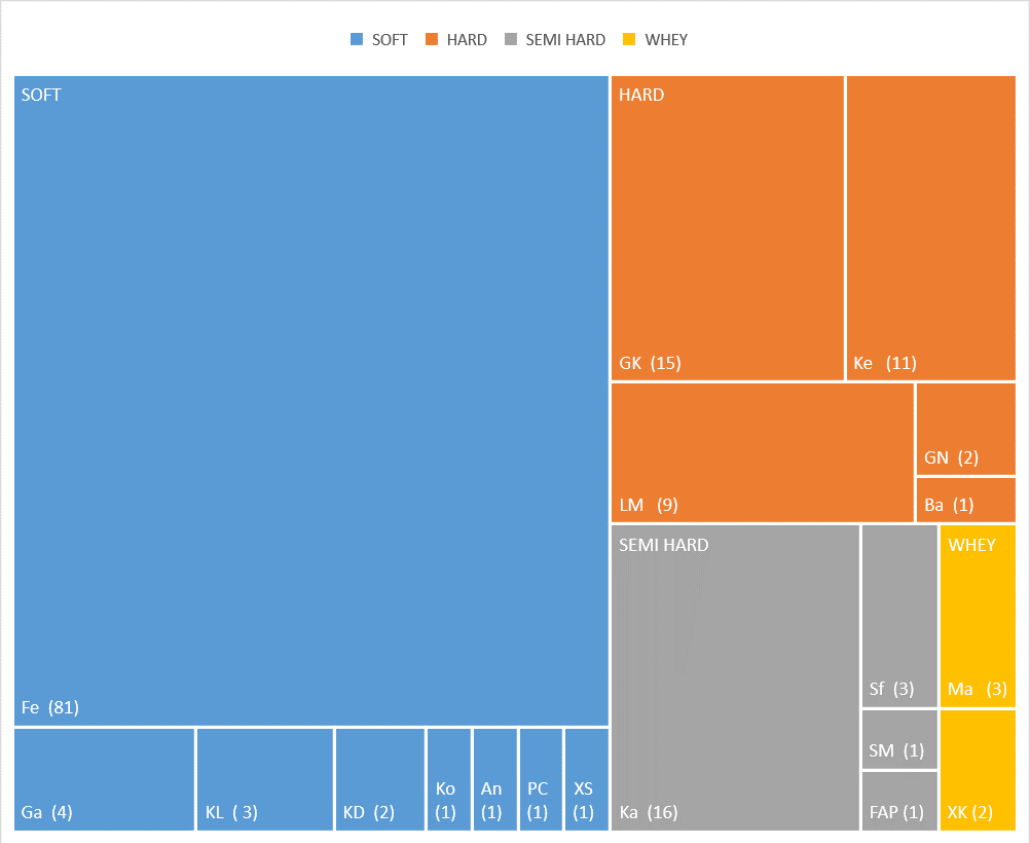


Figure 4.4. Tree map of the distribution of greek “Quality label” cheese products identified in the retail market and grouped per cheese and firmness category. Fe: Feta PDO, KL: Kalathaki Limnou PDO, Ga: Galotyri PDO, KD: Katiki Domokou PDO, Ko: Kopanisti PDO, An: Anevato PDO, PC: Pichtogalo Chanion PDO, XS: Xigalo Siteias PDO, GK: Graviera Kritis PDO, GN: Graviera Naxou PDO, Ke: Kefalograviera PDO, LM: Ladotyri Mytilinis PDO, Ba: Batzos PDO, Ka: Kasseri PDO, Sf: Sfela PDO, SM: San Mihali PDO, FAP: Formaella Arachovas Parnassou PDO, Ma: Manouri PDO, XK: Xinomizithra Kritis PDO.

As shown in the above distribution by the comparative number of products that were found on the market, Feta cheese possesses the greatest market share among greek quality cheeses (81 products found in the market). Kasseri (16 products) comes second while Graviera Kritis (15 products),

Kefalograviera (11 products) and Ladotyri Mytilinis (9 products), following in descending order. The rest of the cheeses are rarely found in the market, 11 of the 23 (47.8%) having none or just one representative.

3.2. Labelling Assessment of greek Prepacked "Quality Label" Cheeses

A labelling assessment was conducted for branded greek prepacked "quality label" cheeses, attempting an overall mapping of the category for the first time. The specific results of the assessment are presented in the following sections.

3.2.1. Assessment of Mandatory Labelling Information

The level of compliance for each mandatory indication according to EU Food Labelling Information System (FLIS) IT Tool for cheeses was assessed for all 158 products identified in the greek market. In particular, the following indications, also described in paragraph 2.3 (I), were evaluated. At first, FIC Regulation's, art.9, (11 indications): 1. food name, 2. ingredients list, 3. allergens declaration, 4. quantitative ingredient declaration QUID, 5. net quantity, 6. date of minimum durability, 7. storage conditions/conditions of use, 8.food business operator's name and address, 9. country of origin or place of provenance, 10. instructions for use, 11. nutritional declaration table. Next, particular indications according to specific legal provisions (three indications): lot number, use of term "milk" and the animal species from which the milk originates. In terms of the present assessment, ingredients list indication, even though it is not always mandatory for cheeses, was considered and evaluated as such.

The results on the compliance for each mandatory indication, according to FIC Regulation, art. 9, for each cheese separately and for all cheeses (overall) based on the total 158 products identified in the greek market are presented in Table 4.2.

The results based on Table 4.2 showed that the majority of mandatory labelling requirement indications according to FIC Regulation are provided correctly to consumers (100% compliance). However, specific omissions and/or non-compliances were observed for certain cheeses and indications.

In particular, among the 14 mandatory labelling indications, the lowest overall compliance was observed on allergens declaration (65%) followed by ingredients list (79%), QUID (90%) and nutritional declaration (92%). For allergen declaration, 100% compliance was found for only six cheeses, while in five, it was totally missing and in the rest of the eight cheeses, it was partly missing. Ingredients list and QUID were found to be fully present (100% compliance) only in 8 and 12 cheeses, respectively, while for the rest of the cheeses, the above mandatory indications were totally or partly missing. The absence of ingredients lists seemed to relate to the allergen declaration omission. Thus, quite often when the ingredients list was absent, allergens were also not declared. Similarly, the nutrition declaration table was absent in various percentages in six cheese categories. Minor nutrition declaration non-compliances were observed for the most abundant cheeses (Fe, KL, GK, Ke, LM, Ka) as expected, due to the multitude of the products with percentages of compliance ranging from 67–96%. The above non-compliances were related mainly to the nutrition declaration table plenitude and the correct sequence of nutrients. The rest of the mandatory indications are presented in Table 4.2, for the majority of products, in general, they were found to be fully provided. In detail, food name, net quantity, date of minimum durability, storage conditions/conditions of use, food business operator's name- address and instructions for use were present in the products' labels with very high percentages of compliance ranging from 95–100%.

From the cheeses point of view (based again on Table 4.2): six cheeses (PC, Ba, SM, FAP, Ma, XK) were found in full compliance (100% compliance in all indications), and six cheeses (Fe, KL, GK, GN, Ke, LM) presented non-compliances on up to three indications. Moreover, five cheeses (KD, Ko, An, XS, GN) were found to totally lack allergen declarations (0% compliance).

Regarding specific label information extracted as metadata, from the labels and not presented in Table 4.2, such as durability time, way of declaration of durability time, milk species from which the cheeses originate, they were also recorded and assessed. Durability time of products was found to vary between and within cheese categories. Thus, although soft cheeses display an average durability time of 21 months, max durability time in soft creamy cheeses like An and PC barely approached 1–2 months, while F found reaching 24 months. Moreover, hard and semi-hard cheeses display average durability times of 11–14 months, while whey cheeses had up to 9.

Regarding the way of declaration of durability times, they were found to be expressed both as “best before” and “use by date” in all cheese categories, while there were also many products in total, declaring durability times with expressions such as “expiry or expiration date“, which is not compliant. The milk species from which greek “quality cheeses” originate are mainly sheep and goat’s milk, while cow’s milk is used only in the production of Graviera Naxou, Kefalograviera and Kopanisti. Regarding mandatory indications according to “quality label” legislation, non-compliances were observed infrequently and mainly in small-scale production firms. Almost all commercialized cheese products were found to bear the PDO mark. The observed scarce omissions and non-compliances were found to be mainly related to packaging date and “quality label” packaging identification number, which was often found to be confused with the lot number. Quite often though, the production establishment’s approval code number was found to be incorrectly expressed.

3.2.2. Assessment of Non-Mandatory Labelling Information

Non-mandatory labelling information including voluntary supplementary nutritional information (FoPs, per portion information, % RI) and claims was also assessed.

In 9 of 19 cheeses, FoP schemes were found to be provided at a 29% overall percentage. The types of FoP schemes observed, were: of only Energy or Energy+ type based on the Guideline Daily Amount (GDA) system [29] were not always placed on the front side of the package. Furthermore, in 5 and 8 of 19 cheeses, per portion information (portion size, number of portions) and % RI information were provided, in percentages of 35% and 31% average, respectively. The portion sizes were declared only in a few packages and varied between 20–50 g in all cheeses.

Regarding claim data findings in relation to NHCR Regulation provisions, nutrition and health claims were rarely displayed on greek “quality label” cheeses. In detail, only one specific comparative nutrition claim was observed in 7.4% of Feta products (5.7% overall). The claim that was recorded in the above cases was the comparative nutrition claim “40% less salt” which was always in full compliance with the claim’s conditions of use according to NHCR Regulation’s requirements. Sometimes, the nutrition claim “low salt” was also observed in Feta products and the statement: “only 13% fat” in Katiki Domokou and Galotyri products, always non-compliant to legislation’s requirements. No claim regarding calcium content, such as “source of calcium” or “rich in calcium” was recorded, even though calcium concentrations of the products could probably support these nutrition claims. No other nutrition or health claims were observed.

Other claims or symbols/marks checked and reported, were mainly claims of “origin” and “organic” type. “Origin” claims were displayed either with a nationally regulated heart-shaped greek flag or with a simple greek flag and/or with the statement: “greek product”. As far as organic claim concerns: it was displayed either with the statements: “organic”, “certified organic” or “bio”, always accompanied by the European symbol for organic certification. The “Organic” claim was observed in five cheese categories and a 6.3% overall percentage. Regarding the “no preservatives” statement, it was identified in quite a few cases. No sustainability, environmental, “natural or health-related” type claims were observed, while at the same time, the recycling mark was very often present.

3.2.3. Assessment of Nutritional Information Data in Relation to FIC Regulation Provisions

Regarding nutritional information data, the nutrition declaration table was displayed in cheeses at a 92% overall percentage. Furthermore, absence of specific nutrients or differences from the standard sequence of nutrients on the nutrition declaration table in terms of the current evaluation constituted non-compliances to FIC. Only an l8.2% overall percentage of the products, (mainly products of Feta), comprised micronutrients concentration (only calcium), in their tables. Fibre, a conditionally declared nutrient according to the FIC, was always assigned 0, either declared so or not, in the cheeses’ tables

The analysis of the nutritional data of quality cheeses, showed—as expected—remarkable variability between the PDO cheeses and products, in all critical macronutrients. Descriptive statistics for nutrients’ contents, conducted for each cheese product and total summarized results are presented in Table 4.3.

With respect to the above statistics, various comments can be made. For example, in soft-brined Feta cheeses, salt ranges from 0–5 g/100 g, in hard aged Graviera Kritis cheeses from 0.78–2 g/100 g while in soft creamy Katiki Domokou raises up to 1 g/100 g). Regarding saturated fat, whey Manouri displays the greater concentration, among all quality cheeses, ranging from29–34.8 g/100 g due to its production technology (addition of whipping cream during production procedure). At the same time, between whey “mizithra” cheeses a great variability was observed in total fat, saturated fat and protein content between Xinomizithra Kritis and Manouri.

As far as protein is concerned, Manouri had the lowest concentration of 6/100 g, and we found protein concentrations up to 30.6/100 g in Graviera Kritis. Finally, regarding calcium, quite high concentrations were observed wherever calcium was declared (up to 500 mg/100 g on Feta, 783 mg/100 g on Kefalograviera, 942 mg/100 g on Ladotyri Mytilinis), a fact that is definitely supported by other studies (Katsouri et al., 2020; Katsouri et al.,2021).

3.3. Initializing an Archival Database and Conceptualizing a Branded Food Composition Database for “Quality Label” Foods

The implementation of the previously described procedure of arranging label data in order to conduct a comprehensive labelling assessment for greek “quality cheeses’” (Table 4.1), led us to the initialization of a database. Label data of original products were entered into an archival database, considering existing harmonization and standardization guidelines and tools (INFORMAS recommendations and Food Labelling Protocol (Rayner and Vandevijvere, 2017; Rayner et al., 2013), EuroFIR AISBL (EuroFIR AISBL, 2021) and FoodEx2 (European Food Safety Authority, 2015).

In the absence of a standard methodology for the development of a database, the previously described procedure, not only provided a methodology for labelling data collection but furthermore formed the basis for the conceptualization of a branded food composition database (BFCD) for “quality label” foods.

A graphical representation of the conceived methodology for the potential development of a BFCD is presented in Figure 4.5.

Regarding the current status of the concept, a total of 158 products were entered into the first version of an archival database, intended for further development with other “quality label” foods. Reported data entered until February 2021.

In reference to classification and description according to FoodEx2, the “Milk and Dairy products” (A02LR) food category and the “Cheeses” (A02QE) subcategory were matched. All the above-described quality label cheeses were found to belong in three of the six subgroups of the above subcategory, and specifically in fresh uncured cheeses (A02QF), brined cheeses (A02RA) and in ripened cheeses (A02RG) subgroups. In total, the following 13 descriptors of the FoodEx2 system were identified: Cheese (A02QE), fresh uncured cheese (A02QF), miscellaneous fresh uncured cheeses (A04NV), cheese mizithra (A02QV), brined cheese (A02RA), feta type and similar soft brined cheese (A02RB), feta (A02RB), firm brined cheese (A02RE), firm ripened cheeses (A02ST), firm semi-hard cheeses (A02SV), kasseri (A02VG), hard cheese (A02YE), aged graviera (A02YF).

During the classification and coding procedure, more than half of the greek PDO cheeses could not be accurately described with existing descriptors and for those, many cheeses were assigned with the wider category code. A limited number of FoodEx2 system descriptors regarding cheeses was observed and the article supports a possible expansion.

Table 4.3. Nutritional composition of greek prepacked “quality label” cheeses, according to their labelling nutrition declaration tables.

Cheese Category	Cheese	Count of Products	Energy (Kcal/100 g)	Total Fat (g/100 g)	Saturated Fat (g/100 g)	Carbohydates (g/100 g)	Sugar (g/100 g)	Protein (g/100 g)	Salt (g/100 g)	Calcium (mg/100 g)
Soft	Fe	81	280.5 ± 20.3	23.4 ± 1.6	15.9 ± 1.4	0.9 ± 0.8	0.5 ± 0.6	16.6 ± 1.1	2.4 ± 0.7	410.0 ± 109.5
	KL	3	276.0 ± 0.0	23.0 ± 0.0	16.5 ± 0.0	1.8 ± 0.0	0.0	15.4 ± 0.0	3.0 ± 0.0	
	Ga	4	155.0 ± 10.9	12.1 ± 1.7	7.2 ± 1.2	2.0 ± 1.9	2.0 ± 2.4	10.8 ± 2.3	1.6 ± 0.0	
	KD	2	166.0 ± 4.2	13.0 ± 0.0	8.0 ± 0.0	2.0 ± 1.4	3.0	10.5 ± 0.7	1.0 ± 1.0	
	Ko	1	304.0	24.0		0.5		22.0		
	An	1	210.0	17.5	12.0	0.7	0.7	12.5	2.5	
	PC	1	127.0	6.7	4.8	4.5	4.2	12.1	0.7	
	XS	1	163.0	11.9	8.5	4.3	1.9	9.4	1.2	
Hard	GK	15	399.2 ± 31.8	30.8 ± 3.9	21.5 ± 2.8	1.9 ± 1.0	0.9 ± 0.8	26.3 ± 2.3	1.6 ± 0.6	
	GN	2	419 ± 55.2	31.3 ± 0.4	20.1 ± 0.2	1.6 ± 1.6	1.5 ± 1.7	24.7 ± 1.8	2.1 ± 0.0	
	Ke	11	378.7 ± 15.5	30.7 ± 1.3	20.7 ± 1.6	0.5 ± 0.9	0.1 ± 0.1	25.3 ± 1.6	2.6 ± 0.4	783.0
	LM	9	370.8 ± 24.8	30.3 ± 3.2	19.2 ± 1.5	0.4 ± 0.3	0.0 ± 0.0	24.2 ± 2.8	2.9 ± 1.3	942.0
	Ba	1	344.0	25.0	17.3	0.7	0.7	29.0	2.5	
Semi Hard	Ka	16	345.9 ± 23.8	27.9 ± 2.8	18.7 ± 1.8	0.7 ± 0.7	0.2 ± 0.2	24.4 ± 1.4	2.1 ± 0.3	
	Sf	3	327.6 ± 12.6	27.9 ± 2.2	19.8 ± 0.7	0.2 ± 3.4	0.2 ± 3.4	19.9 ± 4.9	3.4 ± 0.6	
	SM	1	334.0	23.0	16.0	4.8	0.2	27.0	2.5	
	FAP	1	340.0	25.0	17.4	0.7	0.1	21.0	2.5	
Whey	Ma	3	487.0 ± 62.2	46.9 ± 4.6	32.8 ± 3.3	1.5 ± 0.6	1.2 ± 0.6	7.8 ± 2.0	1.4 ± 0.6	
	XK	2	280.5 ± 5.0	21.5 ± 0.7	15.0 ± 0.0	3.0 ± 0.0	1.8 ±1.8	17.5 ± 0.7	1.7 ± 1.2	

Fe: Feta PDO, KL: Kalathaki Limnou PDO, Ga: Galotyri PDO, KD: Katiki Domokou PDO, Ko: Ko-panisti PDO, An: Anevato PDO, PC: Pichtogalo Chanion PDO, XS: Xigalo Siteias PDO, GK: Gra-viera Kritis PDO, GN: Graviera Naxou PDO, Ke: Kefalograviera PDO, LM: Ladotyri Mytilinis PDO, Ba: Batzos PDO, Ka: Kasseri PDO, Sf: Sfela PDO, SM: San Mihali PDO, FAP: Formaella Ara-chovas Parnassou PDO, Ma: Manouri PDO, XK: Xinomizithra Kritis PDO

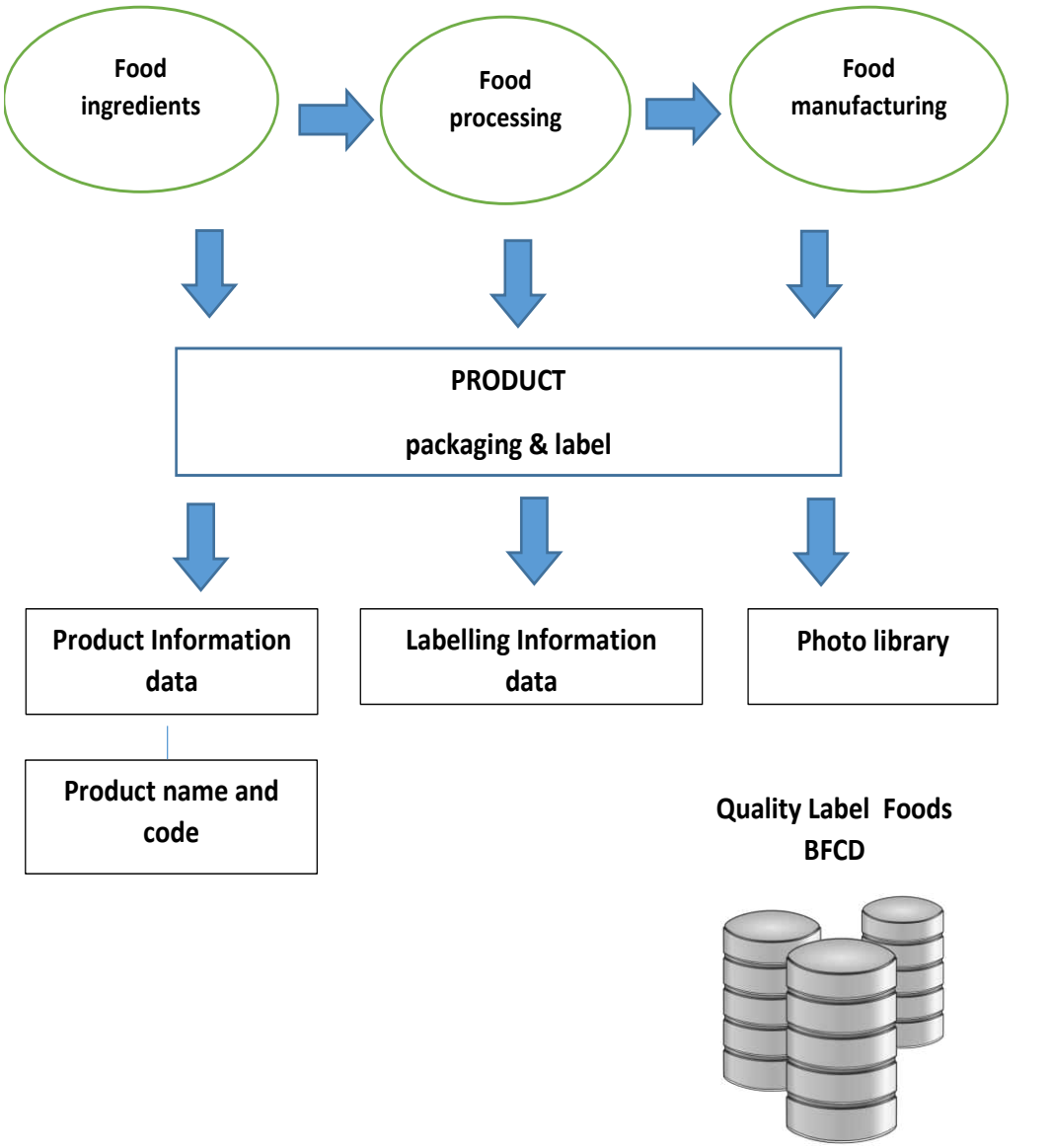


Figure 4.5. Flow-diagram presenting methodology for and the design and development of a branded food composition database (BFCD) for "quality label" foods.

4. Discussion

The marketing findings presented in the first part of the study's results, in relation to the availability of pre-packed greek "quality label" cheeses indicated significant problems in their marketing potential, inside the domestic market and definitely abroad. Indeed, 4 out of total 23 "quality label" greek cheeses were not found at all in the retail market of the three major cities that sampling was carried out in. In addition, 132 (84%) out of total 158 products identified in the market represent 5 cheeses (Feta, Graviera Kritis, Kasseri,

Kefalograviera, Ladotyri Mytilinis) and only 26 (16%) of total 158 products represent the rest of the 14 cheeses. These findings prove that many greek “quality cheeses” do not reach easily make way to the market, a fact that also impacts their state of awareness. This is definitely indicative of the “quality labels” market footprint in regard to their identity and characteristics. Undoubtedly all the above findings are in line with the recent “Evaluation support study on geographical indications and traditional specialties guaranteed protected in the EU: final report” (EC, 2021), which confirms that “quality label” products, are facing a lack of awareness. Moreover, they also confirm specific conclusions from a recently published review study, on the GI’s market and economic issues (Torok et al., 2020). Possible reasons for the limited market representation of “quality cheeses” in Greece could be poor state marketing support and missing marketing strategies also reported in other European countries (Velčovská, 2016) or other indigenous reasons. Indicatively, we can mention the limited production rate, which is linked to the nature of the products (seasonality of production, small scale production firms, local production and sales) as well as the concession of livestock-farming and the reduction in the availability of raw milk, but more research has to be conducted on these issues.

The labelling assessment of prepacked greek “quality cheeses” presented in the second part of the study’s results, depicted their labelling status and compliance to EU legislation, explored problems on their labels and provided a complete overview of their nutritional characteristics for the first time. Mandatory and non-mandatory labelling information of 158 products belonging to 19 cheeses was identified and assessed. The results of the assessment showed a certain pattern of omissions and non-compliances regarding mandatory requirements. Non-compliances in allergen declaration, ingredient list, QUID and nutrition declaration indications were most frequently observed and mainly in brands of small size and scale firms. As far as non-mandatory information is concerned, results showed that claims, innovative tools and on-pack communication information and schemes (such as FoPLs) had limited representation on greek “quality label” cheeses, although many studies have shown that they can help consumers in better understanding nutritional information of food (Egnell et al., 2018; Mazzu et al.,2021). Sustainability marks were also totally absent. Nutritional declaration tables served for conducting a comprehensive statistical analysis of the nutritional characteristics of all greek available “quality label” cheeses, which were presented comparatively per cheese and cheese category. The above assessment, results and information constitute the first study on mapping the labelling status and nutritional characteristics of all “quality label” cheeses in Greece and one of the scarce studies found on labelling compliance assessment against regulated information that should be provided to

consumers. The study's results provide important information for Authorities and FBOs, in order to facilitate labelling requirement monitoring procedures and improve cheeses' labels.

The creation of an archival database and the conceptualization of a branded food composition database (BFCD), presented in the third part of the study's results, was conducted with the view to better the possible depiction of "quality label" cheeses. All steps were designed and carried out using standardized guidelines and tools (Rayner and Vandevijvere, 2017; Rayner et al., 2013; EuroFIR AISBL, 2021; European Food Safety Authority, 2015) while global trends that have been adopted by national BFCDs (such as OQALI (Menard et al.,2011), USDA BFCD (Kretser et al., 2017), UK BFCD (Carter et al., 2016), NUBEL (Seeuws, 2017) and HelTH (Katidi et al., 2021) as well as by specific specialized databases (Durazzo et al., 2020)were followed. Considering also that global harmonization and standardization tools and standardized compilation procedures of data support FAIR (Findable, Accessible, Interoperable, Reusable) data processing, the whole project stays definitely in line with the FAIR data principles adapted to the agrifood sector (Wilkinson et al., 2016). The idea of a "quality label" food database follows, in a way, the previous specialized databases of traditional and ethnic foods and bioactive compounds (Møller et al., 2017). Specialized databases are databases that can capture more detail (e.g., specific descriptions of the foods components identification, values, and measures of variability) and also serve for other uses (Pennington et al., 2002). The prospect of the creation of a specialized branded food composition database deserves scientific attention, considering the lack of centralized data collection about "quality label" products on the EU level (Torok et al., 2020). Except for the official registration databases (eAmbrosia (europa.eu)), only specific initiatives for Geographical Indication (GI) products' data collection were found in EU countries with a strong GI industry, (e.g., Qualivita in Italy) (Torok et al., 2020; Fondazione Qualivita, 2021). A specialized "quality label" BFCD may contribute to better identification of all available "quality" products, considering also that many "quality foods" have not been described yet in terms of classification, as also shown in the present study. Such a database may additionally constitute a comprehensive tool for stakeholders (industry, research and policymakers) supporting them in new product development, product reformulation, food promotion, monitoring, keeping track of changes using other new technologies (e.g., immutable ledgers such as block chain approach, etc.) both from the nutritional point of view and as a key tool for public health (Dwyer et al., 2006; Roseland et al., 2008; Dunford et al., 2012). Better identification of existing problems related to the "quality labels" could facilitate both producers and policymakers in improving the marketing strategies of the labels and in more effectively managing the benefits arising from the certification (Velˇcovská, 2016). In the future, typical dairy and meat products will only be able to

maintain and develop their markets if they are capable enough of holding their commercial ground and adapting to the market's needs and demands without losing their specificity, originality and authenticity (Bertoni et al., 2001). In addition, the rapidly changing food markets and new nutritional and health interests create both needs and gaps in existing food composition databases and the availability of branded food databases provides new opportunities and challenges (Ocke et al., 2021).

CHAPTER 5

General Discussion and Future Perspectives

General Discussion

The present thesis, deals with “quality cheeses” from the perspective of labelling and public health. According to the literature overview in CHAPTER 1, describing the current trends on food labelling, nutrition science and public health, , nutrition labelling –either mandatory or voluntary- has been placed on the core of the global nutrition and public health priorities. In this context, all studies of the present thesis are following the current trends and interests of the scientific community, the industry concerns as well as the public health’s policy priorities. The “quality labels” participate in all of the present thesis’ studies, consisting the pilot for testing novel applications of labelling and nutrition.

Regarding the two first studies, in CHAPTERs 2 & 3, two nutritional and dietary assessments were conducted, applied to the most abundant “quality label” greek cheeses, feta and gravieras PDO. An attempt to provide, the nutrient profile-nutritional characteristics of the “quality” cheeses based on the back of pack labelling data of currently marketed products in the greek market was conducted for the first time. Additionally, an evaluation-classification according to several different profile models (NPMs) as well as an evaluation possible impact of their consumption on greek population’s diet and health, using consumption data from the Hellenic National Nutrition and Health Study (HNNHS) (Magriplis et al., 2019) were also attempted for the first time. The nutritional characteristics for the rest of greek PDO cheeses, were analyzed on the third study in CHAPTER 4. To the best of our knowledge, even though the nutrient concentrations of the above cheeses are scientifically known by older analysis and generic data, the literature available studies occupying with” quality label” cheeses, are focusing on other than nutritional subjects. In particular there are numerous studies occupying with microbiological subjects. Indicatively, Tzanetakis and Litopoulou Tzanetaki worked systematically with the Microfloras of Traditional greek Cheeses (Tzanetakis and Litopoulou-Tzanetaki, 2014), Michailidou et al (Michailidou et al., 2021) analyzed the microbial profiles of six PDO cheeses, Angelidis & Govaris (Angelidis and Govaris, 2012) reviewed the available scientific literature regarding the behavior of L. monocytogenes in 21 greek PDO cheeses. Moreover, Danezis et al. (Danezis et al., 2018; Danezis et al., 2019) was occupied with the authentication of greek PDO cheeses, Vakoufaris H. (Vakoufaris, 2010), Spilioti et al (Spilioti et al., 2021) worked with marketing and economic issues of greek PDO cheeses, and Likoudis et al. (Likoudis et al., 2016) examined consumers’ intention to buy “quality” foodstuffs e.t.c. No studies were found, in relation to the

nutritional characteristics of Greek PDO cheeses or other aspects of nutrition, nutrition labelling, nutrient profiling or FoPs concerning greek products in general.

As shown by the results in all of our studies, greek prepacked “quality label” cheeses present a remarkable variability on their nutritional profile, regarding all nutrients, among and within the different cheese products. Remarkable variability was also observed on the individual daily intake of the cheeses (consumption quantity per capita). The occasionally high salt concentrations that were observed, seem to probably form the main health risk factor due to cheeses’ consumption, with saturated fat concentrations, following in the second place according to the rankings. Of course as it has been discussed within the studies, lack of prominence of beneficiary micronutrients provided by the cheeses in general-such as calcium and proteins- was definitely observed in almost all PDO cheeses, in all studies. This fact was considered as a challenge for potential labelling improvement, in order to provide better information to consumers e.g., with calcium and protein nutrition claims. Moreover, different nutrient profile models (NPMs) and Nutri-Score FoP were pilot tested in terms of the studies, for the first time in the greek market and the products were classified accordingly. Through these evaluations, special deficiencies of current nutritional status, chances for potential improvement of products through reformulation and opportunities for advancing information to consumers, were identified, but certainly, more research has to be done. This approach stays in line with numerous studies that have been occupied with the nutritional evaluation of food products, utilizing various NPMs and have been conducted globally during the last decades (Trichterborn et al., 2011a and 2011b; Franco-Arellano et al., 2018; Egnell at al., 2018; Szabo de Edelenyi et al., 2019).

Regarding the third study in CHAPTER 4, a monitoring and labelling assessment study on greek “quality label” cheeses was conducted for the first time. A sectoral evaluation of compliance to its specific labelling legislation requirements was made, deploying data of all sampled cheeses. To the best of our knowledge, no published food monitoring or labelling assessment studies for any food category was identified in the literature, for the greek market. The lack of monitoring -through the labels- studies, for the greek market and the greek products was catholic, while at the same time numerous studies have taken place among and within several countries in Europe and in the world, during the recent years- either connected with databases or not. Indicatively, the Food Labelling of Italian Products (FLIP) study (Angelino et al., 2019; Dall’ Asta et al., 2020 etc.,), the Food Label Information Program (FLIP) for the evaluation of the Canadian food supply- a big data approach (Ahmed et al., 2022) etc. Furthermore, in the same third study, an attempt to create a specialized branded food composition database (BFCD) with focus on “quality label” foods, using harmonization & standardization tools, was made. In detail, a methodology, following

approved instructions and guidelines was presented. According to our knowledge, an ongoing attempt, for the creation though of a general BFCD, has been also also initiated recently in Greece by Katidi et al. (Katidi et al., 2021)- following many other countries' paradigm (Carter et al., 2016; Seeuws, 2017; Ahmed et al., 2022) .Results of our final third study, showed very high percentages of compliance in "quality label" cheeses, regarding almost all labelling indications, except for the "allergens declaration" indication, which showed the lower percentage of compliance among the products. Marketing findings of the study, revealed limited representation, penetration and distribution of "quality label" cheeses, in the central points of sale, in numbers that definitely confirm the results of the recently published final report of the evaluation support study on Geographical Indications and Traditional Specialties Guaranteed protected in the EU (EC, 2021).

The present thesis supports that food in its present form (processed, industrialized, prepacked, labeled, reformulated) must be systematically monitored and must be connected and interact with consumers, industry, nutrition and medical science in order to confront the rising world's epidemic of obesity and diet-related diseases as well as many other environmental and economic challenges. In consequence, the need for further involvement and utilization of labelling as a tool for constant and continuous food monitoring, is further supported in order to establish an industry and market observatory in the public health's authorities service. Such a tool could be useful for the evaluation of compliance to legislation, food fraud vigilance, public health policy practicing and development, scientific research as well as for guidance on potential targeted reformulation activities in the service of food industry.

Regarding the results referring to the greek "quality label" cheeses, that have been selected as a pilot to all of the present thesis, our studies stay in line with other European and greek literature. Even though Greece has a rich cheese tradition and there are twenty-three (23) cheeses registered as Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI), great differences were observed concerning their marketing representation in our studies. As Spilioti et al, also reported (Spilioti et al., 2021), reduced business interest and high production and standardization costs lead some of the PDO cheeses in Greece to zero production. Despite the fact that the greek certified cheeses showed a great marketing dynamic, with increasing output and exports in recent years, they have not taken actual advantage of their "quality label's" value. Quite proportional observations were reported also in other European countries. Specifically, according to Torok et al. despite the European commitment to food quality, the share of GI products in the national food and drink industry in 2017, in the EU Member States was reported around 7% with the main beneficiaries of GI labelled exports to be the south Mediterranean countries and mainly France and Italy (Torok

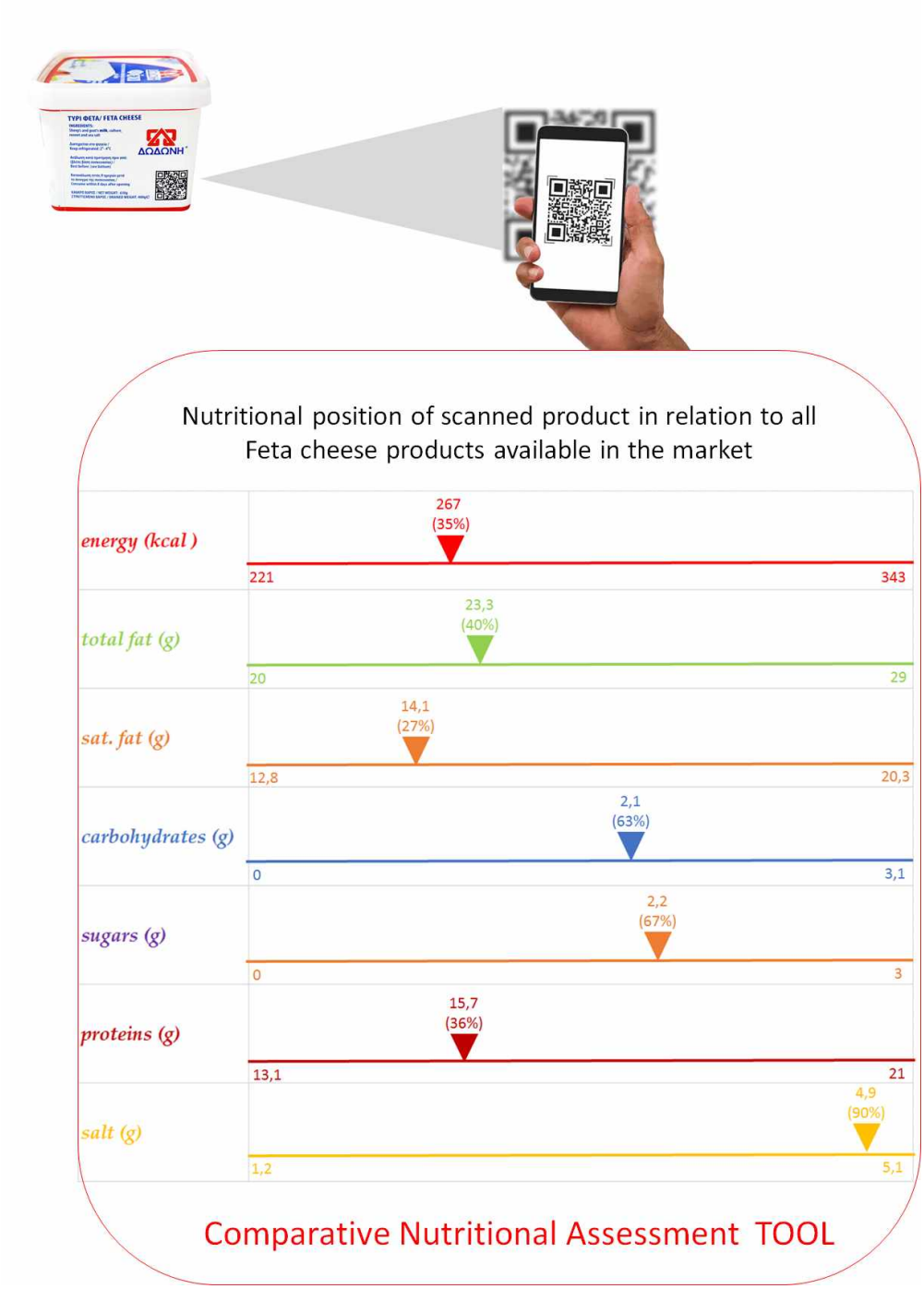
et al., 2020). Moreover Sorgho and Larue (Sorgho and Larue, 2017), indicated that GI-products have ambiguous effect on international trade. In detail. their trade-impact found to depend on the importance of each product for consumers and as it was expected, the heterogeneity in consumers' preference – due to home bias about local or foreign varieties – is able to increase or decrease trade, despite the presence of GI- "quality label".

Finally, regarding our studies' involvement with new trends and technologies, AI technologies and applications with various orientations, are definitely supported. As for instance, the data and analysis presented in chapters 2 and 3 can be translated into useful applications which can effectively improve consumer information about the nutritional characteristic of foods and support consumer's choices based on their needs and preferences. In this context a special application example in terms of our findings has been indicatively designed in the present PhD study. and presented hereupon, in Figure 5.1., which shows the design of a Comparative Nutritional Assessment Tool (ComNutri-Tool) based on the database of prepacked greek "quality label" cheeses nutritional characteristics constructed in this thesis in tandem with the Quick Response-code (QR) technology. The unique identifiers such as QR and NFC (near-field communication) tags have become a common technology for consumer information as well as allow for continuous food quality control in an online food chain management platform (Nychas et al 2021). Typically, a smartphone is used as a QR code scanner, which translates the image into data e.g., a standard URL for a website.

As shown in Figure 5.1, the consumers by scanning the QR code of a Feta cheese product, can be directed to a specific website e.g., the ComNutri-Tool website, where they can access to information related to the ranges of nutritional characteristics of all feta cheese products available in the market, as well as on the nutritional position of the scanned product in relation to them. In the above-mentioned use case, the range of salt content of all feta cheeses available in the market ranges from 1,2 to 5,1 g per 100g while the salt content of the scanned product is 4.9 g being at the 90th percentile. The latter means that 90% of the products available in the market have less salt than the scanned one.

The ultimate goal of such an approach is to establish the foundation for developing next generation monitoring platforms for food quality/safety parameters through a simple profile of given category food products. To achieve this, (a) simple recording practices of labels in the food sector, (b) strategic collaborations with companies/institutions and appropriate consortia that will drive progress and standardization on food labelling, are definitely proposed.

Figure 5.1. Design of the Comparative Nutritional Assessment Tool (ComNutri-Tool) developed in the present PhD study.



Future Perspectives

General, findings and results, for the “quality label” cheeses, as presented in chapters 2, 3, 4 are suggested to be further applied , in other “quality label” foods or other food categories in the greek market, in terms of analogous research studies in order to extend conclusions and complete a potential integrated national Food Labeling and Nutrition Project. Such an extension, could provide valuable data and tools for scientists, risk managers and decision makers in order to advance their work. Monitoring, cross sectional, or comparative studies as well as cooperations with other European countries’ projects must be certainly encouraged and pursued.

Specific future uses, advantages, targets and perspectives of the individual topics analyzed in the present thesis, are mentioned below:

Monitoring of labelling compliance to legislation requirements –as a part of monitoring of the food supply chain –is crucial and inseparably connected to the risk-based approach of official controls. Monitoring procedures can permit the early and easy identification, improvement and correction of specific labelling non-compliances, deficiencies and mistakes and can further provide early information on potential food fraud and consumer’s misleading incidents, supporting an early warning system for potential food risks. Furthermore, all labelling data (often “under-utilized”), could provide an important data depository for the official control plans as well as relative scientific research studies e.g. by monitoring all labelling indications such as ingredients’ list, durability date, origin declaration etc.,.

Pilot application of FoPs as conducted, in research level, provides a guidance for their potential market and/or institutional adoption and implementation, both in national and European level. Their application in other foods beyond cheeses, is definitely supported by the thesis, while their adoption as mandatory in the European Union, is clearly suggested by the European report regarding the use of additional forms of expression and presentation of the Nutrition Declaration (EC, 2020). Research on this field, can be further extended under different perspectives and scientific approaches to other foods or relative fields. As per example, another recent research in Greece comparing different FoPs in Greece, using an online consumer survey, stays in line with these suggestions (Kontopoulou et al., 2021). There is no doubt, that various knowledge gaps related to FoPs, exist with a) their effect on purchasing behavior and b) to whether they can improve overall diets and health and certainly, more research and better data are needed to fill these gaps. On the other hand, though, the lack of strong evidence for a beneficial effect of FoPs on diet and health should not be mistaken as evidence for a lack of effectiveness of FoP schemes. In addition,

researchers need to develop better tools on the evaluation of the impact of interventions such as FoPs towards promoting healthier food preferences and enabling individuals to manage and improve their own health (Storcksdieck et al., 2020). Moreover, future opportunities for FoPs may include potential more integrated nutritional profiles comprising all identified factors related to a healthy and sustainable diet (El-Abbadi et al., 2020). Educational campaigns oriented to consumers enabling with skills to effectively use labelling and especially FoPs are definitely needed. Furthermore, monitoring tools for the evaluation of the long-term effectiveness of different policies in promoting healthier food choices, and in reducing the burden of diet-related non-communicable diseases should be decisively considered (Feteira-Santos et al., 2021).

Reformulation of products could derive as an application of the present thesis' scientific evidence as well as of similar results. Seeing that according to Belc et al., reformulation can be defined as the modification of food composition by reducing certain ingredients, with the main goal to develop healthier food products (Belc et al., 2018), targeted and a potentially more effective versions of foods' could derive

Regarding the creation of the branded composition database for "quality labels", this comes under the current necessity for food data collection and management and must be seen as a part of the potential future objectives for Food Authorities. Both Composition and Consumption data of foods consumed in a population's diet are of extreme importance and have a wide variety of uses, in nutrition and epidemiology, public health interventions and practice, the industry, as well as the Authorities, decision-makers, and consumers (Pravst et al., 2022). From a public health perspective, monitoring of food composition and labeling of branded foods –already currently available in many countries, can provide insights into numerous, different public health interventions. Thus, there is no doubt that food datasets and branded food datasets will obtain great importance in the future through progress in information technology and in order to confront future challenges (Ocke et al., 2021).

Food data management and analytics, as well as constant training of the involved scientists on their development, management and maintenance must definitely be another main priority to the Authorities. The creation –development of modern infrastructures to manage and deploy food data, including labelling data, is of paramount importance.

In this context, numerous complex, multitasking and sophisticated data analytics' infrastructures emerged and are currently functioning in Europe and all over the world, with the interaction between them –using harmonization and standardization tools- to remain a challenge. In this context, per example, the European commission HORIZON2020 framework program funded the European Food Nutrition Security (FNS) Cloud project with major

objectives to demonstrate the usability of such datasets and to support standardization, highlighting the need for readily found, accessible, interoperable, or reusable (FAIR) data. The project Food Nutrition Security (FNS) Cloud), is developing the first generation 'food cloud' by federating existing and emerging datasets (Popovski et al., 2019; https://www.fns-cloud.eu ; Assessed 11.3.2022).

Regarding greek "quality label" cheeses, despite of the problems confirmed in our third study, in CHAPTER 4, the thesis supports the empowerment of the "quality labels" as a pillar to sustainability.

This concept stays in line with, a recent study by the European project Strength2Food, which is dedicated to the quality and sustainability of food. The study, as presented in the project's websites, was carried out in order to understand the impacts of food quality schemes on the territory. The findings indicated that the implementation of a holistic approach considering both environmental and socio-economic features, can improve the effectiveness of EU food quality policies. These could lead to more benefits from these schemes for the producers and rural communities, including the creation of new job opportunities, receive of a fair price for "quality" products, and the preservation of cultural practices. (https://www.strength2food.eu ; Assessed 20 March 2022). However, not all of these initiatives that have been taken over, were equally successful, and much potential remains unfulfilled. A simpler and speedier registration process and stronger action against fraud and falsification are important so that producers and consumers can benefit from the quality schemes. It is also important for consumers to better understand the diversity of "quality" products from conventional products, and how their quality and reputation is linked to the production methods and/or a specific territory. A major challenge, therefore, is to more effectively communicate the benefits of food "quality labels" to consumers, to implement policy strategies to raise consumer awareness, with comprehensive labelling schemes, proper communication and to shape the food environment with integrated policies for the Member States creating also new markets for labelled products (Mattas et al., 2022).

In this context, the proposal for better and systematic monitoring of the "quality labels", through a specialized BFCD seems quite suitable and compatible with the current need for sustainability. Such an approach, appropriately developed and adjusted, could provide a specialized monitoring tool for this special category, linked to all possible analyzed aspects through labelling (diversity, awareness to consumers, economic value etc.), in order to better manage and advance their production and management. Besides, as Torok et al. concluded (Torok et al., 2020), there is a lack of statistics on the EU GI sector, in the

whole, while only specific European food “quality labels” (specifically “certified organic”), are supported with centralized data collection and through Eurostat.

Annex

Labelling Legislation on cheese products

Council Directive 79/112/EEC of 18 December 1978 on the approximation of the laws of the Member States relating to the labelling, presentation and advertising of foodstuffs for sale to the ultimate consumer. Official Journal of the European Communities, L 33, 8 February 1979

Council Directive 90/496/EEC of 24 September 1990 on nutrition labelling for foodstuffs Official Journal L 276 , 06/10/1990 P. 0040 – 0044

European Commission Regulation No. 2081/92 on the protection of geographical indications and designations of origin for agricultural products and foodstuffs. Off. J. Eur. Communities 1992, L208, 1–8.

European Commission Regulation No.1107/96 on the registration of geographical indications and designations of origin under the procedure laid down in Article 17 of Council Regulation (EEC) No 2081/92. Off. J. Eur. Communities 1996, 148, 1–10.

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