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# Whey protein stories – An experiment in writing a multidisciplinary biography

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ABSTRACT

This is an experimental, dual-purpose article about whey protein and how to conduct interdisciplinary analyses and writings. On the one hand, this article is a multidisciplinary commodity biography, which consists of five descriptions of whey protein written by the five different research groups involved in the interdisciplinary research project CALM(Counteracting Age-related loss of Skeletal Muscle Mass). On the other hand, it is a meta-analysis, which aims to uncover and highlight examples of how the five descriptions contribute to each other with insights into the contextualisation of knowledge, contrasts between the descriptions and the new dimensions they bring to established fields of interest. The meta-analysis also contains a discussion of interdisciplinary study objects and the usefulness of the multidisciplinary commodity biography as a format for interdisciplinary publications. The article contributes to the field of food studies with a multidisciplinary biography of whey protein – including its sensory qualities and challenges, insights into its cultural history, its nutritional value and effects on the human body and an analysis of how it is perceived by people who consume it. The biography thereby expands upon existing understandings of whey protein while discussing the usefulness of employing the commodity biography format in interdisciplinary writing. Moreover, the article contributes to the field of interdisciplinary research by providing a practical example of a joint publication and reflections upon the existence, interaction and possibilities of monodisciplinary knowledge structures within interdisciplinary studies and publications.



## 1. Introduction

The international research community currently considers collaborative interdisciplinary or multidisciplinary research to be promising methods for bridging the gap between scientific findings and durable solutions to societal challenges (The Lancet, 2015; Nature, 2015). Even though there is an increased awareness of the benefits of integrating research traditions in interdisciplinary and multidisciplinary research designs and projects, it is still difficult to write and publish joint publications that afford equal weight and position the hard sciences and the humanities. Articles that attempt to take an interdisciplinary approach often end up being constructed either within the framework of a single research branch or within that of two or more research traditions that share methodological or theoretical approaches, in order to accommodate the demands of desirable (i. e. high ranking) journals (Lyall & Meagher, 2012). However, while they may be practical, none of these solutions allows for the equal co-existence of the different kinds of questions, realities and findings that characterise interdisciplinary studies. This article attempts to do just that by combining texts about whey protein written by the research groups participating in the interdisciplinary research project CALM (Counteracting Age-related loss of Skeletal Muscle Mass) in an

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experimental form, which consists of two textual sections, each with its own objective.

The first part consists of five descriptions, which, together, form an eclectic commodity biography of whey protein. The purpose of this is to present a multifaceted biography in which the monodisciplinary perceptions of whey protein that exist within the CALM project are equally represented. In doing so, the aim is to contribute to the field of food studies with an alternative version of a food or commodity biography, in which we highlight the composite nature of the product.

The second part consists of a meta-analysis of the five descriptions. The aim in this section of the article is to investigate what happens when the many existing versions of interdisciplinary study objects are unfolded, uncovered and discussed. Moreover, the meta-analysis discusses the usefulness of the multidisciplinary commodity biography as a format for interdisciplinary publications. To this end, the meta-analysis contains reflections about the following series of explorative questions: Which kinds of knowledge patterns, differences and similarities are revealed by the unfolding of the many versions of whey protein as a study object? Does the commodity biography format create a pathway that enables us to go beyond monodisciplinary interests, perceptions and themes and pose new types of research questions? Does the biography lead to the equalisation of the different contributing research traditions? Is this desirable? In which ways does the methodology expand or contribute to the uses and format of commodity biographies?

The article thereby simultaneously investigates a food commodity whose potency and potential is currently of great interest to researchers and the food industry, and seeks to increase awareness and knowledge about the many realities that exist in collaborative research projects and how their mono and interdisciplinary insights and potentials can be explored through experimental publications. Thus, the article is an explorative experiment, which attempts to offer an alternative to the existing discipline-based publication traditions that dominate research journals, even broad interdisciplinary publications such as *Appetite*.

## 2. Background

To the common consumer, the theme of this article, whey protein, is a food element rather than a food commodity. However, among specialists and in the food industry, it is a commodity with a large market potential, which is produced, sold and incorporated into industrial food products targeted consumers such as patients, older people and athletes, for whom protein-enhanced products are of relevance. To understand why we have chosen to make whey protein the theme of a collaborative publication experiment, it is important to know who *we* are. We are researchers working in the five research groups involved in the Danish interdisciplinary research project CALM, based at the University of Copenhagen. The CALM project brings together researchers from ethnology, history, microbiology and metabolome, sensory science and physiology in a combined intervention and innovation study with the aim of finding appropriate and implementable solutions to help prevent age-related loss of skeletal muscle mass in older people – also called sarcopenia. In the intervention part of CALM, we measure the effect of different combinations of whey protein supplements and exercise on the muscle mass, gut microbiome and metabolome of elderly Danes. In the innovation part of CALM, we develop and test products containing whey protein in a range of specialist and user settings, and investigate the elderly Danish participants' attitudes and preferences with regard to a selection of exercise programs. The project thereby both tests the potency of whey protein and investigates how, when and why it is perceived as desirable, edible, culturally appropriate and possible to integrate into the everyday habits of elderly Danes. As such, whey protein is one of two shared core objects of study in CALM (the other being exercise)(Holm et al., 2015).[1] As whey protein is part of all of the sub-projects in CALM, we were all immediately able to agree upon its existence and relevance as a study object when discussing possible themes for joint publications.

From the very beginning of the project, it has been clear that even though whey protein is a shared core object of study, it is perceived and studied in a variety of different ways by the different disciplines. One cornerstone of CALM is that all of the research traditions involved are equally important to the success of the project. However, our discussions regarding a joint publication on whey protein showed that it would be difficult to transfer this trait to a single shared text. Nevertheless, inspired by the varying availability of references and knowledge about whey protein, we started to look for a form that would be able to include each of the participating research groups on equal terms. The search led us to the form of the food biography, which cultural geography professor Peter Atkins has renamed the 'commodity biography' (Atkins, 2011). This refers to a food biography that considers and includes the physical, chemical and cultural realities of a certain product, how they differ over time and influence not only what a food is at a given time but how it is experienced and used.

The food or commodity biography is a format that is relatively common in studies of the history and culture of a specific food product. Although such biographies aim to tell the full story of a food product, they often employ perspectives that are relevant to the research tradition of the author. Product-specific, historically oriented works tend to focus on aspects of industry/production, consumption, regulation and marketing (Pelzer & Reith, 2001; Mintz, 1985). In contrast, cultural geography and anthropology tend to investigate the geography, food chain and cultural significance of a food product in a given location (Cook, 2004; Errington, 2008). In this article, we include five different perspectives and research traditions into the biography format; a manoeuvre that transforms it into a new form, which we have chosen to call the *multidisciplinary commodity biography*.

However, in addition to being a multidisciplinary commodity biography, which can be seen as a contribution to food studies in itself, the writing of this text was also an occasion to experiment with and reflect upon interdisciplinary work. Thus, in this article, we pursue the dual aim of writing collectively about whey and of thinking about what collective, interdisciplinary writing entails.

## 3. Material and methods

The analytical section of this article consists of two distinct parts. The first part is made up of five disciplinary descriptions of whey protein. The five descriptions are written by one or more members of the five participating research groups in the CALM project. All of the research traditions involved in CALM are thereby represented in the biography. The idea of experimenting with the format and content of joint publications originated in the network for young researchers working in CALM. Therefore, the five monodisciplinary descriptions that make up the biography are mainly written by young researchers at PhD and postdoc level. The stipulated maximum length of the descriptions was 700 words, and the only guideline specified with regard to their content was that they should include a definition of whey protein as seen from the author's disciplinary perspective. We have chosen to retain all of the

[1] For more information about CALM and its design, see the project website www.calm.ku.dk.

individual features of the five descriptions. Therefore, the references and language in the five texts have not been edited for consistency because to do so would compromise the different monodisciplinary writing and reflection styles. However, all of the authors were asked to use short-form references so that we could compile a common bibliography.

Human perception as well as the mental and linguistic categorisation of objects has long been a heavily researched field within cognitive sciences (Rosch, 1973, Rosch, Mervis, Gray, Johnson &, Boyes-Braem, 1976; Geeraerts, Kristiansen &, Peirsman, 2010). This research highlights, among other things, the challenges of getting multiple contrasting epistemologies to coexist and cooperate in a single text. The five descriptions in the biography section, which are written without any mediating explanations, were inspired by *the theory of doors*, as depicted by professor in terminology and linguistics Teresa Cabré Castellví (Cabré Castellví 2003). Cabré Castellví introduces the theory of doors to allow for the creation of insights into the multidimensionality of terminological units. She emphasises that analyses that aim to embrace more than one theoretical perspective need conscious structuring in order to ensure the fruitful co-existence of different approaches within a single text. According to Cabré, the multidimensional aspects of such units are best investigated opening up one analytical door after another. This approach provides new access to the object of study each time a new door is opened and allows different theories and analyses to co-exist in a single text or study. In the present biography, the five monodisciplinary descriptions function as doors to the object of whey protein, which are opened for the reader one at a time. By choosing not to add any mediating text to this section, we allow the doors to provide unmediated access to each version of whey protein. Depending on the reader's background, some of the doors will open onto versions of the object that are more easily recognisable than others. In this way, the biography represents the everyday challenges (and benefits) researchers deal with when communicating and working in an interdisciplinary manner.

The second part is a meta-analysis of what happens to whey protein as a mono and interdisciplinary study object and to the format of the commodity biography once all the doors have been opened. The analysis is inspired by recent cultural theories about how the nature of objects, facts and phenomena differ according to their context and describer, and how their being is constantly shaped through negotiations of these differing perspectives (Law & Singleton, 2003; Mol, 2002; Tsing, 2012; de Laet & Mol, 2000). Thus, the analysis investigates types of weak or strong, direct or indirect, realised or possible connections between the different types of knowledge about whey protein that the five descriptions create. Furthermore, it reflects upon what the descriptions reveal about the challenges and potential benefits of doing interdisciplinary research and of choosing the commodity biography as a format for interdisciplinary experimental writing. Within the vaguely defined fields of inter, multi, and transdisciplinary studies, identifying and describing possible kinds of collaboration and the challenges and possibilities that they entail has attracted a great deal of attention (see for instance Chettiparamb, 2007; Klein, 2008). This article contributes to this discussion with a practical example of a joint publication that attempts to repurpose a known monodisciplinary format and reflect upon what happens when all the participating research traditions are given equal space and importance.

The chosen format means that the article belongs to two distinct research fields. As a commodity biography, it belongs to the field of cultural food studies, while as a joint publication experiment, it belongs to the more ambiguous field of research discussing the challenges and possibilities of inter and multidisciplinary research.

## 4. The Biography. Opening five doors to whey protein

### Whey in 19th century Denmark – a historical perspective

Production of whey increased in Denmark throughout latter half of the 19th century due to the industrialisation of the dairy industry. Whey was originally seen as a by-product, and it was commonly used by dairy farmers as feed in a complementary production of pigs. However, the rapid professionalisation of the pork industry from the 1880s onwards brought about an increased focus on the nature of whey. Therefore, historically speaking, in the Danish context, whey is closely tied to both dairy and pork production. Even though historians have investigated the Danish dairy, pork and slaughter industries as well as the qualitative developments of some dairy and meat products, no historical analyses of whey exist as yet.[2]

This analysis contributes with insights into how the combination of scientific knowledge and pork production practices in the late 19th century changed the perception of whey in Denmark.

From 1883, the *Laboratorium for Landøkonomiske Forsøg* (Laboratory for Agri-economical Trials) located at the *Royal Veterinary and Agricultural College* in Copenhagen started several series of tests with the aim of improving the quality of Danish agricultural products. One of these series became known as *the feeding trials*. The aim was to investigate how different types of feedstuff influenced the growth of farm animals and the quality of their meat.[3]

From 1883 to 1886, the first systematic trials with pig feed were conducted. One of the aims of these trials was to establish how and to what degree skimmed milk and whey could substitute each other.[4]The trial report shows that the relationship between the two products was debated among pig farmers. *"Alongside these considerations, the question of the relationship between the feed value of skimmed milk on the one hand and whey on the other always presents itself."*[5]Thus, skimmed milk and whey were both perceived as dairy waste products with unknown nutritional value. The report shows that the trial set-up was inspired by the practical experiences of pig farmers, which indicated that the products were interchangeable, rather than by scientific knowledge or theories.[6]Hence, the scientists had doubts as to whether it was at all possible to exchange skimmed milk with whey without making substantial changes to the remaining feed (grain). The report shows that the trial proved that the whey-fed pigs gained a little more fat and resultantly developed slightly inferior meat compared to the milk-fed animals.[7]In spite of these minor differences, the scientists determined that the rate of substitution whey/

[2] Bjørn, *Dansk mejeribrug*; Leisner, "Weeds, heat"; Nielsen, "The making of"; Jensen, "The consumption"; Jensen "The nutritional transformation".

[3] For insights into the measurement of meat quality, see Gjerløff & Jensen, "Svin – Kvalitet og kontrol".

[4] Beretning (10.), 3.

[5] Ibid, 15. In Danish, *"Med ved disse Overvejelser opstaar altid Spørgsmaalet om Forholdet mellem Foderværdien af skummet Mælk paa den ene Side og Valle paa den anden."*

[6] Ibid., 17.

[7] Ibid., 53–55.

skimmed milk was 2 to 1 and that the products were therefore interchangeable.

After the completion of the trial, both products were chemically tested to determine their protein, carbohydrate and fat content. The chemical test proved that the 2 to 1 relationship made sense in terms of chemistry, as the protein content of skimmed milk is twice as high as that of whey. [8] The trial thereby showed that the protein component of these dairy products determined their value as feedstuffs. The combination of the chemical test and the practical experiment showed that chemical analyses of feedstuffs could provide trustworthy insights into the usefulness and effects of different kinds of feed. This was not new knowledge, as it built upon the work of German chemists, starting with Justus Liebig in the 1840s, but it was the first time that this combination of tests were systematically performed on pigs in Denmark. From then on, chemical analyses of feedstuffs were integrated into *the feeding trials* and thereby changed the way in which feedstuffs in Denmark were measured and perceived. As a result, the perception of the nature and capacities of whey also changed. It went from being a waste product with uncertain properties to being a useful protein source in pig production that, when substituted at a 2 to 1 ratio, had the same impact on pigs' meat as skimmed milk.

**What is whey protein? A physiological reality**

Food primarily consists of the macronutrients fat, carbohydrate, and protein. The human body can store and utilise all of the macronutrients for energy production, but only protein also serves as a structural and functional compound, providing structure in all organs and cells as well as function (e.g. contraction of muscles).

Protein consists of long chains (i.e. peptides) of a variety of the 20 different amino acids, of which 9 amino acids are essential and must be provided through the diet.

Protein quality and effect on the human body

In a physiological setting, the biological quality of a given protein can be categorised by the protein digestibility corrected amino acid score (PDCAAS), (WHO, 2007), which reflects the physiological efficiency and utilisation of a protein. Whey, milk proteins and animal proteins in general are considered good quality proteins based on PDCAAS. Whey makes up around 20% of protein in normal bovine milk and the remainder consists of different forms of casein (Bylund, 1995). Based on its molecular structure and digestibility, whey is considered to be a 'fast' protein, and casein is considered to be a 'slow' protein (Boirie et al., 1997). In young humans, the digestibility of a protein has been shown to have an independent effect on the whole-body protein metabolism, where slow casein is superior to fast whey (Boirie et al., 1997; M; Dangin et al., 2001). The difference between whey and casein is reversed in elderly individuals, for whom whey has been shown to be superior to casein (Dangin et al., 2003).

Beside differences in digestibility, whey and casein also differ in their amino acid compositions. For example, the leucine concentration is roughly 11% in whey protein isolate and 9% in caseinate, and the concentration of branched-chain amino acids/total amino acids is around 23% in whey protein isolate versus 20% in caseinate. The branched-chain amino acids and especially leucine have been shown to be highly potent with regard to the cellular mechanisms underlying muscle protein synthesis (Atherton, Smith, Etheridge, Rankin, & Rennie, 2010; Kimball & Jefferson, 2006), but human studies are more equivocal (Matthews, 2005). In elderly people, leucine has a profound effect (Katsanos, Kobayashi, Sheffield-Moore, Aarsland, & Wolfe, 2005; Rieu et al., 2006), and high leucine content in ingested protein is required to reach the optimal muscle protein synthesis response in the elderly and thereby overcome the age-related anabolic resistance (Katsanos, Kobayashi, Sheffield-Moore, Aarsland, & Wolfe, 2006). Although whey with high leucine content is considered to be highly effective for muscle protein metabolism, it is important to bear in mind that only a small number of comparative studies between milk proteins and other types of protein (e.g. meat or vegetable protein) have been conducted.

Whey protein has been studied in detail in several short-term studies involving both young and elderly people, but there are not many longitudinal studies on elderly people. A few have been conducted, and in one of them, the group included 65 frail elderly people (80 years) randomised to either 15 g of milk protein twice daily or a placebo twice daily for 24 weeks. They found a significant increase in physical performance in the protein group, whereas no change was seen in the placebo group. The muscle mass or strength did not change in the protein group (Tieland et al. 2012a). Another study by the same group (Tieland et al., 2012b) found that in frail elderly people, the same supplement induced muscle growth when combined with heavy strength training, whereas strength training alone did not. These two studies underline the efficiency of ingesting milk protein; it can improve physical function, but to gain muscle mass, strength training is necessary. In contrast, strength training's amplification of the effect of protein supplementation on muscle size, strength and function seems to disappear if subjects are healthy and a little younger (70 years) (Leenders et al., 2013).

In summary, despite a clear effect of whey and casein on muscle protein synthetic response, the long-term beneficial effects of protein ingestion are modest in the healthy adult, although frail elderly people might benefit from supplementation in terms of improved physical function.

**Sensory properties of whey proteins and their application as a functional food ingredient**

One of the most important factors in consumer acceptance of food is its flavour and texture. The sensory properties of whey proteins (WP) in addition to their functional and nutritional properties are therefore crucial in determining their adoption and performance compared to other protein sources.

WP are recovered via membrane processing of the fresh liquid whey stream resulting from cheese making, and thus the very first source of flavour variability is the type of raw product stream (Drake, Miracle, & Wright, 2009). However, finished dried proteins (concentrates and isolates) also display flavour variability (Drake, Karagul-Yuceer, Cadwallader, Civille, & Tong, 2003; Russell, Drake, & Gerard, 2006). The host of processing techniques used to concentrate and

[8] Ibid., 61–64.

separate the WP (e.g., pasteurisation, membrane filtration, concentration and spray drying) is undoubtedly responsible for this variation, though the impact of specific processing parameters on the final WP flavour is poorly reported in the literature (Drake et al., 2009). Accordingly, a number of studies have looked at the sensory properties of WP and their flavour contribution in ingredient applications (e.g., Childs, Yates, & Drake, 2007; Drake et al., 2003; Evans, Zulewska, Newbold, Drake, & Barbano, 2010; Lee, Dangaran, Guinard, & Krochta, 2002; Russel et al., 2006).

Sensory variations between different WP products were documented by Russel et al. (2006), who compared WP concentrate (WPC80, 80% protein content) and WP isolate (WPI, min. 90% protein) available from commercial suppliers. They discovered a large variation among samples pertaining to visual characteristics (opacity, colour intensity), mouthfeel characteristics (astringency, viscosity) and many primary flavours (cardboard, sweet aromatic, metallic, soapy and so on). In addition to whey sources, Russel et al. (2006) suggest that processing differences (storage of liquid whey, processing temperatures) at different production plants may be responsible for sensory differences among whey products.

In addition to displaying their own sensory properties, WP can also interact and bind with volatile compounds, and the flavour properties of whey-enhanced products can be influenced in this way (Kuhn, Considine, & Singh, 2006). Therefore, it is necessary to understand what flavours WP impart in specific applications and thus, due to the importance of whey as an ingredient, previous work has also addressed sensory properties of whey when incorporated in different food matrices. Common food applications include meal replacement bars and beverages, seasonings, coatings for snacks, dairy desserts, infant formulas, sauces and soups, among others. Whey-based products can fulfil a variety of functions – e.g. carrying and enhancing flavours, increasing volume, modifying texture, and increasing nutritional value – which can improve consumer acceptance of the finished product.

In recent years, the main drive behind the interest in WP is the growing health and wellness trend, which has led to an increased interest among food and beverage manufacturers in boosting the protein content of products. Whey has long been popular in the sports industry as a muscle-building supplement, and current trends point to a much wider range of applications as a functional food ingredient. Generally speaking, dairy products and, by extension, dairy proteins are perceived as healthy and palatable by consumers (Russell et al., 2006), which should further facilitate the adoption of functional foods containing these proteins. For example, consumer segments who are motivated by weight-control may be interested in whey-enriched products that "increase feelings of satiety" (van der Zanden, van Kleef, de Wijk, & van Trijp, 2014). Accordingly, appetite suppression and weight control are reportedly among the top 3 most important motives for purchasing protein bars (the last one being that protein bars help develop lean body mass and muscle – see Russel et al., 2006).

A particularly important field of application is elderly nutrition: a high-quality protein such as whey is particularly suitable for promoting optimal protein intake in the elderly (Wolfe, Miller, & Miller, 2008).

As applications for WP continue to increase, their flavour and performance as a food ingredient will determine their widespread adoption and appropriateness compared to other protein sources. Consumers' perception of functional foods containing whey is crucial to the successful design and market ingredient applications of WP products. Positive consumer attitudes towards dairy proteins, combined with the high functional versatility and nutritional value of whey, are a promising starting point for food product development. Accordingly, documenting the flavour properties of these proteins in specific product applications is an important area for future research.

**Whey, ageing bodies and everyday life practices**

In the ethnological study in CALM, the clinical trial is studied as a knowledge tool of active ageing; i.e. it mobilises and configures ageing bodies and "good later life". Thus, an area of interest in the study in relation to whey is ageing bodies and the heterogeneous everyday practices in which whey protein "is enacted into being" (Law & Singleton, 2005, p. 5).

Based on ethnographic fieldwork in the clinic and in the homes of the research participants, the ethnologist shows how the clinical intervention offers research participants new forms of knowledge, insights, vocabulary and understanding related to their ageing bodies. The British sociologist Nicolas Rose has argued that biological knowledge forms us as biological subjects and bodies, and that we are becoming more and more aware of how to form, work on and change our physical potentials (Rose, 2007). As biological subjects, it has become our duty to care for ourselves. The older research participants are aware of the current scientific and political preoccupation with and expectations related to protein in the sense that they prefer to eat protein, though not specifically whey protein, rather than carbohydrates. Some trial participants mention that they have skyr[9] or eggs for breakfast in order to achieve what one of them describes as "*(…) a longer sense of satiety and a body that can just go on and also stay adequate just a little longer. I told my grandchildren that I would like to live until I'm 114.*" (Niels 29.6.2014). This shows how preferences for food not only depend upon biologically determined needs but also upon the cultural and individual values ascribed to them in a given time/place (Haraway, 1997).

In line with physical activity (e.g. Katz, 1996; Juul Lassen & Moreira 2014), protein, as something both nebulous and recognisable, becomes a means to achieve the good and, not least, the long life. While they are involved in the trial, the research participants are introduced to protein as an abstract notion related to concepts of well-being, maintenance of the body, and physical autonomy. However, unlike actors involved in the diverse scientific practices of CALM or in fitness or training environments, the research participants do not, in general, have much knowledge about or reflect upon different types of protein, and they do not consider consuming ***whey*** to be a possible way to sustain the body: "*I don't think the supplement makes a difference, you know. I can't feel it, I just drink it. But training has made me stronger – that is why I'm planning on continuing*

[9] Skyr is an Icelandic dairy product which is very popular being a high-protein and low-fat product.

*training.* (Finn, 10.3.2015). Rather, the whey supplement that is given to the participants in small foil bags becomes a part of everyday routines disconnected from any sense of muscular or bodily strength. The supplement is not necessarily perceived as a food or a drink. One research participant, Anne, takes her whey protein supplement along with her vitamins every morning because: "*(…) it is not a meal, but I know it is probably good for something somehow. That is why I take it with my vitamins* (Anne, 1.7.2014). Another research participant points to what he calls the "unnatural" nature of the supplement. He does not want to help "*science and industry develop new types of products that are not even real food!*" (Svend, 17.12.2014). Other research participants, primarily women, are interested in how many calories the small bags of whey powder might contain. For them, stabilising their weight is an important element in a good ageing process, both in terms of their health and their looks: "*If I gain weight, I will stop eating that supplement. People still turn their heads, when I walk down the street. Looking good is ageing well!*" (Lene, 25.11.2014). Thus, whey can be seen as "a pattern of presences and absences" (Law & Singleton, 2005, p. 342f).Whey is present in the clinical practices but it is also enacted as an element in the everyday lives of the participants. However, generally, it is absent from everyday practices and the ways in which research participants cope with the ageing process. This means that, for the research participants, whey protein is not important *in itself.* Its importance depends upon everyday practices, tacit and embodied routines, affects and emotions, all of which are negotiated and shaped by lifetime experiences, different agendas and discourses, and in different socio-material settings (Löfgren, 2015).

**Whey proteins and the gut microbiome and metabolome**

The human gut microbiota (GM) is inhabited by trillions of microorganisms that perform a wide variety of metabolic roles, such as the extraction of nutrients from otherwise indigestible food matrices (Ley et al., 2005). GM dysbiosis has been associated with metabolic imbalances and several chronic human diseases, such as obesity, type-1 and type-2 diabetes, Crohn's disease, and others (Iliev et al., 2012; Larsen et al., 2010; Musso, Gambino, & Cassader, 2011; Nielsen, Krych, Buschard, Hansen, & Hansen, 2014; Rajca et al., 2014; Soyucen et al., 2014; Tremaroli & Bäckhed, 2012).

For many years, whey proteins have been investigated due to their high nutritional value and functionality for the human body (Cooper, Brown, Hocking, & Mullen, 2016; Nilsson, Holst, & Björck, 2007). In our gastrointestinal tract, proteins are primarily degraded in the small intestine by the action of host proteases and proteolytic bacteria like those belonging to *Clostridium* and *Bacteroides* genera, propionibacteria, bacilli, and streptococci (Bröer, 2008; Scott, Gratz, Sheridan, Flint, & Duncan, 2013). The breakdown of proteins creates a pool of small peptides (tetra-, tri-, di-) and amino acids, which can either be up-taken by intestinal absorptive cells to be used in further protein synthesis (anabolic activity), energy and bioactive precursors (Bröer, 2008) and/or be metabolised by gut microbial members, thus generating a large diversity of secondary metabolites. These bacterial products include ammonia, hydrogen sulfide ($H_2S$), short-chain fatty acids (SCFA), phenolic compounds and others, some of which are well known for their beneficial and adverse effects, while others have as yet unknown health effects (David et al., 2014; Mafra, Barros, & Fouque, 2013; Scott et al., 2013). Remarkably, adverse effects of increased protein fermentation implicated by high protein intake have also been suggested (Yao, Muir, & Gibson, 2016).

It is well known that factors such as age, exercise, use of antibiotics, location, and diet shape the GM composition (Claesson et al., 2012; Clarke et al., 2014; Power, O'Toole, Stanton, Ross, & Fitzgerald, 2014). However, our current understanding of how whey and other dietary proteins influence the composition and functionality of our GM is still limited. The interactions between diet and the GM composition of healthy individuals have mainly been evaluated using non-protein diets (Power et al., 2014), although recent work focused on long-term food frequency questionnaires (FFQ) showed that GM composition driven by intake of animal protein, fat and amino acids (more westernised diets) can be classified in two enterotypes (Wu et al., 2011). However, the very few attempts that have been made to describe the direct impact of whey (whey protein isolates; WPI), milk-derived and other proteins on GM have only been performed in animal and *in vitro* models.

In mice, McAllan et al. (2014) showed that the inclusion of WPI in the diet (using WPI as $\leq$20% of the energy intake) changed the relative distribution of the GM members, increasing the abundance of beneficial *Lactobacillus* while decreasing *Clostridium* abundance compared to non-protein diets. The metabolome of the mice revealed that the inclusion of WPI reduced the levels of plasma leptin, liver triacyglycerol and increased the levels of essential amino acids in plasma. In *in vitro* models (using microbiota of ulcerative-colitis patients), the intake of different quality of bovine serum albumin (BSA) was also associated with changes in GM composition. Glycated BSA promoted high abundance of clostridia, *Bacteroides* and sulfate-reducing bacteria, meanwhile the abundance of functional taxa, such as eubacteria and bifidobacteria decreased compared to native BSA. Additionally, the intake of native BSA was significantly associated with higher levels of beneficial SCFA (Mills et al., 2008).

Undoubtedly, the intake of whey protein and its by-products has potential benefits for the human body, and thus their application in the food industry will continue to increase steadily. However, there is also clear evidence that proteins, depending on their nature and status, can influence our GM composition and functionality. To our knowledge, no human-intervention trials studying the impact of protein on the gut microbial members have yet been carried out. Consequently, it would be very interesting to design longitudinal and cross-sectional studies establishing in detail how the ingestion of whey, its by-products and other dietary proteins influence the GM composition, identifying potential interactions with the overall metabolome and its relationship to health benefits and human diseases.

## 5. Mutual contributions; contextualisation of knowledge, contrasts and new dimensions

The biography clearly shows that within the CALM project, whey protein is imagined, described and exists in numerous ways in spite of being a common object of study. What emerges is a biography composed of a series of stories about whey protein, which reveals that it is not one thing, i.e. one coherent object, but rather a partially known object embedded in partially related realities (Law & Singleton, 2003).

Despite the apparently fragmented narrative created by the door methodology, a closer investigation of the biography reveals that the descriptions contribute and relate to each other in various ways. One link is what we call the contextualisation of knowledge, where one description of whey protein provides the context for some of the other descriptions. Another is the production of contrasts, where, for instance, different and contrasting understandings of value become visible. The descriptions are also interconnected in that they add new (interdisciplinary) dimensions to the monodisciplinary fields.

One linkage between the descriptions that contributes to a contextualisation of knowledge is the prominent presence of the chemical definition of whey protein. This feature is present in all of the descriptions except the ethnological. In the historical description, we hear about the origin of the dominant understanding of whey as a chemical entity. This story provides a historically situated account of how the chemical definition of whey protein came to dominate as a result of changing knowledge structures and technologies. The physiological, sensory and microbiological descriptions all display certainty about the chemical composition of whey protein. The historical account conveys a contextualisation of this certainty, characterised by the fact that it recounts *a* history of the construction of whey protein as an entity whose fundamental characterisation changes over time and is produced in specific settings. It is also striking that to the physiologists, microbiologists and sensory scientists, this uncertainty is non-existent. The certainty in these descriptions of the chemical composition and the positive influence on human muscle tissue portray whey protein as a cocoon or carrier of a specific set of chemically identifiable abilities and proven physiological effects.

However, even though the certitude about the chemical nature of whey protein is prominent in all three descriptions, it becomes clear that the sensory and microbiological texts both display uncertainties as they go beyond the established knowledge about the effect of whey on muscles and bring the protein into new areas where it is the doings or the workings of protein, rather than its effects, that are of interest. For the sensory scientists, whey protein is defined as a) a protein b) with a specific flavour. Whereas the chemical composition of whey is black boxed, its taste is surrounded by uncertainties. In the sensory description, it becomes apparent that the taste is far from stable and is presumably dependent upon external production conditions. Moreover, when mixed with other flavours, the whey protein changes not only its own taste but also that of the other ingredients in ways that are hard to grasp; there are no previous trials or prior knowledge to tell the researchers what to expect. Therefore, for the sensory scientists, much of what characterises whey protein is what it has in common with other kinds of dairy proteins. This way of understanding whey protein through comparisons of its effects is similar to that of the physiologists, but due to the lack of knowledge about how it interacts with and influences flavour properties, it is also profoundly different. This mixture of certainties and uncertainties is also prominent in the gut microbiome/metabolome text. For the microbiologists, the effect of whey protein on gut microbiota and metabolome is as unknown as its effect on taste. This uncertainty pertains to whether whey protein intake modulates the GM in a way that could provide health benefits or, conversely, cause adverse effects.

In this way, the different descriptions of the nature of whey reveal contrasts in the degree of certainty about the nature of the object as well as differences in the perception of the contextualisation that is needed to properly understand and situate whey protein in the four research traditions. Viewed as a whole, the descriptions, their uncertainties and situatedness thereby give rise to new discussions about the nature of whey protein and what we think we know about the influence of the protein structure on, for instance, its taste and its effects on tissue, gut and muscles in general.

Another link between the descriptions is what we have called the production of contrasts. The five descriptions all portray whey as a potentially valuable product but they do so in very different ways. The physiological text shows that whey protein is a specific kind of protein – specific because of its chemical nature and its potential effect on muscle tissue. This, in turn, determines its value as a potential 'muscle-booster' compared to the abilities of other proteins with less potential. Thus, whey is not a valuable product simply because it is a protein but because it is a specific protein that is considered to be better at stimulating muscle protein metabolism than other proteins. To the microbiologists, the value of whey protein is more linked to its ability to provide new knowledge about the influence of specific kinds of protein on the human gut and the mechanisms of the GM and metabolome. Whey protein per se is not their main interest, but they use the protein as a gateway to understand processes and compositions. To the sensory scientist, whey protein has value as a potentially healthy food additive and nutritious supplement, but this value is challenged by its bitter and unstable taste properties, which make it difficult to integrate into food products in a way that is sensorically appealing. To the ethnologist, the value of whey protein in everyday practices is harder to identify, as the trial participants were generally unaware of its existence before volunteering for the intervention. To them, whey protein is a commodity and food item without meaning. This may stem from its historical use. Indeed, according to the historical description, the value of whey was determined by its effect as pig feed. This value is disconnected from the human body and the realm of food and instead attached to the production of pork. This suggests that whey protein, at least in the Danish context, does not have cultural value as food but is instead perceived as a waste product or pig feed. However, this absence of cultural value does not mean that the value, or potential value, of whey protein is completely absent in the minds of the trial participants, who generally recognise the importance of eating protein as part of a healthy diet. Thus, this version of value is, as in the physiologist's description above, solely related to the protein-as-muscle-builder aspect of the commodity. Viewed together, the descriptions thereby shed light on how value is present in the project in various ways, which partially relate to and contrast each other. Furthermore, the construction and assessment of the value of whey protein and the way in which this changes depending on by whom, how and where value is assigned are brought to the fore. The descriptions also show that the way in which the value of whey protein is perceived and constructed influences the understandings of its usefulness and acceptability.

A final dimension we would like to illuminate is how the very different stories of whey protein open up for 'hidden' interdisciplinary doors within the mono-disciplinary descriptions. They show, for instance, how the chemical structure of whey protein appears to be a shared interest, which is present across disciplinary boundaries even though it is handled and perceived differently. Additionally, they show how some research traditions such as

ethnology and physiology, which belong to very different areas of science and are normally believed to have differing perspectives and research questions, share interests in themes such as paying attention to the (healthy and fit) body and, thus, the processes and practices involved in increasing muscle strength. Finally, they also expose the clefts between the creation of value in the different research traditions. Together, the five descriptions thereby exemplify the contextualisation of knowledge as well as the contrasts and the interdisciplinary features of an interdisciplinary project, and how this way of analysing a shared object of study opens up a range of new perspectives and questions. This occurs when different research traditions are allowed to co-exist in the same multidisciplinary text.

## 6. Rethinking the commodity biography

It is evident that the five descriptions in the biography neither add up to a coherent and seamless whole nor provide an overarching solution to the challenges of interdisciplinary thinking and writing.

The present commodity biography differs from previous biographies in that it dissolves the commodity into a range of fragments that describe the many lives – or realities – of whey protein. The additional layers of knowledge created through this fragmentation indicate that the differences between the multiple realities are not a problem but rather an asset that can bring about a better understanding of the object of study while also opening up pathways to new types of overlapping fields of interest. The multidisciplinary commodity biography has the ability to provide multiple insights into a given commodity and has methodological potential as a tool that can be used to increase awareness about common objects of study and to open up discussions about working, thinking and writing in an interdisciplinary manner. However, the biography, at least in the form we have chosen, does not bring forth new types of research questions, as such. Rather, it indicates how such questions may arise as a result of the construction of this kind of experiment.

Thus, the biography format has the ability to include multiple perspectives and highlight overlapping interests. This allows the participating research traditions to play an equal role as valuable discussion partners without assuming equality or essential underlying similarities with regard to the knowledge and perspective they bring into the discussion. The format thereby facilitates coexistence and the creation of an analytical platform that may assist researchers in identifying common or overlapping interests, perspectives and research questions.

## 7. Concluding remarks

This article presents a multidisciplinary commodity biography of whey protein with an experimental format that doubles as an interdisciplinary experiment and the subject of a meta-analysis. In many respects, it is an article that breaks with established publication formats. As a commodity biography, it provides multiple types of insight into whey protein and offers a new type of commodity biography – the multidisciplinary commodity biography. As an interdisciplinary experiment, it shows how rethinking existing formats may facilitate the integration of multiple perspectives into a single text on equal terms, without equalising or adapting the perspectives and insights they bring to the table. It also shows that this type of experiment has the potential to bring forth new knowledge about the object of study as well as how different research traditions can contribute to each other.

However, this article does not reach any specific conclusion that provides a complete insight into all of the possible realities of whey protein or solves the challenges of interdisciplinary research. Nevertheless, we hope that it can serve as both a source of knowledge about the multiple realities of whey protein as a commodity and an inspiration to other researchers to invest in experiments that fall outside of established categories but have the potential to illuminate the multiple realities, points of departure and analytical possibilities of collaborative research.

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1: Have made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data:
Conception and design: TJ, RB, SR,DG, MO, JC, HA, AJ.
Acquisition of data: TJ, RB, SR, DG, MO, JC, HA.
Analysis and interpretation of data: TJ, RB, SR, DG, MO, JC, HA, AJ.

2: Have been involved in drafting the manuscript or revising it critically for important intellectual content:
Drafting manuscript: TJ, RB, SR,DG, MO, JC, HA, AJ.
Revising manuscript critically: TJ, RB, SR, DG, MO, JC, HA, AJ.

3: Have given final approval of the version to be published.
Final approval of published version: TJ, RB, SR, DG, MO, JC, HA, AJ.

4: Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Each author should have participated sufficiently in the work to take public responsibility for appropriate portions of the content. Acquisition of funding, collection of data, or general supervision of the research group, alone, does not justify authorship.

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