The impact of raw fermented milk products on perceived health and mood among Dutch adults

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Abstract

Purpose – The purpose of this paper was to evaluate health conditions prior to and at least two months after the start of consuming raw fermented milk (RFM) products.

Design/methodology/approach – One-Item health score, 1-item immunity score, immune status (ISQ), mood, bowel and skin conditions were rated for the period prior and post switching to RFM products. A linear mixed model was used to evaluate the post to prior RFM health and mood scores, taking into account gender, location of living and health group. Data from 390 participants (mean age of 54 years old) were included for the analysis, of which 277 (45 per cent) were allocated to the poor health group. Participants were allocated to the poor health group if they reported being immune depressed or suffering from a chronic disease prior to RFM; otherwise, they were allocated to the normal health group.

Findings – The highest intake of RFM was from RF kefir. Post RFM, people consumed around 1 glass (200 ml) of RF kefir per day. After switching to RFM, significant improvements on health and mood scores were reported. The strongest improvements after switching to RFM consumption were seen in subjects from the poor health group. With the exception of skin score, all measured health items significantly improved ($p < 0.001$). Health, immunity, bowel and mood scores increased with around 20 per cent in the poor health group and around 8 per cent in the normal health group. Women had more health complaints prior to RFM and had stronger health improvement post RFM compared to men. Bowel and mood scores were overall lower in women than in men. Living location had no significant impact on RFM-related health changes. This consumer survey suggests that positive health and mood changes are associated with the consumption of RFM products.

Originality/value – The consumption of RFM products improved the self-reported health status of adults. Immune-depressed people or people suffering from a chronic disease prior to RFM reported the strongest impact on their health, immunity, bowel and mood scores post switching RFM consumption compared to people with a normal health.

Keywords Mood, Perceived health, Gastro-intestinal complaints, Kefir, Perceived immune functioning, Raw fermented milk products, Skin complaints

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Introduction

Globally, there is considerable interest in increasing consumption of raw milk products as consumers have recognized the health promoting effects of raw milk (Schmid, 2009; Baars, 2013; Whitehead and Lake, 2018). People have consumed raw fermented milk beverages (RFM), such as kefir, over thousands of years. RFM products have traditionally been produced on the basis of spontaneous acidification (Macori and Cotter, 2018; Velikova *et al.*, 2018). Nowadays, selected bacteria found in raw milk (*Lactococcus*, *Bifidobacteria* and *Enterococci*) are used as probiotic fermenters. It has been shown that various strain specific bacteria can improve immunity (Rosa *et al.*, 2017). Pro-, pre- and syn-biotics play an important role in the development of the intestinal flora and the production and availability of nutrients. The intestinal flora composition has been associated with a range of non-infectious diseases (such as asthma, allergies, autoimmune diseases, osteoporosis, Type 2 diabetes, obesity, hypertension, heart failure, fatigue and emotions) (Marco *et al.*, 2017; Xu *et al.*, 2017; Buendia *et al.*, 2018; Beltrán-Barrientos *et al.*, 2018; Hsu *et al.*, 2018). Gut microbes show psychotropic properties and specific strains are used as psychobiotics in relation to neurological conditions such as stress, anxiety and depression (Selhub *et al.*, 2014; Misra and Mohanty, 2019). The intake of fermented dairy products may compensate for the negative effect of low bacterial count in the Western diet (Marco *et al.*, 2017). Although most supportive evidence comes from preclinical studies, there are also some human data that have demonstrated the effects of fermented dairy products on the microbiome and associated health effects. Rezac *et al.* (2018) evaluated nine groups of fermented foods and showed that the intake of lactic acid bacteria in fermented milk products (yoghurt, kefir and buttermilk) are in the range of 10^5-10^9 live bacteria/ml. Probiotic beverages, such as kefir and yogurt, contain 10^6-10^9 live bacteria/ml, and a large proportion of bacteria can pass through the stomach alive and reach the intestines (Marco *et al.*, 2017). Various substances play a role in regulating the gut microbiome and maintaining a healthy gut epithelial barrier. The probiotic microorganisms can change the composition and function of the intestinal flora present, especially for daily intake. After a four-week administration of *Lactobacillus kefiri* in healthy volunteers, bacteria causing pro-inflammatory response decreased, thereby reducing gastro-intestinal complaints (Toscano *et al.*, 2017). After 12-week administration of several specific probiotic yoghurt strains, healthy elderly people (>65 years) showed positive changes in their immune function by enhancing the activity of natural killer cells (Lee *et al.*, 2017). Three mechanisms for the gastro-intestinal improvements are the production of metabolic products such as short-chain fatty acids and grow factors; the suppression or stimulation of competing microorganisms and effects on the epithelial layers of the host intestine (Derrien and Van Hylckama Vlieg, 2015). Besides fermented milk products, a wide range of often plant-based fermented foods and beverages is found across the world, all of which contain a diversity of microorganisms (Tamang *et al.*, 2016; Chaiyasut *et al.*, 2018; Jans *et al.*, 2017; Rezac *et al.*, 2018; Agyei *et al.*, 2019).

Almost all studies on milk and health have been performed on pasteurized dairy products; therefore, the possibility of an additional effect of raw milk compared to pasteurized milk might be overlooked. Epidemiological studies among children have shown that consumption of raw milk at a young age is protective against asthma, hay fever and allergies (Riedler *et al.*, 2001; Perkin and Strachan, 2006). Since 2012, kefir and yoghurt based on raw organic milk rather than heat-treated milk have been produced in The Netherlands. The yearly sales are rapidly increasing and people pay a relatively high price per liter for these products. Although preclinical data are supportive of RFM products having health benefits, currently no information is available about the relationship of consumer's health and the consumption pattern of RFM beverages. It is, however, important to investigate how

consumers experience possible health changes associated with RFM use. Therefore, the goal of the current study was to evaluate consumer-perceived changes in health and immune function after the consumption of raw fermented milk products such as raw milk-derived kefir, yogurt, whey and drained RFM products (quark).

Methodology

A study was conducted among current Dutch RFM consumers from February 2018 to April 2018 to evaluate their perceived health and mood prior to and after the start of consuming RFM. Subjects were recruited using a collar on the bottles of organically produced raw milk kefir in various stores in The Netherlands. Subjects were invited to complete an online survey, designed using SurveyMonkey (www.surveymonkey.com). Subjects were included if they were at least 18 years old and changed their dairy consumption more than two months ago. Informed consent was obtained from all participants, and the Ethics Committee of the Faculty of Social and Behavioral Sciences of Utrecht University granted ethical approval.

Background information of subjects

Information on age, height, weight, gender and whether they live in a rural or urban environment was collected. Subjects were asked if before they start using RFM they were suffering from a chronic disease and/or reduced perceived immune functioning. If subjects answered positively in at least one of the two questions, they were allocated to the poor health group. Other subjects were allocated to the normal health group. From the initial survey, 573 questionnaires were returned, of which 450 were complete. Outlier subjects for patterns of milk consumption ($\geq$3 SD from mean) were excluded from the analysis. The final data set comprised 390 subjects, of these 176 subjects (45.0 per cent) were allocated to the poor health group (see Table I).

Dairy consumption

Dairy consumption was assessed both before and after switching to RFM. Before switching to RFM, daily intake of pasteurized milk (200 ml servings), fermented milk (200 ml servings), cheese (portion 50 g), and butter (portion 15 g) was recorded. After switching to RFM, daily intake of raw milk kefir (200 ml servings), raw milk yoghurt (200 ml servings), raw milk whey (200 ml servings) and quark (portion 50 g) made from kefir or yoghurt was recorded. The amount of quark was recalculated to raw milk kefir or raw milk yoghurt intake through a 1:3 factor. A single company produces all raw fermented milk in The Netherlands, and no other producers deliver such products into stores. Therefore, subjects could consume the following raw fermented milk products alone or in combination:

- Raw milk kefir made from fresh, warm, full fat organic milk. Raw milk kefir was based on a standardized fermenter (eXact® Kefir 12, Hansen, Denmark). Hansen indicates that their culture is composed of 14 different microorganisms.
- Raw milk yoghurt made from fresh, warm, full fat organic milk. The yogurt culture contains only two different genera of bacteria, *Acidophilus* and *Bifidobacteria*.
- Quark made from raw milk kefir or raw milk yoghurt is based on the loss of whey after the fermented milk is hanged in cloth during a period of 20-24 h. No rennet is used.
- Raw milk whey from RFM kefir is bottled after mixing a concentrate of Mango fruits.

Table I.
Background information and milk consumption before and after switching to RFM[a]

Population characteristics and consumption pattern	Health status			Gender			Living location		
	Poor	Normal	*p*-value	Men	Women	*p*-value	Urban	Rural	*p*-value
n	176	214		137	253		197	193	
BMI (kg/m[b])	24.0 ± 3.9	23.7 ± 3.2	0.083	25.3 ± 3.4	23.0 ± 3.3	<0.001	23.8 ± 3.6	23.8 ± 3.5	0.944
Age (years)	54.1 ± 13.8	53.7 ± 13.9	0.439	56.6 ± 14.1	52.5 ± 13.5	0.002	52.8 ± 13.8	55.0 ± 13.8	0.028
Years post RFM	2.1 ± 2.4	2.0 ± 2.4	0.649	2.4 ± 2.8	1.9 ± 2.1	0.064	2.0 ± 2.3	2.1 ± 2.5	0.526
Prior to RFM									
Milk [b]	3.2 ± 4.3	2.5 ± 3.6	0.015	4.0 ± 4.7	2.2 ± 3.3	<0.001	2.8 ± 3.8	2.9 ± 4.1	0.497
Fermented milk [b]	5.5 ± 4.0	5.3 ± 4.4	0.608	5.2 ± 4.3	5.5 ± 4.2	0.595	5.0 ± 4.1	5.7 ± 4.3	0.375
Cheese [c]	5.1 ± 3.6	4.7 ± 3.5	0.193	4.6 ± 3.5	5.0 ± 3.5	0.451	4.7 ± 3.3	5.0 ± 3.7	0.697
Butter [d]	4.7 ± 4.5	4.5 ± 4.3	0.892	4.6 ± 4.6	4.6 ± 4.2	0.917	4.0 ± 3.9	5.2 ± 4.7	0.009
Post to RFM									
RFM Kefir [b]	6.2 ± 4.0	5.9 ± 3.5	0.249	6.3 ± 4.2	5.9 ± 3.5	0.263	5.9 ± 3.7	6.1 ± 3.8	0.419
RFM Yoghurt [b]	2.0 ± 3.3	1.2 ± 2.4	0.006	1.6 ± 3.0	1.5 ± 2.8	0.695	1.3 ± 2.7	1.7 ± 3.0	0.262
Sum RF milk [b]	8.3 ± 4.6	7.2 ± 4.3	0.010	8.0 ± 5.0	7.6 ± 4.1	0.208	7.4 ± 4.3	8.0 ± 4.7	0.115

Notes: [a]Mean ± SD and the level of significance for the three main factors: health status, gender and living location based on a general linear model. Differences are statistically significant if $p < 0.05$; [b](200 ml servings); [c](portion 50 g); [d](portion 15 g); and abbreviations: RFM = raw fermented milk products, BMI = body mass index

Perceived immune functioning and health

Perceived immune functioning was assessed with a scale ranging from 0 (very poor) to 10 (excellent), (Van Schrojenstein Lantman *et al.*, 2017). Previous studies revealed significant correlations of 1-item perceived immune functioning scores with mental resilience (Van Schrojenstein Lantman *et al.*, 2017), autism traits (Mackus *et al.*, 2017) and the Immune Function Questionnaire (Van Schrojenstein Lantman *et al.*, 2017). Using a comparable 11-point scale, perceived overall health was assessed.

General immune status

To assess the immune status, the immune status questionnaire (ISQ) was completed (Van de Loo *et al.*, 2018). The ISQ comprises seven items, including common cold, diarrhea, sudden high fever, headache, muscle and joint pain, skin problems and coughing. The items are scored on a five-level Likert scale stating how often the subjects experienced these complaints. Item scores use a bipolar scaling, defining negative and positive responses on a statement (Likert, 1932). The range used is from 0 (never), 1 (sometimes), 2 (regularly), 3 (often), to 4 ((almost) always) and the sum score is calculated. The overall ISQ score ranges from 0 (excellent) to 28 (very poor).

Gastro-intestinal conditions: diarrhea and constipation

The questions were based on the Birmingham Irritable Bowel Syndrome Questionnaire (IBS), (Roalfe *et al.*, 2008), and 10 out of 11 IBS questions were considered. The question of whether people passed mucus or slime was left out. Diarrhea items included leaked or soiled yourself, feeling to immediately rush to the toilet to pass your stool, trouble with loose motions, watery stool and trouble with diarrhea. A five-level Likert scale from 1 (extremely) to 5 (not at all) was used to answer the questions. The sum of the Likert scores was used as an outcome variable in the statistical analysis. The diarrhea score was based on four items (range of 4-20) with higher scores indicating less diarrhea-related disease problems.

Constipation items included pain or discomfort in abdomen, trouble with hard bowel movements, needing to strain to pass a bowel movement, trouble with constipation, pain or discomfort in abdomen after eating, abdominal pain preventing sleeping or waking up during the night. The constipation score was based on the sum of the six items (range of 5-30) with higher scores indicating lesser constipation-related problems.

Skin conditions

The questions were based on the Dermatology Life Quality Index (DLQI) Questionnaire (Finlay and Khan, 1994), and 10 out of 11 DLQI questions were used. The question on sexual difficulties because of skin issues was taken out. The skin score assessed skin conditions: itchy, sore, painful or stinging skin, skin embarrassment or self-consciousness, skin interference with shopping or gardening, skin influencing wearing clothes, skin affecting social or leisure activities, skin interference with any sport, skin influencing work or studying, skin creating problems with partner or close friends and skin treatment making home messy or taking up time. A five-level Likert scale from 1 (extremely) to 5 (not at all) was used to answer the questions. The sum of the Likert scores was used as an outcome variable for the statistical analysis. The overall skin score was based on ten items (range of 10-50), with higher scores indicating a better skin status.

Mood

The questions were based on the profile of mood status scale that describes the psychological distress of people (Grulke *et al.*, 2006). Five mood items included the level of fatigue, level of tension/anxiety, level of depression or dejection, level of anger or hostility and the level of vigor or activity. A five-level Likert scale from 1 (extremely) to 5 (not at all) was used to answer the questions. The sum of the Likert scores was used as an outcome variable in the statistical analysis. The overall mood score was based on four items (range of 5-25) with higher scores indicating a better mood.

Statistical analysis

All statistical analysis was conducted with SPSS (version 20). Mean and SD were computed for each outcome variable. Level of significance was set at $\alpha = 0.05$ for all analysis. To compare the health outcomes before and after switching to RFM (RFM-time), a linear mixed model was used including the factors "health status" (poor health and normal health group), "RFM-time" (prior RFM and post RFM), "gender" (men and women), "location of living" (urban and rural) and their two-way interactions. Participants were the subjects in the mixed model and "RFM-time" was used as a repeated measure, and the covariance was analyzed according the compound symmetry. A two-step transformation to normality was performed for all health outcome sum scores to correct for the skewness of the data (Templeton, 2011). For the statistical analysis of the background information and dairy consumption, a univariate GLM was made based on factors such as health status, gender, location of living and their two-way interactions.

Results

The mean age was 53.8 years old, and 65 per cent were women with 49 per cent reported living in rural areas. Subjects reported 240 different health conditions, of which 26 per cent were related to inflammation and immunity conditions, and 22 per cent were related to bowel conditions. The normal health group comprised 214 subjects (55 per cent) (Table I).

Subjects in the poor health group consumed more RFM Yoghurt and total RFM products than those with normal health. Men were older, had a higher BMI and consumed more pasteurized milk prior RFM than women. Urban living subjects had a lower BMI and consumed less pasteurized butter prior RFM than rural subjects. There were no significant two-way interactions with the exception of Health x Gender for the amount of butter consumed prior RFM ($p = 0.033$) (data not shown).

The health outcomes according to condition (poor versus healthy group), gender, and living location are summarized in Tables II and III.

Overall health outcome and mood score

Both RFM consumption (RFM-time) and health status had a highly significant positive effect on all health outcome variables (see Table II). For gender, effects were smaller and not for all outcomes. Diarrhea was not affected by gender. Living location had no significant impact on any health outcome except for mood. Urban subjects scored their mood significantly lower than rural subjects both prior and post RFM. The improvement of the mood score, however, was the same between subjects with a poor or a normal health (data not shown).

The mixed model showed the significant interactions between health status x RFM-time ($p < 0.01$) for all outcomes, indicating differences in subjects with poor health status compared to subjects in the normal health status group prior and post RFM. Health x Location, Location x Time and Gender x Location were not significant (data not shown).

Table II. Overall health and mood assessed and *P*-values for the main significant factors and relevant interactions[a]

Health and mood score	Overall mean Mean ± SD	*p*-value Health	Time	Gender	Location	Health × Time	Health × Gender	Gender × Time
Perceived health	7.5 ± 1.5	<0.001	<0.001	0.043	0.804	<0.001	0.831	0.387
Perceived immune functioning	7.6 ± 1.5	<0.001	<0.001	0.052	0.475	<0.001	0.814	0.111
Immune status questionnaire	4.4 ± 3.4	<0.001	<0.001	0.010	0.231	<0.001	0.782	0.126
Constipation score	26.0 ± 4.3	<0.001	<0.001	<0.001	0.398	0.002	0.042	0.005
Diarrhea score	18.2 ± 2.3	<0.001	<0.001	0.776	0.557	0.006	0.692	0.909
Skin score	43.5 ± 3.3	<0.001	0.001	0.034	0.577	<0.001	0.837	0.834
Mood score	16.4 ± 3.3	<0.001	<0.001	<0.001	0.001	<0.001	0.859	0.464

Notes: [a]Mean ± SD and level of significance for the main factors Health, Time, Gender and Location and the interaction between Health × Time, Health × Gender and Gender × Time, based on a Linear Mixed Model. Differences are statistically significant if $p < 0.05$

Health and mood score in two groups	Men Prior RFM Mean ± SD	Men Post RFM Mean ± SD	Men *p*-value	Women Prior RFM Mean ± SD	Women Post RFM Mean ± SD	Women *p*-value
Poor health group						
Perceived health	6.5 ± 1.4	7.7 ± 1.3	<0.001	6.2 ± 1.6	7.5 ± 1.4	<0.001
Perceived immune functioning	6.6 ± 1.7	7.9 ± 1.3	<0.001	6.3 ± 1.7	7.7 ± 1.5	<0.001
Immune status questionnaire	6.8 ± 4.0	3.5 ± 2.8	<0.001	7.7 ± 3.7	4.0 ± 2.8	<0.001
Constipation score	24.5 ± 5.0	27.8 ± 2.7	<0.001	21.3 ± 5.4	26.2 ± 3.7	<0.001
Diarrhea score	16.6 ± 2.8	18.4 ± 2.0	<0.001	16.6 ± 2.9	18.5 ± 1.9	<0.001
Skin score	42.1 ± 4.4	44.2 ± 1.2	0.001	41.5 ± 5.1	43.3 ± 4.0	0.002
Mood	15.0 ± 3.9	17.4 ± 2.6	<0.001	13.6 ± 3.6	16.6 ± 3.2	<0.001
Normal health group						
Perceived health	7.9 ± 1.1	8.4 ± 1.0	0.009	7.6 ± 1.3	8.2 ± 1.0	<0.001
Perceived immune functioning	8.0 ± 1.2	8.5 ± 1.0	0.004	7.6 ± 1.3	8.3 ± 1.0	<0.001
Immune status questionnaire	3.7 ± 2.2	2.3 ± 2.0	<0.001	4.6 ± 2.9	2.6 ± 2.4	<0.001
Constipation score	26.9 ± 3.2	28.5 ± 2.1	<0.001	25.6 ± 3.5	28.3 ± 2.0	<0.001
Diarrhea score	18.1 ± 1.6	19.2 ± 1.1	<0.001	18.1 ± 2.0	19.2 ± 1.5	<0.001
Skin score	44.2 ± 1.2	44.6 ± 0.6	0.003	43.6 ± 2.5	44.3 ± 1.5	0.008
Mood	17.2 ± 2.8	18.6 ± 1.9	<0.001	16.1 ± 3.0	17.5 ± 2.6	<0.001

Table III.
Health effects and mood before and after changing to RFM according to gender[a]

Notes: [a]Above: differences for men and women in the poor health group, mean ± SD prior and post RFM and level of significance based on a linear mixed model; Below: differences for men and women in the normal health group, mean ± SD prior and post RFM and level of significance based on a linear mixed model. Differences are statistically significant if $p < 0.05$; Abbreviation: RFM = raw fermented milk products

Because of the interaction between Health x Time, a health status stratified analysis was carried out to see the effects for the two health groups separately and split for men and women.

Health outcome in subject with a poor and normal health, both in men and women

Table III separately summarizes gender effects for subjects with a poor health and a normal health. The effect of gender was larger in the poor health group. Women significantly improved their health scores more than men, especially in the poor health group.

Discussion

This consumer survey on the effects of RFM products on health, immunity, gastro-intestinal, skin and mood conditions indicates that RFM consumers experienced a relevant clinical improvement in several areas of health after at least two months of daily RFM consumption. Subjects classified with a poor health prior RFM experienced the largest health and mood improvement. Women mentioned more health challenges prior RFM than men but also showed a larger improvement in their health conditions after introducing RFM into their diets. Living location had no relevant impact on perceived health. A modern Western diet may have a negative impact on the gut microbiome and increase the risk for associated non-infectious diseases (Lallès, 2016; Zinöcker and Lindseth, 2018). Thus, a change in diet to reduce dysbiosis of the gut flora could have beneficial health effects. This was shown, in the current study, in which even a relatively small change toward the dietary intake of RFM (i.e. on average subjects consumed only one glass of RFM dairy per day) was associated with significant and relevant positive health changes. There are several

functional characteristics in RFM products that could have promoted the increased health of the volunteers in the present study. The functional properties of RFM cannot be separated because we are dealing with a whole food matrix, and the different food characteristics can reinforce each other. To explain the outcomes post and prior RFM, we are dealing with effects of the inclusion of active, living rather than killed or dead microorganisms (Sarkar, 2018), the dose and frequency of bacteria (Rezac *et al.*, 2018), the amount of food bacteria entering the gut and complementing the gut microbiome (Derrien and Van Hylckama Vlieg, 2015; Kok and Hutkins, 2018), the specificity of bacterial strains and yeasts in RFM products (Jans *et al.*, 2017) although shared communalities and mechanisms among probiotic taxa were found (Sanders *et al.*, 2018) and the additional effect of raw milk used rather than heat-treated milk (Chowdhury and Bhattacharyya, 2014). Furthermore, it cannot be claimed that we deal with specific effects of milk products because general effects of other fermented non-milk beverages and foods are also known (Chaiyasut *et al.*, 2018), and there is a global biodiversity of microorganisms and the bio-active metabolites and nutrients produced in all kinds of fermented foods (Savaiano, 2014; Tamang *et al.*, 2016; Şanlier *et al.*, 2017). In a similar retrospective approach based on questionnaires, Chaiyasut *et al.* (2018) showed that Thai consumers were very satisfied about the health benefits of fermented plant beverages. On a five-point scale from excellent (5) till poor (1), the average level of satisfaction was 4.1 (very good), which is comparable with our outcomes.

Findings of studies with probiotics are in line with the current observations of RFM-associated health improvement. In a meta-analysis, including randomized controlled trials in children, it was shown that the consumption of probiotics (*Lactobacillus* and *Bifidobacterium* strains) reduced the prescription of antibiotics for common, acute infections (Pimentel *et al.*, 2018). These bacteria are found abundantly in RFM products that were consumed in the current study, which may explain the reported health benefits of switching to RFM. Thus, further research in consumers on possible health effects and safety of RFM use are essential. Therefore, the replication of the current findings, preferably also in other countries, is warranted.

The present study has several limitations, which should be considered when interpreting the data. The data are self-reported and were collected in a group of people who voluntarily decided to start consuming RFM products and continued to use these products for two months or longer. The study does not capture the people that started to consume RFM products but stopped after a short time. It can be speculated that only people that experienced positive health effects continued RFM consumption over a longer time, which may have biased the outcome of the study. Furthermore, there was no control group of people not consuming RFM. The study is retrospective and its outcome is therefore subject to recall bias. The study should therefore be seen primarily as a first scientific evaluation of such raw fermented dairy products.

Future prospective double-blind studies can overcome some of the limitations described above. These studies should include two groups of subjects: group 1 switches to RFM and group 2 switches to placebo-RFM. Health outcomes of both groups can then be followed over time. The design also allows to differentiate between subjects who benefit from switching to RFM and those who do not. Regarding health outcomes, such studies can focus on patients with either intestinal problems or immune-related health complaints because subjects with a poor health status reported the greatest health benefits from switching to RFM products.

In further research, attention should be paid to the whole matrix of the RFM products. Issues such as the processing of the milk (e.g. heating), milk content (e.g. fatty acid composition), geographic location and system origin (e.g. organic, non-organic) as well as the influence of fermenter composition should be examined to identify the RFM dairy

products have the biggest impact in health outcomes. Finally, supportive evidence provided by animal research (Seo *et al.*, 2018; Qu *et al.*, 2017; Abbring *et al.*, 2017) and research into the changes of the protein, peptide or metabolite pattern (Brick *et al.*, 2017) is required to elucidate the underlying immunological mechanisms.

Conclusions

This retrospective consumer survey indicates that after at least two months consumption of RFM products consumers report significant, relevant clinical improvement in overall health and perceived immune functioning and a reduction in diarrhea, constipation, skin and mood complaints. The largest improvement was reported by subjects with poor health. The effects were more pronounced in women compared to men.

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