Measurement of heart rate variability and emotional profiling to characterize milk quality?

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Abstract

This study examined whether emotional profiling (EP) and heart rate variability (HRV) measurement are suitable for differentiating milk samples. Three different milk samples with the same fat content were tested: one ultra-high temperature (UHT) milk (conventional), one extended shelf-life (ESL) milk (organic), and one pasteurized only milk (organic). The standard chemical parameters were analysed and a sensory descriptive analysis was performed. Two panels (12 and 13 subjects) experienced in introspection underwent HRV measurements and responded to an EP questionnaire. The panels differed in food testing experience. The food experienced panel distinguished the pasteurized milk from the ESL and the UHT milk samples through EP, while the panel without food testing experience found no differences. No significant differences between the samples were detected using HRV. Sensory descriptive analysis revealed a difference only in one taste characteristic between the UHT and the pasteurized milk. Fatty acid patterns of the UHT sample differed from ESL and pasteurized milk samples. The results indicate that the applied methods characterize milk differently: While HRV measurement in our set-up was not suitable to discriminate the samples, EP with food experienced tasters could detect more differences as the sensory analysis.

Keywords: milk quality, emotional profiling, heart rate variability

Introduction

Assessments of the product quality of milk are performed by determining microbiological and chemical parameters and sensory properties [1, 2]. In sensory analysis, a distinction is made between assessments by trained panellists and those by untrained consumers. Each testing method describes different aspects of product quality.

A relatively new approach to assessing food quality is the measurement of bodily and emotional responses on food, which has already been applied to dairy products [3, 4]. In recent years, questionnaires focusing on the perceptions of food-induced emotions have been used [5–8]. The current literature on emotional questionnaires focuses on several aspects, including product specificity, questionnaire length, language, derivation of terms [9], nationality of test persons, frequency of consumption for certain products [10], number of products offered, order of questions [5], temporal dynamics of sensory and emotional effects [11] and the measurement period itself [12]. Panellists' preparatory exercises are not integrated into most methods for measuring food-induced emotions. In the Empathic Food Test (EFT) questionnaire [13] used in this study, a preparatory framework based on the Kabat-Zinn [14] concept of "mindfulness-based stress reduction" was developed as an element. Panellist preparation was introduced because emotions are localized in the somatosensory system [15]. Thus, it was assumed that an improvement in body awareness through preparatory tests leads to an improved perception of emotions evoked by food. A training in self-observation changed the emotional response to food products [16].

The effect of food on physiological parameters has been demonstrated in various studies. One parameter that has been investigated in several nutritional studies is heart rate variability (HRV). HRV is the variation in the time intervals between two heartbeats and reflects the functional state of the autonomic nervous system [17]. A decreased HRV is an indication of increased psycho-mental but also physical stress, whereas an increased HRV indicates a state of relaxation and potential for recovery [18, 19]. A recent South American study, for example, showed that children with a poor diet have lower HRV than those with a healthy, high-quality diet [20]. Other studies have shown that nutrition with different fat or carbohydrate contents have different effects on HRV [21] and that fish oil supplementation can specifically influence important parameters of HRV [22].

The aim of the study was to test whether HRV and emotional profiling are suitable to evaluate milk qualities. For this purpose a comparison was carried out with the results of established methods of milk analysis, namely sensory and chemical analysis.

The research questions of this study were as follows:

- Are emotional profiling (EP) and HRV suitable for the differentiation of similar milk samples? In our case, the fat content was comparable. The samples differed in process methods and origin.
- Are milk samples distinguished differently by means of EP and HRV than by standard chemical analysis and descriptive sensory analysis?

For the study's purposes, three differently processed commercial milks were purchased: one ultra-high temperature (UHT) milk (conventional farming), one extended shelf-life (ESL) milk (organic) and one pasteurised only milk (organic). Two panels trained in self-observation, underwent HRV measurements and responded to an EP questionnaire. By self-observation, we refer to observing how actions affect one's own physical and emotional state.

Table 1: The milk samples used in this study.

Type	Product	Processing	Farming method
Pasteurized	Schrozberger, fresh whole milk, Demeter, 3.8% fat, Molkereigenossenschaft Hohenlohe Franken, brown glass bottle, Schrozberg	Pasteurization only	Organic
ESL	Aldi Bio fresh whole milk, Tetra Pak, pasteurized, homogenized, 3.8% fat	Extended shelf-life	Organic
UHT	Landliebe, long-life milk, Tetra Pak, 3.8% fat, homogenized	Ultra-high temperature	Conventional

Material and Methods

Milk samples: Milk samples were obtained from the commercial market. Samples for the sensory analysis and the chemical analysis were sent to laboratories for testing. The samples for sensory and chemical analysis were transported and refrigerated on 14 May 2018. The HRV and EP measurements were performed between 23 April and 9 May 2018 at the Forschungsring and the ARCIM Institute. To avoid changes due to cow feeding, all analyses were performed over a period of three weeks of 2018. The three milk variants used in this study are displayed in Table 1.

Table 2: The 12 polar items of the EFT questionnaire and their corresponding factor scale.

	Polar items		Scale
My body feels...	Warm	Cold	-
	Bright	Dark	1
	Light	Heavy	2
	Fresh	Exhausted	2
I feel ...	energized	not energized	2
	Awake	Sleepy	2
	concentrated	distracted	2
	Relaxed	Nervous	1
	comforting	Unwell	1
	Satisfied	Unsatisfied	1
	Balanced	Unbalanced	1
The impact feels...	long lasting	Short	-

Sensory profiling – method: A panel of 10 assessors from the Technologie-Transfer-Zentrum Bremerhaven was selected and trained according to the guidelines of the ISO standard (1993). Conventional profiling according to DIN 10967-1 was conducted to determine the objective characteristics of the three types of milk. The characteristics were recorded separately in the order of their perception, and the intensity of each characteristic was rated on a scale from 0 (absent) to 10 (very strong). The creation of a conventional profile includes a collection and reduction of terms, the selection of suitable references and an intensity measurement in individual tests. For this study, the panellists were initially trained to detect the following flavours: creme, cooked, acidic, sweet, vanilla, bitter, dull, astringent and barnyard stable.
The assessors were blinded to the samples' processing method, the origin and the brand. An analysis of variance was used to determine whether there were significant differences between the products with respect to the individual attributes (ANOVA, Tukey Test, FIZZ Software).

Chemical analysis – method: The fatty acid patterns of the three samples were detected by the milk research institute MUVA Kempten according to ISO 15885/IDF 184:2002. To evaluate relevant differences between the samples, a confidence interval was derived from the data of Wohlers and Stolz (2019) [23], calculated as mean of the standard deviation of the means per farming system. If, in addition, the scale level coincided with that of Wohlers and Stolz (2019) and was similar to those of Kusche et al. (2015) and Schwendel et al. (2015) [23–25], relevant differences were assumed.

Heart rate variability measurements and emotional profiling methods:

Participants: Individuals trained in self-observation were recruited from two study centres (centre 1: Filderstadt ARCIM Institute; centre 2: Forschungsring Darmstadt). The participants of centre 1 (n = 13) regularly observe by introspection the effects of therapeutic measures. This panel had no experience in observing food effects. The centre 2 (n = 12) participants regularly conduct observations on emotional responses to food using the EFT. For three months prior to this study, centre 2 panel conducted six experiments with a total of 20 milk samples (all randomized and coded). In each of the six experiments, raw milk was tasted as a pre-sample.

Emotional profiling: The participants sat in a circle in chairs looking outwards. In front of each were five glasses on a tray. The first one was filled with clear water, the second contained the "0-sample" (raw milk), and the last three contained the study samples, each marked with a number according to the randomization list. The samples (100 mL) were offered in clear glass containers. The test lasted 20 minutes per milk sample using a standardized sequence: minutes 1–4, moderated body screen; minute 5, tasting of the sample and then swallowing; minutes 6–7, perception of emotions and bodily sensations, minutes 8–17, filling out the standardized Empathic Food Test questionnaire [13]; minute 18, drinking water to wash down traces of the milk; minutes 19–20, washout phase with relaxed sitting in the chair. This procedure started with the raw milk ("0-sample") and was then repeated with each sample. The assessors were blinded to the samples.
The perceived observations were recorded using the EFT questionnaire. The EFT was selected because it had already proven effective in differentiating milk [13]. The (EFT) measures the emotional response of food on the basis of 12 polar perceptions / feelings (Table 5), which are rated on a five-step scoring e. g. "relaxed", "rather relaxed", "neutral", "rather nervous" or "nervous". Based on exploratory factor analysis, ten of the twelve measured items were integrated into two scales (Table 2). Scale 1 describes items that are more related to emotions whereas the items of scale 2 pertain more to the mind or body perceptions.
Values of the scales and the items were averaged and scaled to range from 1 to 5, with lower values (i.e. 1 and 2) indicating a positive perception (i.e., awake, concentrated), high values (i.e., 4 and 5) indicating a negative perception (i.e., tired, not energized), and a value of 3 indicating indifference.

Measurement of physiological parameters (heart rate variability): One day later, to measure the heart rate variability, five electrocardiogram

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(ECG) electrodes were attached to each participant's thorax, and a CardioScout Multi-ECG recorder, (SR-Medizinelektronik, Stuttgart, Germany) was used to record the ECGs with a sampling frequency of 1000 Hz. The procedure was identical to the previous day with the only difference that instead of 10 minutes to complete the questionnaire, three minutes of quiet sitting followed the two-minute perception phase.

For further analyses, the measurements were imported into the HRV-Scanner software (version 3.02.13; Biosign, Ottenhofen, Germany), where they were checked for artefacts. Subsequently, the following HRV parameters were measured from five-minute sections (three minutes of quiet sitting following the two-minute perception phase): heart rate, standard deviation of all normal-to-normal (SDNN) RR intervals (R describes the upper turning point in an electrocardiogram), low-to-high frequency ratio (based on parameters of a spectral analysis; low frequency: 0.04–0.15 Hz, high frequency: 0.15–0.4 Hz), respiratory rate, pulse-respiration quotient (heart rate divided by respiration rate) and stress index. The formula for the stress index, which was developed by Russian space scientist Professor Roman Baevsky, is AMo / 2Mo × MxDMn, where modal value Mo represents the most frequently measured duration of an RR interval, the amplitude of the model value AMo describes the percentage in relation to all RR intervals surveyed, and variability width MxDMn is the difference between the maximum and minimum measured RR intervals [26].

Statistical analysis: Mean values and standard deviations were calculated for the HRV parameters. Differences between the three interventions were calculated using one-way analysis of variance (with the milk samples as factors). The variance equality between samples was evaluated using Levene's test. In cases of significant differences, post hoc tests were performed with the Bonferroni adjusted correction for multiple testing. The analyses were performed for the two study centres both separately and combined. A linear mixed model was used for the EP results. The dependent variables are the item-related mental and physical effects. The variants were modeled as fixed factors, while "person" was taken into account as cluster variable. The significance level was set to $p < 0.05$.

Results and Discussion

Sensory profiling: Besides the "UHT milk" taste attribute, analysis of variance found no differences between the three milk samples. The "UHT milk" taste attribute was significantly lower in the pasteurized than in the UHT milk (Table 3).

Sensory analyses of milk were effective in describing oxidative influences [27, 28] and the feeding regime [29]. Scientific literature includes some studies that describe the effects of processing on sensory quality and acceptance [30, 31]. Li et al. (2018) describe how the pasteurization method, high-temperature short-time pasteurization compared to ultrapasteurization, alters the sensory properties of milk [32].

The significant difference in the UHT flavor characteristics in our study was therefore to be anticipated. It is unexpected that the differences in the sample are not more pronounced and that the ESL and the PAST sample do not differ.

Chemical analysis: The fat (Röse-Gottlieb) and protein (Kjehldahl) content of the three samples varied slightly: Pasteurized (3.94%/3.20%), ESL (4.04%/3.29%) and UHT (3.82%/3.29%).

The fatty acid patterns of the three samples were detected according to ISO 15885/IDF 184:2002. To assess differences between the samples, SEM-values were taken from Kusche et al. (2014) [23], and confidence intervals were derived, calculated as twice the standard error of the mean (2*SEM), assuming that the hypothetic variance is the same as in Kusche et al. 2014.

In particular, the content of many fatty acids in the conventional (UHT) milk was significantly different from those in the organic ESL and pasteurized samples, whereas the two organic variants had similar contents in many cases, as can be seen, for example, in the n3 fatty acid contents, the n6/n3 ratio and the ALA contents (table 4).

Table 4: Selected fatty acid concentrations of the samples and their possible confidence intervals.

Fatty acid (mg/g fat)	Pasteurized	ESL	UHT				SEM*
n3	1.20	1.30	0.60	a	a	b	0.0405
n6/n3	1.42	1.31	3.00	b	c	a	0.0097
CLA c9t11	1.04	1.23	0.57	a	a	b	0.0502
ALA	0.92	1.03	0.45	a	a	b	0.033
tVA	1.89	2.32	0.80	b	a	c	0.089
C20:0	0.18	0.16	0.1	a	b	b	0.0026

*SEM: Standard error of the mean; derived from Kusche et al. (2014).
Different letters in one row indicate that the confidence intervals of 2 x SEM do not overlap.

However, there were also differences between the organic ESL and the organic pasteurized milk. For example, the ESL milk had higher tVA and CLA contents.

Table 3: Analysis of variance and sensory descriptive statistics of the three samples.

Attributes	ESL*	Pasteurized*	UHT*	F-value	p-value
Creme flavour	3.30 (2.16)	3.90 (2.02)	4.90 (1.10)	1.96	0.1601
Cooked flavour	1.90 (1.66)	1.90 (1.97)	3.40 (1.17)	2.80	0.0782
Flavour intensity	3.00 (1.83)	4.00 (2.40)	5.20 (1.48)	3.22	0.0555
Sweet taste	4.60 (0.84)	4.50 (0.97)	5.20 (1.14)	1.46	0.2499
Creme taste	4.70 (2.11)	4.60 (1.71)	4.40 (0.70)	0.09	0.9152
Vanilla taste	0.50 (0.53)	0.40 (0.52)	0.50 (0.53)	0.12	0.8860
Acidic taste	0.90 (0.57)	0.40 (0.52)	1.10 (0.99)	2.47	0.1033
Barnyard taste	1.80 (1.23)	1.20 (1.14)	1.30 (1.25)	0.71	0.5006
Bitter taste	1.00 (0.94)	0.60 (0.70)	1.20 (0.92)	1.26	0.2998
UHT milk taste	2.20 (1.32)	1.30 (1.25)[a]	3.00 (3.00)	4.27	**0.0244**
Mouth feeling dull	3.20 (1.62)	2.60 (1.71)	3.70 (1.34)	1.24	0.3056
Mouth feeling astringent	1.20 (1.32)	0.70 (0.95)	1.50 (0.97)	1.37	0.2713
Mouth feeling fat	3.40 (1.17)	3.90 (1.20)	3.80 (1.55)	0.40	0.6723
Mouth feeling creamy	5.60 (1.90)	6.20 (2.15)	6.00 (0.94)	0.31	0.7380

*Values are mean (standard deviation).
P-values in bold indicate significant differences ($p < 0.05$).
[a] Significantly lower than UHT

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Table 5: Differences between the three types of milk with respect to Empathic Food Test questionnaire parameters (study centres 1 and 2 separately).

		UHT*	ESL*	Pasteurized*	F-value	p-value (p_{holm})
Centre 1	I feel my body warm/cold	2.31 (±0.66)	2.38 (±0.76)	2.62 (±0.80)	0.179	0.837
	I feel my body light/dark	2.62 (±0.66)	2.38 (±0.69)	3.23 (±0.69)	1.644	0.207
	I feel my body light/heavy	3.08 (±0.62)	2.85 (±0.63)	3.00 (±0.72)	0.114	0.892
	I feel my body refreshed/exhausted	3.00 (±0.60)	2.92 (±0.64)	3.62 (±0.83)	1.087	0.348
	I feel motivated/unmotivated	3.31 (±0.78)	3.00 (±0.76)	3.38 (±0.67)	0.278	0.759
	I feel awake/sleepy	3.15 (±0.67)	2.54 (±0.74)	3.15 (±0.78)	0.861	0.431
	I feel concentrated/ distracted	2.62 (±0.76)	2.54 (±0.76)	3.15 (±0.76)	0.797	0.458
	I feel relaxed/nervous	2.46 (±0.75)	2.46 (±0.65)	2.62 (±0.77)	0.055	0.947
	I feel comforting/unwell	2.46 (±0.74)	2.46 (±0.67)	3.23 (±0.87)	1.268	0.294
	I feel satisfied/unsatisfied	2.77 (±0.71)	2.54 (±0.54)	2.92 (±0.75)	0.300	0.743
	I feel balanced/unbalanced	2.77 (±0.70)	2.85 (±0.85)	3.31 (±0.88)	0.457	0.637
	I feel the effect long/short	2.15 (±0.60)	2.38 (±0.45)	2.69 (±0.63)	0.910	0.412
	EFT mean score–emotional	2.62 (±0.65)	2.54 (±0.85)	3.06 (±0.77)	0.706	0.500
	EFT mean score–body	3.03 (±0.62)	2.77 (±0.56)	3.26 (±0.77)	0.561	0.576
Centre 2	I feel my body warm/cold	3.17 (±0.66)	2.75 (±0.66)	1.50 (±0.66)	12.00	**<.001**
	I feel my body light/dark	3.58 (±0.67)	2.50 (±0.67)	2.42 (±0.67)	5.12	**0.015**
	I feel my body light/heavy	3.83 (±0.64)	3.25 (±0.70)	2.50 (±0.67)	4.93	**0.017**
	I feel my body refreshed/ exhausted	3.83 (±0.72)	3.42 (±0.72)	2.83 (±0.72)	2.22	0.132
	I feel motivated/unmotivated	3.75 (±0.72)	3.25 (±0.73)	2.83 (±0.72)	1.88	0.177
	I feel awake/sleepy	3.42 (±0.83)	3.00 (±0.86)	2.75 (±0.84)	0.978	0.392
	I feel concentrated/distracted	3.33(±0.74)	3.25 (±0.69)	3.00 (±0.76)	0.260	0.774
	I feel relaxed/nervous	3.50 (±0.77)	3.58 (±0.84)	2.67 (±0.70)	1.74	0.192
	I feel comforting/unwell	3.92 (±0.75)	3.75 (±0.75)	2.58 (±0.75)	3.86	**0.031**
	I feel satisfied/unsatisfied	4.00 (±0.77)	3.75 (±0.75)	2.67 (±0.77)	3.907	**0.030**
	I feel balanced/unbalanced	4.25 (±0.77)	3.75 (±0.77)	2.67 (±0.77)	6.58	**0.006**
	I feel the effect long/short	2.00 (±0.49)	2.00 (±0.50)	1.67 (±0.49)	1.07	0.359
	EFT mean score–emotional	3.85 (±0.64)	3.47 (±0.64)	2.60 (±0.64)	4.23	**0.028**
	EFT mean score–body	3.63 (±0.68)	3.23 (±0.68)	2.78 (±0.68)	2.37	0.117

*Values are mean (95 % confidence intervals).
P-values in bold indicate statistical significance.
EFT: Empathic Food Test.

The fatty acid pattern is thought to withstand processing effects, especially heating, in dairy [33, 34]. Nevertheless, minor changes in fatty acid patterns have been reported [33, 35], for example, in C17:1 and n3, including the CLA content (reduced with heating), or trans fatty acids (increased with heating). Therefore, the observed sample differences may also be due to the different processing or heating effects.

Of greater importance for the fatty acid pattern, however, is the origin of the sample, and especially the cows' diet [36, 37]. Effects related to differences between breeds are also known [38].

The higher contents of n3 fatty acids and the correspondingly lower n6/n3 ratio have often been reported as typical for organic samples [23–25, 39]. The same is true of the CLA content and its precursors tVA and ALA, which can be explained especially by the feedstuffs used. A grass (especially pasture) diet without concentrate supplementation leads to higher CLA contents in milk [25, 40, 41]. It can be assumed that the organic ESL milk comes from cows with an intensive, grass-based diet, whereas the organic pasteurized milk may come from less intensive farming or cows fed with less fresh grass. The high content of C20:0 fatty acid in Demeter milk also indicates more extensive or organic feeding [24, 40].

Heart rate variability measurements and emotional profiling: Table 5 summarises the differences between the three types of milk with respect to the EFT questionnaire parameters of both panels separately. In center 1, no differences between the samples were detected.

In centre 2, significant differences were found between the three samples in the parameters "I feel my body warm/cold" (p = <.001), "I feel my body light/dark" (p = 0.015), "I feel my body light/heavy" (p = 0.017), "I feel comforting/unwell" (p = 0.031), "I feel satisfied/unsatisfied" (p = 0.03) and "I feel balanced/unbalanced" (p = 0.006), as well as in the sum score "EFT mean score–emotional" (p = 0.028).

In all cases, post hoc tests revealed significant differences between the UHT and pasteurized milk samples: "I feel my body warm/cold" (p = <.001), "I feel my body light/dark" (p = 0.027), "I feel my body light/heavy" (p = 0.015), "I feel comforting/unwell" (p = 0.047), "I feel satisfied/unsatisfied" (p = 0.045) and "I feel balanced/unbalanced" (p = 0.005), as well as for the sum score "EFT mean score–emotional" (p = 0.029) (Table 6), indicating that after testing the pasteurized milk, the participants of centre 2 felt their body warmer, lighter and themselves more well, satisfied, balanced and comfortable. The comparison of pasteurized and ESL milk revealed fewer differences. After consumption of the pasteurized milk, the test subjects felt significantly warmer (p = 0.004) and more balanced (p = 0.048). Comparing UHT and ESL milk, only one item responded significantly. After consumption of ESL milk, the test person perceived their body as lighter (p = 0.028).

The panel with experience (centre 2) in milk testing observed significant differences between UHT and past milk. The missing experience may be the cause of the lack of discrimination capability in the panel of centre 1. Dairy products have already been evaluated using EP. Geier et al. 2016 compared organic past milk with conventional ESL milk by 60 consumers [13]. Using the EFT, the organic milk was rated higher in the EFT mean score-body in both repetitions. The conventional ESL milk was

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rated better in terms of appearance in a hedonic consumer test with 60 persons. In a comparison of UHT and pasteurised milk with soy milk by consumers, the cow's milk was clearly rated differently from the soy milk [42]. Study participants were able to perceive an effect of warmth while consuming the two organic milk samples UHT milk (REWE organic whole milk) and fresh milk (Soebbeke Demeter whole milk) in comparison to soy milk (Alprosoja natural) and water with high significance, although the drinks had the same serving temperature. Moreover, milk led to a highly significant better overall mood than soy milk and water.

Otherwise, hardly any studies with EP of dairy products can be found. Schouteten et al. (2016) compared yoghurt using sensory and emotional profiling [43]. He concludes that both approaches are necessary for a sensory-emotional optimisation of products. Gandy et al. (2008) also report that consumer acceptability and sensory analytics can lead to differing results in the evaluation of fluid milk [44]. Increasing the temperature of the milk did not affect the sensory descriptors, but it had an impact on consumer acceptability. The effects of panel preparation on EP were investigated by [16]. Trained experts (n = 12) and three groups of consumers (n = 60) examined three pairs of samples with similar sensory properties (noodles, water, chocolate) using the EFT. The consumers were given four hours, half an hour or no preparation. The trained experts and the consumers, who had been prepared for the test for a long time, evaluated the samples with EFT mean score-emotional very consistently.

For heart rate variability parameters, neither study center 1 nor study center 2 nor the combination showed significant effects (tables 7 and 8).

In several studies, reactions of different food expectations on the autonomic nervous system (ANS) were measured [45, 46].

Table 6: Post hoc analysis of the analysis of pairs of variants with respect to Empathic Food Test questionnaire parameters (study centre 2).

	Difference	SE	p-value
Differences between UHT and pasteurized milk			
I feel my body warm/cold	1.667	0.355	**<.001**
I feel my body light/dark	11.667	0.407	**0.027**
I feel my body light/heavy	1.333	0.426	**0.015**
I feel well/unwell	1.33	0.523	**0.047**
I feel satisfied/unsatisfied	1.33	0.520	**0.045**
I feel balanced/unbalanced	1.583	0.446	**0.005**
EFT mean score–emotional	1.25	0.441	**0.029**
Differences between ESL and pasteurized milk			
I feel my body warm/cold	1.25	0.355	**0.004**
I feel balanced/unbalanced	1.083	0.446	**0.048**
Differences between ESL and UHT milk			
I feel my body light/dark	10.823	0.407	**0.028**

P-values in bold indicate statistical significance.
SE: standard error; EFT: Empathic Food Test.

Bensafir et al. (2002) detected a correlation with HRV for odour characteristics [47].

Tentolouris et al. (2003) observed a significant effect on the HRV parameter LF/HF after a carbohydrate-rich nutrition. Saito et al. (2018) also detected effects from a milk protein drink, in contrast to a placebo without milk protein [48].

In a meta-analysis, Xin et al. (2013) examined possible effects of fish-oil supplementation on HRV parameters [22]. The authors conclude that the HRV parameters HF (high-frequency power) and the LF/HF (ratio low-frequency power/high-frequency power) react significantly to fish-oil supplementation. However, the duration of treatment in all studies was several weeks.

Rousmans et al. (2000) examined the relationship between various characteristics of the ANS and the four primary tastes [49]. There were highly significant effects between characteristics of the ANS of the participants, e.g. skin blood flow amplitude and skin blood flow amplitude in relation to their hedonic valence.

Table 7: Differences between the three types of milk with respect to heart rate variability parameters (study centres 1 and 2 combined).

	UHT*	ESL*	Pasteurized*	F-value	p-value
Heart rate (beats per minute)	71.91 (5.95)	72.14 (7.60)	71.78 (7.31)	0.013	0.987
SDNN (ms)	48.66 (21.94)	51.51 (19.32)	47.26 (14.42)	0.252	0.778
Low-to-high frequency ratio	4.73 (7.35)	5.33 (5.40)	8.21 (12.92)	0.785	0.461
Stress index	205.63 (150.06)	194.59 (179.34)	193.21 (143.99)	0.035	0.966
Respiration rate (breaths per minute)	14.65 (2.35)	14.20 (2.61)	14.00 (2.67)	0.320	0.727
Pulse-respiration quotient	5.06 (1.20)	5.31 (1.52)	5.39 (1.62)	0.258	0.773

*Values are mean (standard deviation).
SDNN: standard deviation of all normal-to-normal RR intervals.

Danner et al. (2014) examined the reaction to self-reported liking, facial expression and various characteristics of the ANS on the basis of different vegetable and fruit juices [50]. Only some characteristics of the ANS reacted to the different juices and there was only a moderate correlation with self-reported liking. The authors conclude that self-reported liking cannot be explained simply by ANS (and facial expression parameters).

It is possible that the differences between the samples in this study were too small to induce effects detectable by HRV measurements. Another reason may be related to the setup. HRV was measured immediately after consumption, and the amount of milk consumed was small (0.1 L). The experimental design was mainly based on the measurement of food-induced emotions.

Conclusion

In this study, three commercial milks were tested using various methods. Fatty acids, sensory properties, food-induced emotions and HRV after consumption were analysed. The aim was to determine whether EP and HRV provide additional information that leads to a different evaluation of the samples.

The effects of food and nutrition on the autonomic nervous system are described in the scientific literature. However, if, as in our study, a measurement is taken shortly after consumption and there are only slight differences between the samples, the HRV method does not appear to be suitable for evaluating food.

Chemical and sensory analyses revealed differences between the samples. These were to be expected based on the scientific literature. The differences in the sensory analysis were small: only the past milk and the UHT milk were distinguished, and only with one descriptor.

EP using the EFT was able to determine differences between the samples with food experienced observers. In our study, the samples were more clearly distinguished by means of EP than by sensory analysis.

Table 8: Differences between the three types of milk with respect to heart rate variability parameters (study centres 1 and 2 separately).

		UHT*	ESL*	Pasteurized*	F-value	p-value
Centre 1	Heart rate (beats per minute)	71.34 (4.86)	71.55 (5.44)	71.57 (5.27)	0.006	0.994
	SDNN (ms)	45.94 (15.64)	51.25 (17.31)	44.49 (12.63)	0.541	0.588
	Low-to-high frequency ratio	2.56 (1.69)	3.67 (2.82)	4.12 (3.68)	0.794	0.462
	Stress index	184.80 (73.07)	189.92 (140.56)	214.51 (128.56)	0.182	0.835
	Respiration rate (breaths per minute)	15.76 (1.96)	15.17 (1.91)	15.51 (1.72)	0.249	0.781
	Pulse-respiration quotient	4.57 (0.49)	4.79 (0.81)	4.67 (0.69)	0.270	0.765
Centre 2	Heart rate (beats per minute)	72.54 (7.23)	72.80 (9.78)	72.01 (9.42)	0.019	0.982
	SDNN (ms)	51.69 (28.08)	51.80 (22.43)	50.33 (16.38)	0.012	0.989
	Low-to-high frequency ratio	7.15 (10.28)	7.18 (7.04)	12.75 (17.79)	0.596	0.559
	Stress index	228.77 (208.61)	199.77 (223.79)	169.54 (163.89)	0.197	0.823
	Respiration rate (breaths per minute)	13.41 (2.20)	13.12 (2.96)	12.32 (2.57)	0.427	0.657
	Pulse-respiration quotient	5.61 (1.52)	5.88 (1.93)	6.19 (2.00)	0.223	0.802

*Values are mean (standard deviation).
SDNN: standard deviation of all normal-to-normal RR intervals.

Because EP describes new characteristics compared to chemical and sensory analysis, namely physical and emotional well-being, EP can complement established measurement methods. The relationship between EP, sensory and chemical analysis should be examined in a more extensive study.

Disclosure of conflicts of interest

The authors declare no potential conflicts of interest.

Compliance with Ethical Standards

This study has been conducted in compliance with ethical standards.

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