

**Table 2. Differentiation in physico-chemical properties of hard cheese types (means ± standard deviation of means).**

Cheese Types	pH	Firmness (kg cm <sup>-2</sup> )	Water activity (a <sub>w</sub> )	Moisture	Fat/DM	Total protein	WSN/TN	PTA-SN	Salt/water phase
Mild Ras cheese	5.07 <sup>bc</sup> ±0.02	4.12 <sup>ab</sup> ±0.47	0.912 <sup>b</sup> ±0.03	34.72 <sup>b</sup> ±3.92	56.17 <sup>a</sup> ±0.94	22.87 <sup>a</sup> ±0.61	10.54 <sup>d</sup> ±2.43	1.26 <sup>c</sup> ± 0.44	11.52 <sup>b</sup> ±3.29
Over ripened Ras cheese	5.11 <sup>b</sup> ± 0.09	6.05 <sup>a</sup> ±1.28	0.890 <sup>c</sup> ±0.10	30.98 <sup>c</sup> ±1.53	56.17 <sup>a</sup> ±1.85	23.80 <sup>a</sup> ±2.19	20.17 <sup>b</sup> ±1.64	2.56 <sup>a</sup> ± 0.48	16.61 <sup>a</sup> ±1.46
Cheddar cheese	4.96 <sup>c</sup> ±0.10	3.97 <sup>bc</sup> ±0.27	0.941 <sup>a</sup> ±0.01	33.67 <sup>bc</sup> ±1.41	55.87 <sup>a</sup> ±1.41	23.96 <sup>a</sup> ±1.08	14.08 <sup>c</sup> ±2.88	1.28 <sup>d</sup> ± 0.28	7.02 <sup>cd</sup> ±0.55
Edam cheese	5.26 <sup>a</sup> ±0.02	3.22 <sup>cd</sup> ±0.67	0.940 <sup>a</sup> ±0.01	39.02 <sup>a</sup> ±2.62	52.50 <sup>b</sup> ±1.53	24.27 <sup>a</sup> ±1.29	18.65 <sup>b</sup> ±2.04	3.02 <sup>a</sup> ± 0.81	8.25 <sup>c</sup> ±0.97
Gouda cheese	5.06 <sup>bc</sup> ±0.02	2.78 <sup>d</sup> ±0.59	0.942 <sup>a</sup> ±0.01	40.40 <sup>a</sup> ±1.19	52.17 <sup>b</sup> ± 2.31	23.53 <sup>a</sup> ± 0.9	23.13 <sup>a</sup> ±2.41	1.94 <sup>b</sup> ± 0.56	6.31 <sup>d</sup> ±1.31

Means with the same letter are not significantly different (P≤0.05).  
WSN: water soluble nitrogen, PTA-SN: phosphotungstic acid-soluble nitrogen.

**Table 3. Differentiation in sensorial texture attributes of hard cheese types (means ± standard deviation of means).**

Cheese Types	Sensorial texture attributes									
	hfm	hsp	hrc	ffm	ffr	chr	cco	cad	csm	rsm
Mild Ras cheese	4.08 <sup>ab</sup> ±0.52	2.91 <sup>cb</sup> ±1.11	3.50 <sup>cb</sup> ± 1.00	3.33 <sup>a</sup> ± 0.49	4.43a±0.63	3.92 <sup>a</sup> ± 0.52	1.25 <sup>b</sup> ± 0.45	1.33 <sup>b</sup> ± 0.49	1.08 <sup>c</sup> ± 0.29	1.17 <sup>c</sup> ± 0.38
Over ripened Ras cheese	4.42 <sup>a</sup> ±0.99	2.51 <sup>c</sup> ±1.48	3.00 <sup>c</sup> ± 1.47	3.42 <sup>a</sup> ± 0.90	4.75a±0.45	4.67 <sup>a</sup> ± 0.49	1.41 <sup>b</sup> ± 0.67	1.42 <sup>ab</sup> ± 0.67	1.33 <sup>c</sup> ± 0.78	2.08 <sup>b</sup> ± 1.62
Cheddar cheese	3.69 <sup>b</sup> ±0.48	3.52 <sup>ab</sup> ±0.40	3.8 <sup>ab</sup> ± 0.75	3.12 <sup>ab</sup> ± 0.72	4.41a±0.79	2.94 <sup>b</sup> ± 1.44	2.81 <sup>a</sup> ± 1.60	2.19 <sup>a</sup> ± 1.38	3.12 <sup>b</sup> ± 1.45	2.44 <sup>b</sup> ± 1.36
Edam cheese	3.00 <sup>c</sup> ±0.43	3.6 <sup>ab</sup> ±0.99	4.00 <sup>ab</sup> ± 0.52	2.91 <sup>ab</sup> ± 1.00	4.25a±0.75	2.46 <sup>b</sup> ± 1.55	3.58 <sup>a</sup> ± 0.67	2.08 <sup>ab</sup> ± 1.16	3.67 <sup>ab</sup> ± 0.65	3.67 <sup>a</sup> ± 0.78
Gouda cheese	2.81 <sup>c</sup> ±1.17	4.12 <sup>a</sup> ±0.83	4.53 <sup>a</sup> ± 0.90	2.54 <sup>b</sup> ± 1.24	4.04a±1.20	2.33 <sup>b</sup> ± 1.44	3.64 <sup>a</sup> ± 0.67	2.00 <sup>ab</sup> ± 1.09	4.00 <sup>a</sup> ± 1.10	4.36 <sup>a</sup> ± 0.67

Means with the same letter are not significantly different (P≤0.05).  
hfm: hand firmness, hsp: hand springiness, hrc: hand rate of recovery, ffm: first bite firmness, ffr: First bite fracturability, chr: breakdown, cco: cohesiveness, cad: adhesiveness, csm: mass smooth, rsm: residual smooth.

**Table 4. Correlation coefficient (R) and regression coefficient (R<sup>2</sup>) between physico-chemical properties and sensorial texture attributes of hard cheese types**

Sensorial texture attributes	Physico-chemical properties															
	a <sub>w</sub>		Firmness		Moisture		Total protein		Fat/DM		WSN		Salt/water phase		PTA-SN	
	R	R <sup>2</sup>	R	R <sup>2</sup>	R	R <sup>2</sup>	R	R <sup>2</sup>	R	R <sup>2</sup>	R	R <sup>2</sup>	R	R <sup>2</sup>	R	R <sup>2</sup>
<b>hfm</b>	-0.45**	0.21	0.45**	0.20	-0.58**	0.33	-0.08	0.01	0.39**	0.15	-0.24	0.06	0.51**	0.27	-0.15	0.02
<b>hsp</b>	0.40**	0.16	-0.32**	0.11	0.35*	0.11	0.13	0.02	-0.39**	0.15	0.14	0.02	-0.36**	0.13	0.11	0.01
<b>hrc</b>	0.29*	0.08	-0.55**	0.29	0.46**	0.21	-0.07	0.01	0.31*	0.09	0.14	0.02	-0.33**	0.09	0.17	0.03
<b>ffm</b>	-0.22	0.05	0.21	0.06	-0.29*	0.07	0.01	0.01	0.29*	0.08	-0.20	0.05	0.21	0.04	-0.07	0.00
<b>ffr</b>	-0.25	0.06	0.25	0.04	-0.12	0.20	-0.09	0.00	0.24	0.06	0.01	0.00	0.17	0.02	-0.01	0.00
<b>chr</b>	-0.52**	0.27	0.44**	0.19	-0.46**	0.21	-0.34**	0.11	0.44**	0.20	0.09	0.01	0.53**	0.27	0.04	0.00
<b>cco</b>	0.54**	0.29	-0.52**	0.27	0.44**	0.19	0.02	0.00	0.36**	0.13	0.35**	0.13	0.57**	0.33	-0.08	0.03
<b>cad</b>	0.26*	0.07	-0.17	0.03	0.09	0.01	0.10	0.10	-0.05	0.02	0.14	0.2	-0.30*	0.09	0.13	0.02
<b>csm</b>	0.63**	0.40	-0.57**	0.32	0.45**	0.21	0.10	0.10	0.43**	0.18	0.37**	0.13	-0.62**	0.38	0.12	0.20
<b>rsm</b>	0.45**	0.20	-0.43**	0.18	0.44**	0.19	0.08	0.01	-0.41**	0.17	0.55**	0.30	0.44**	0.19	0.29*	0.09

a<sub>w</sub>: water activity, WSN: water soluble nitrogen, PTA-SN: Phosphotangestic acid-soluble nitrogen.  
 hfm: hand firmness, hsp: hand springiness, hrc: hand rate of recovery, ffm: first bite firmness, ffr: First bite fracturability, chr: breakdown, cco: cohesiveness, cad: adhesiveness, csm: mass smooth, rsm: residual smooth.

**Table 5. Correlation coefficient (R) and regression coefficient (R<sup>2</sup>) among sensorial texture attributes of hard cheese types**

Sensorial texture attributes	Sensorial texture attributes																	
	rsm		csm		cad		cco		chr		ffr		ffm		hrc		hsp	
	R	R <sup>2</sup>	R	R <sup>2</sup>	R	R <sup>2</sup>	R	R <sup>2</sup>	R	R <sup>2</sup>	R	R <sup>2</sup>	R	R <sup>2</sup>	R	R <sup>2</sup>	R	R <sup>2</sup>
<b>hfm</b>	-0.51**	0.26	-0.46**	0.21	-0.23	0.05	-0.50**	0.25	0.23	0.05	-0.10	0.01	0.43**	0.19	-0.23	0.06	-0.37**	0.14
<b>hsp</b>	0.37**	0.14	0.38**	0.15	0.11	0.01	0.45**	0.20	-0.09	0.01	0.07	0.01	-0.31*	0.09	0.37**	0.14	1.00	
<b>hrc</b>	0.46**	0.21	0.44**	0.19	0.12	0.02	0.33**	0.11	-0.22	0.05	-0.28*	0.08	-0.24	0.06	1.00			
<b>ffm</b>	-0.41**	0.17	-0.41**	0.17	0.01	0.02	-0.38**	0.15	-0.10	0.01	-0.01	0.00	1.00					
<b>ffr</b>	-0.15	0.02	-0.223	0.06	-0.13	0.00	0.01	0.00	0.26*	0.07	1.00							
<b>chr</b>	-0.22	0.04	-0.28*	0.08	-0.12	0.02	-0.20	0.04	1.00									
<b>cco</b>	0.71**	0.49	0.70**	0.49	0.40	0.16	1.00											
<b>cad</b>	0.44**	0.19	0.50**	0.25	1.00													
<b>csm</b>	0.77**	0.60	1.00															
<b>rsm</b>	1.00																	

hfm: hand firmness, hsp: hand springiness, hrc: hand rate of recovery, ffm: first bite firmness, ffr: First bite fracturability, chr: breakdown, cco: cohesiveness, cad: adhesiveness, csm: mass smooth, rsm: residual smooth.