



# Potential of Bioactive Protein and Protein Hydrolysate from *Apis mellifera* Larvae as Cosmeceutical Active Ingredients for Anti-Skin Aging

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**Table S1.** The p-values demonstrate statistically significant differences ( $p < 0.05$ , labeled in red) in yields among defatted *A. mellifera* larvae, as well as in their crude protein extracts and protein hydrolysates.

Samples	Group	DL	SHE		WTE		AAE		CAE		HCE		
			CP	PH	CP	PH	CP	PH	CP	PH	CP	PH	
DL	a		0.004	0.000	0.000	0.000	0.003	0.002	0.000	0.000	0.000	0.000	
SHE	CP	b	0.004		0.613	0.003	0.002	1.000	1.000	0.997	0.988	0.067	0.018
	PH	b,c,d	0.000	0.613		0.233	0.170	0.680	0.759	0.982	0.995	0.944	0.665
WTE	CP	d	0.000	0.003	0.233		1.000	0.004	0.005	0.024	0.035	0.936	0.999
	PH	d	0.000	0.002	0.170	1.000		0.003	0.004	0.016	0.023	0.874	0.995
AAE	CP	b	0.003	1.000	0.680	0.004	0.003		1.000	0.999	0.995	0.084	0.023
	PH	b	0.002	1.000	0.759	0.005	0.004	1.000		1.000	0.998	0.110	0.031
CAE	CP	b,c	0.000	0.997	0.982	0.024	0.016	0.999	1.000		1.000	0.345	0.123
	PH	b,c	0.000	0.988	0.995	0.035	0.023	0.995	0.998	1.000		0.440	0.169
HCE	CP	b,c,d	0.000	0.067	0.944	0.936	0.874	0.084	0.110	0.345	0.440		1.000
	PH	c,d	0.000	0.018	0.665	0.999	0.995	0.023	0.031	0.123	0.169	1.000	

Note: DL = defatted *A. mellifera* larvae; CP = crude proteins; PH = proteins hydrolysates; PHs were obtained from CPs extracted using various media, including sodium hydroxide (SHE), DI water (WTE), ascorbic acid (AAE), citric acid (CAE), and hydrochloric acid (HCE). The identical letters (a, b, c, and d) represent values that do not exhibit statistically significant differences among *A. mellifera* larvae extracts, while differing letters indicate significant differences. The data were analyzed using One-Way ANOVA followed by Tukey's post-hoc test ( $p < 0.05$ ).

**Table S2.** Tukey's honestly significant difference (HSD) test results ( $\alpha = 0.05$ ) for yields among defatted *A. mellifera* larvae, crude protein extracts, and protein hydrolysates.

Samples	Subset for alpha = 0.05				Group
	a	b	c	d	
DL	78.1433				a
SHE-CP		48.7458			b
AAE-CP		48.0669			b
AAE-PH		47.2338			b
CAE-CP		43.1178	43.1178		b,c
CAE-PH		42.0457	42.0457		b,c
SHE-PH		36.0181	36.0181	36.0181	b,c,d
HCE-CP		27.5665	27.5665	27.5665	b,c,d
HCE-PH			23.8157	23.8157	c,d
WTE-CP				18.9331	d
WTE-PH				17.8022	d

Note: DL = defatted *A. mellifera* larvae; CP = crude proteins; PH = proteins hydrolysates; PHs were obtained from CPs extracted using various media, including sodium hydroxide (SHE), DI water (WTE), ascorbic acid (AAE), citric acid (CAE), and hydrochloric acid (HCE). The identical letters (a, b, c, and d) represent values that do not exhibit statistically significant differences among *A. mellifera* larvae extracts, while differing letters indicate significant differences. The data were analyzed using One-Way ANOVA followed by Tukey's post-hoc test ( $p < 0.05$ ).

**Table S3.** The p-values demonstrate statistically significant differences ( $p < 0.05$ , labeled in red) in total protein contents among crude protein extracts and protein hydrolysates of *A. mellifera* larvae.

Samples	Group	SHE		WTE		AAE		CAE		HCE	
		CP	PH	CP	PH	CP	PH	CP	PH	CP	PH
SHE	CP	a	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	PH	b	0.000	1.000	0.000	0.003	0.000	0.096	0.000	0.874	0.000
WTE	CP	b	0.000	1.000	0.000	0.011	0.000	0.246	0.000	0.990	0.000
	PH	e	0.000	0.000	0.000	0.000	1.000	0.000	0.080	0.000	0.000
AAE	CP	c	0.000	0.003	0.011	0.000	0.000	0.841	0.000	0.083	0.000
	PH	e	0.000	0.000	0.000	1.000	0.000	0.000	0.181	0.000	0.000
CAE	CP	b,c	0.000	0.096	0.246	0.000	0.841	0.000	0.000	0.783	0.000
	PH	e	0.000	0.000	0.000	0.080	0.000	0.181	0.000	0.000	0.000
HCE	CP	b,c	0.000	0.874	0.990	0.000	0.083	0.000	0.783	0.000	0.000
	PH	d	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: CP = crude proteins; PH = proteins hydrolysates; PHs were obtained from CPs extracted using various media, including sodium hydroxide (SHE), DI water (WTE), ascorbic acid (AAE), citric acid (CAE), and hydrochloric acid (HCE). The identical letters (a, b, c, d, and e) represent values that do not exhibit statistically significant differences among *A. mellifera* larvae extracts, while differing letters indicate significant differences. The data were analyzed using One-Way ANOVA followed by Tukey's post-hoc test ( $p < 0.05$ ).

**Table S4.** Tukey's HSD test results ( $\alpha = 0.05$ ) for total protein contents among crude protein extracts and protein hydrolysates of *A. mellifera* larvae.

Samples	Subset for alpha = 0.05					Group
	a	b	c	d	e	
SHE-CP	173.1030					a
SHE-HP		6.2087				b
WTE-CP		6.0976				b
HCE-CP		5.8915	5.8915			b,c
CAE-CP		5.5339	5.5339			b,c
AAE-CP			5.2006			c
HCE-HP				3.1501		d
WTE-HP					0.8026	e
AAE-HP					0.7097	e
CAE-HP					0.1077	e

Note: CP = crude proteins; PH = proteins hydrolysates; PHs were obtained from CPs extracted using various media, including sodium hydroxide (SHE), DI water (WTE), ascorbic acid (AAE), citric acid (CAE), and hydrochloric acid (HCE). The identical letters (a, b, c, d, and e) represent values that do not exhibit statistically significant differences among *A. mellifera* larvae extracts, while differing letters indicate significant differences. The data were analyzed using One-Way ANOVA followed by Tukey's post-hoc test ( $p < 0.05$ ).

**Table S5.** Antioxidant activities of *A. mellifera* larval extracts.

Samples	TEAC ( $\mu\text{g}$ Trolox/mg sample)		NO• inhibition (%)	
GA	N/A		$73.63 \pm 1.46^b$	
ASC	$36.65 \pm 0.11^a$		$89.79 \pm 2.57^a$	
LYS	$31.97 \pm 0.67^{b,c}$		$82.43 \pm 1.57^{a,b}$	
<i>A. mellifera</i> larval extract	Crude protein	Protein hydrolysate	Crude protein	Protein hydrolysate
SHE	$29.06 \pm 0.99^{c,d,e}$	$34.64 \pm 0.27^{a,b}$	$10.11 \pm 4.23^e$	$15.20 \pm 4.02^{d,e}$
WTE	$29.50 \pm 2.71^{c,d}$	$31.89 \pm 0.05^{b,c}$	$25.01 \pm 1.48^d$	$20.59 \pm 5.36^{d,e}$
AAE	$33.81 \pm 1.15^{a,b}$	$34.02 \pm 0.24^{a,b}$	$51.98 \pm 9.88^c$	$43.84 \pm 5.16^c$
CAE	$25.95 \pm 2.25^e$	$32.00 \pm 1.05^{b,c}$	$14.91 \pm 2.53^{d,e}$	$11.48 \pm 2.66^e$
HCE	$29.26 \pm 0.67^{c,d,e}$	$28.23 \pm 0.82^{d,e}$	$20.48 \pm 5.04^{d,e}$	$13.08 \pm 3.43^{d,e}$

Note: TEAC = Trolox equivalent antioxidant capacity; NO• = nitric oxide; GA = gallic acid; ASC = ascorbic acid; LYS = lysine; crude proteins and their hydrolysates extracted using various media, including sodium hydroxide (SHE), DI water (WTE), ascorbic acid (AAE), citric acid (CAE), and hydrochloric acid (HCE); N/A = not available. Lowercase letters (a, b, c, d, and e) indicate significant differences among *A. mellifera* larvae extracts. The identical letters represent values that do not exhibit statistically significant differences. The data were analyzed using One-Way ANOVA followed by Tukey's post-hoc test ( $p < 0.05$ ).

**Table S6.** The p-values demonstrate statistically significant differences ( $p < 0.05$ , labeled in red) in Trolox equivalent antioxidant capacity (TEAC) among crude protein extracts and protein hydrolysates of *A. mellifera* larvae.

Samples	Group	ASC	LYS	SHE	WTE	AAE	CAE	HCE
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				CP	PH	CP	PH	CP	PH	CP	PH	CP	PH
ASC	a		0.004	0.000	0.661	0.000	0.003	0.207	0.294	0.000	0.004	0.000	0.000
LYS	b,c	0.004		0.181	0.281	0.379	1.000	0.768	0.643	0.000	1.000	0.261	0.032
SHE	CP	c,d,e	0.000	0.181	0.000	1.000	0.212	0.003	0.002	0.125	0.171	1.000	0.999
	PH	a,b	0.661	0.281	0.000	0.001	0.242	0.999	1.000	0.000	0.294	0.001	0.000
WTE	CP	c,d	0.000	0.379	1.000	0.001	0.429	0.009	0.005	0.050	0.362	1.000	0.972
	PH	b,c	0.003	1.000	0.212	0.242	0.429	0.716	0.586	0.000	1.000	0.302	0.039
AAE	CP	a,b	0.207	0.768	0.003	0.999	0.009	0.716	1.000	0.000	0.785	0.005	0.000
	PH	a,b	0.294	0.643	0.002	1.000	0.005	0.586	1.000	0.000	0.661	0.003	0.000
CAE	CP	e	0.000	0.000	0.125	0.000	0.050	0.000	0.000	0.000	0.000	0.082	0.492
	PH	b,c	0.004	1.000	0.171	0.294	0.362	1.000	0.785	0.661	0.000	0.248	0.030
HCE	CP	c,d,e	0.000	0.261	1.000	0.001	1.000	0.302	0.005	0.003	0.082	0.248	0.994
	PH	d,e	0.000	0.032	0.999	0.000	0.972	0.039	0.000	0.000	0.492	0.030	0.994

Note: ASC = ascorbic acid; LYS = lysine; CP = crude proteins; PH = proteins hydrolysates; PHs were obtained from CPs extracted using various media, including sodium hydroxide (SHE), DI water (WTE), ascorbic acid (AAE), citric acid (CAE), and hydrochloric acid (HCE). The identical letters (a, b, c, d, and e) represent values that do not exhibit statistically significant differences among *A. mellifera* larvae extracts, while differing letters indicate significant differences. The data were analyzed using One-Way ANOVA followed by Tukey's post-hoc test ( $p < 0.05$ ).

**Table S7.** Tukey's HSD test results ( $\alpha = 0.05$ ) for TEAC among crude protein extracts and protein hydrolysates of *A. mellifera* larvae.

Samples	Subset for alpha = 0.05					Group
	a	b	c	d	e	
ASC	36.6563					a
SHE-PH	34.6415	34.6415				a,b
AAE-PH	34.0193	34.0193				a,b
AAE-CP	33.8119	33.8119				a,b
CAE-PH		32.0044	32.0044			b,c
LYS		31.9748	31.9748			b,c
WTE-PH		31.8859	31.8859			b,c
WTE-CP			29.5007	29.5007		c,d
HCE-CP			29.2637	29.2637	29.2637	c,d,e
SHE-CP			29.0563	29.0563	29.0563	c,d,e
HCE-PH				28.2267	28.2267	d,e
CAE-CP					25.9452	e

Note: ASC = ascorbic acid; LYS = lysine; CP = crude proteins; PH = proteins hydrolysates; PHs were obtained from CPs extracted using various media, including sodium hydroxide (SHE), DI water (WTE), ascorbic acid (AAE), citric acid (CAE), and hydrochloric acid (HCE). The identical letters (a, b, c, d, and e) represent values that do not exhibit statistically significant differences among *A. mellifera* larvae extracts, while differing letters indicate significant differences. The data were analyzed using One-Way ANOVA followed by Tukey's post-hoc test ( $p < 0.05$ ).

**Table S8.** The p-values demonstrate statistically significant differences ( $p < 0.05$ , labeled in red) in nitric oxide (NO<sup>•</sup>) inhibition among crude protein extracts and protein hydrolysates of *A. mellifera* larvae.

Samples	Group	GA	ASC	LYS	SHE		WTE		AAE		CAE		HCE	
					CP	PH	CP	PH	CP	PH	CP	PH	CP	PH
GA	b		0.001	0.088	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ASC	a	0.001		0.693	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LYS	a,b	0.088	0.693		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SHE	CP	e	0.000	0.000	0.000	0.962	0.015	0.212	0.000	0.000	0.975	1.000	0.224	1.000
	PH	d,e	0.000	0.000	0.000	0.962	0.290	0.943	0.000	0.000	1.000	0.997	0.950	1.000
WTE	CP	d	0.000	0.000	0.000	0.015	0.290	0.987	0.000	0.001	0.255	0.037	0.984	0.097
	PH	d,e	0.000	0.000	0.000	0.212	0.943	0.987	0.000	0.000	0.921	0.393	1.000	0.668
AAE	CP	c	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.557	0.000	0.000	0.000	0.000
	PH	c	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.557	0.000	0.000	0.000	0.000
CAE	CP	d,e	0.000	0.000	0.000	0.975	1.000	0.255	0.921	0.000	0.000	0.999	0.930	1.000
	PH	e	0.000	0.000	0.000	1.000	0.997	0.037	0.393	0.000	0.000	0.999	0.410	1.000
HCE	CP	d,e	0.000	0.000	0.000	0.224	0.950	0.984	1.000	0.000	0.000	0.930	0.410	0.687
	PH	d,e	0.000	0.000	0.000	1.000	1.000	0.097	0.668	0.000	0.000	1.000	1.000	0.687

Note: GA = gallic acid; ASC = ascorbic acid; LYS = lysine; CP = crude proteins; PH = proteins hydrolysates; PHs were obtained from CPs extracted using various media, including sodium hydroxide (SHE), DI water (WTE), ascorbic acid (AAE), citric acid (CAE), and hydrochloric acid (HCE). The identical letters (a, b, c, d, and e) represent values that do not exhibit statistically significant differences among *A. mellifera* larvae extracts, while differing letters indicate significant differences. The data were analyzed using One-Way ANOVA followed by Tukey's post-hoc test ( $p < 0.05$ ).

**Table S9.** Tukey's HSD test results ( $\alpha = 0.05$ ) for NO<sup>•</sup> inhibition among crude protein extracts and protein hydrolysates of *A. mellifera* larvae.

Samples	Subset for alpha = 0.05					Group
	a	b	c	d	e	

ASC	89.7935				a
LYS	82.4303	82.4303			a,b
GA		70.3335			b
AAE-CP			51.9850		c
AAE-PH			43.8439		c
WTE-CP				25.0134	d
WTE-PH				20.5874	d,e
HCE-CP				20.4802	d,e
SHE-PH				15.1958	d,e
CAE-CP				14.9142	d,e
HCE-PH				13.0767	d,e
CAE-PH				11.4807	e
SHE-CP				10.1127	e

Note: GA = gallic acid; ASC = ascorbic acid; LYS = lysine; CP = crude proteins; PH = proteins hydrolysates; PHs were obtained from CPs extracted using various media, including sodium hydroxide (SHE), DI water (WTE), ascorbic acid (AAE), citric acid (CAE), and hydrochloric acid (HCE). The identical letters (a, b, c, d, and e) represent values that do not exhibit statistically significant differences among *A. mellifera* larvae extracts, while differing letters indicate significant differences. The data were analyzed using One-Way ANOVA followed by Tukey's post-hoc test ( $p < 0.05$ ).

**Table S10.** Anti-skin ageing activities of *A. mellifera* larval extracts.

Samples	Collagenase inhibition (%)		Hyaluronidase inhibition (%)	
EGCG	75.74 ± 4.98 <sup>a</sup>		N/A	
OA	N/A		85.66 ± 6.59 <sup>a</sup>	
ASC	31.15 ± 10.81 <sup>b,c,d,e</sup>		0.00 ± 3.65 <sup>h</sup>	
LYS	39.86 ± 9.84 <sup>b,c,d</sup>		4.48 ± 2.95 <sup>g</sup>	
<i>A. mellifera</i> larval extract	Crude protein	Protein hydrolysate	Crude protein	Protein hydrolysate
SHE	12.54 ± 1.182 <sup>e,f</sup>	14.82 ± 2.22 <sup>d,e,f</sup>	78.15 ± 1.55 <sup>a</sup>	13.79 ± 4.32 <sup>e,f,g</sup>
WTE	0.00 ± 3.28 <sup>f</sup>	34.00 ± 8.20 <sup>b,c,d,e</sup>	56.40 ± 1.36 <sup>b</sup>	37.58 ± 5.37 <sup>c</sup>
AAE	48.11 ± 14.26 <sup>b</sup>	44.54 ± 1.34 <sup>b,c</sup>	27.54 ± 2.27 <sup>c,d</sup>	4.09 ± 1.86 <sup>g</sup>
CAE	32.11 ± 8.04 <sup>b,c,d,e</sup>	2.51 ± 0.24 <sup>f</sup>	18.39 ± 5.18 <sup>d,e,f</sup>	14.60 ± 2.08 <sup>e,f,g</sup>
HCE	18.67 ± 1.02 <sup>c,d,e,f</sup>	14.85 ± 4.07 <sup>d,e,f</sup>	24.24 ± 5.11 <sup>d,e</sup>	8.68 ± 1.36 <sup>f,g</sup>

Note: EGCG = epigallocatechin gallate; OA = oleanolic acid; ASC = ascorbic acid; LYS = lysine; crude proteins and their hydrolysates extracted using various media, including sodium hydroxide (SHE), DI water (WTE), ascorbic acid (AAE), citric acid (CAE), and hydrochloric acid (HCE); N/A = not available. Lowercase letters (a, b, c, d, e, f, g, and h) indicate significant differences among *A. mellifera* larvae extracts. The identical letters represent values that do not exhibit statistically significant differences. The data were analyzed using One-Way ANOVA followed by Tukey's post-hoc test ( $p < 0.05$ ).

**Table S11.** The p-values demonstrate statistically significant differences ( $p < 0.05$ , labeled in red) in collagenase inhibition among crude protein extracts and protein hydrolysates of *A. mellifera* larvae.

Samples	Group	EGCG	ASC	LYS	SHE		WTE		AAE		CAE		HCE	
					CP	PH	CP	PH	CP	PH	CP	PH	CP	PH
EGCG	a		0.001	0.006	0.000	0.000	0.000	0.002	0.046	0.019	0.001	0.000	0.000	0.000
ASC	b,c,d,e	0.001		0.977	0.339	0.504	0.020	1.000	0.454	0.743	1.000	0.036	0.811	0.506
LYS	b,c,d	0.006	0.977		0.049	0.084	0.002	0.999	0.985	1.000	0.991	0.004	0.201	0.085
SHE	CP	e,f	0.000	0.339	0.049		1.000	0.806	0.190	0.007	0.016	0.281	0.941	0.999
	PH	d,e,f	0.000	0.504	0.084	1.000		0.628	0.303	0.012	0.028	0.430	0.822	1.000
WTE	CP	f	0.000	0.020	0.002	0.806	0.628		0.010	0.000	0.001	0.016	1.000	0.335
	PH	b,c,d,e	0.002	1.000	0.999	0.190	0.303	0.010		0.686	0.922	1.000	0.018	0.585
AAE	CP	b	0.046	0.454	0.985	0.007	0.012	0.000	0.686		1.000	0.530	0.001	0.030
	PH	b,c	0.019	0.743	1.000	0.016	0.028	0.001	0.922	1.000		0.814	0.002	0.070
CAE	CP	b,c,d,e	0.001	1.000	0.991	0.281	0.430	0.016	1.000	0.530	0.814		0.028	0.740
	PH	f	0.000	0.036	0.004	0.941	0.822	1.000	0.018	0.001	0.002	0.028		0.517
HCE	CP	c,d,e,f	0.000	0.811	0.201	0.999	1.000	0.335	0.585	0.030	0.070	0.740	0.517	1.000
	PH	d,e,f	0.000	0.506	0.085	1.000	1.000	0.625	0.305	0.012	0.028	0.432	0.820	

Note: EGCG = epigallocatechin gallate; ASC = ascorbic acid; LYS = lysine; CP = crude proteins; PH = proteins hydrolysates; PHs were obtained from CPs extracted using various media, including sodium hydroxide (SHE), DI water (WTE), ascorbic acid (AAE), citric acid (CAE), and hydrochloric acid (HCE). The identical letters (a, b, c, d, e, and f) represent values that do not exhibit statistically significant differences among *A. mellifera* larvae extracts, while differing letters indicate significant differences. The data were analyzed using One-Way ANOVA followed by Tukey's post-hoc test ( $p < 0.05$ ).

**Table S12.** Tukey's HSD test results ( $\alpha = 0.05$ ) for collagenase inhibition among crude protein extracts and protein hydrolysates of *A. mellifera* larvae.

Samples	Subset for alpha = 0.05						Group
	a	b	c	d	e	f	

EGCG	75.7432													a
AAE-CP		48.1141												b
AAE-PH		44.5373	44.5373											b,c
LYS		39.8644	39.8644	39.8644										b,c,d
WTE-PH		34.0022	34.0022	34.0022	34.0022									b,c,d,e
CAE-CP		32.1070	32.1070	32.1070	32.1070									b,c,d,e
ASC		31.1501	31.1501	31.1501	31.1501									b,c,d,e
HCE-CP			18.6734	18.6734	18.6734	18.6734								c,d,e,f
HCE-PH				14.8458	14.8458	14.8458								d,e,f
SHE-PH				14.8180	14.8180	14.8180								d,e,f
SHE-CP						12.5416	12.5416							e,f
CAE-PH							2.5084							f
WTE-CP							0.0000							f

Note: EGCG = epigallocatechin gallate; ASC = ascorbic acid; LYS = lysine; CP = crude proteins; PH = proteins hydrolysates; PHs were obtained from CPs extracted using various media, including sodium hydroxide (SHE), DI water (WTE), ascorbic acid (AAE), citric acid (CAE), and hydrochloric acid (HCE). The identical letters (a, b, c, d, e, and f) represent values that do not exhibit statistically significant differences among *A. mellifera* larvae extracts, while differing letters indicate significant differences. The data were analyzed using One-Way ANOVA followed by Tukey's post-hoc test ( $p < 0.05$ ).

**Table S13.** The p-values demonstrate statistically significant differences ( $p < 0.05$ , labeled in red) in hyaluronidase inhibition among crude protein extracts and protein hydrolysates of *A. mellifera* larvae.

Samples	Group	OA	ASC	LYS	SHE		WTE		AAE		CAE		HCE	
					CP	PH	CP	PH	CP	PH	CP	PH	CP	PH
OA	a		0.000	0.000	0.573	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ASC	h	0.000		0.011	0.000	0.000	0.000	0.000	0.000	0.040	0.000	0.000	0.000	0.000
LYS	g	0.000	0.011		0.000	0.154	0.000	0.000	0.000	1.000	0.005	0.091	0.000	0.964
SHE	CP	a	0.573	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	PH	e,f,g	0.000	0.000	0.154	0.000		0.000	0.006	0.225	0.932	1.000	0.072	0.874
WTE	CP	b	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000
	PH	c	0.000	0.000	0.000	0.000	0.000		0.096	0.000	0.000	0.000	0.008	0.000
AAE	CP	c,d	0.000	0.000	0.000	0.006	0.000	0.096		0.000	0.170	0.011	0.995	0.000
	PH	g	0.000	0.000	1.000	0.000	0.225	0.000	0.000		0.013	0.145	0.000	0.969
CAE	CP	d,e,f	0.000	0.000	0.005	0.000	0.932	0.000	0.170	0.013		0.028	0.740	0.432
	PH	e,f,g	0.000	0.000	0.091	0.000	1.000	0.000	0.011	0.145	0.028		0.517	0.820
HCE	CP	d,e	0.000	0.000	0.000	0.000	0.072	0.000	0.008	0.995	0.000	0.740	0.517	1.000
	PH	f,g	0.000	0.000	0.964	0.000	0.874	0.000	0.000	0.969	0.432	0.820	1.000	

Note: OA = oleanolic acid; ASC = ascorbic acid; LYS = lysine; CP = crude proteins; PH = proteins hydrolysates; PHs were obtained from CPs extracted using various media, including sodium hydroxide (SHE), DI water (WTE), ascorbic acid (AAE), citric acid (CAE), and hydrochloric acid (HCE). The identical letters (a, b, c, d, e, f, g, and h) represent values that do not exhibit statistically significant differences among *A. mellifera* larvae extracts, while differing letters indicate significant differences. The data were analyzed using One-Way ANOVA followed by Tukey's post-hoc test ( $p < 0.05$ ).

**Table S14.** Tukey's HSD test results ( $\alpha = 0.05$ ) for hyaluronidase inhibition among crude protein extracts and protein hydrolysates of *A. mellifera* larvae.

Samples	Subset for alpha = 0.05								Group
	a	b	c	d	e	f	g	h	
OA	85.6566								a
SHE-CP	78.1451								a
WTE-CP		56.4032							b
WTE-PH			37.5762						c
AAE-CP			27.5384	27.5384					c,d
HCE-CP				24.2360	24.2360				d,e
CAE-CP				18.3922	18.3922	18.3922			d,e,f
CAE-PH					14.6003	14.6003	14.6003		e,f,g
SHE-PH					13.7870	13.7870	13.7870		e,f,g
HCE-PH						8.6820	8.6820		f,g
LYS							4.4834		g
AAE-PH							4.0916		g
ASC								0.0000	h

Note: OA = oleanolic acid; ASC = ascorbic acid; LYS = lysine; CP = crude proteins; PH = proteins hydrolysates; PHs were obtained from CPs extracted using various media, including sodium hydroxide (SHE), DI water (WTE), ascorbic acid (AAE), citric acid (CAE), and hydrochloric acid (HCE). The identical letters (a, b, c, d, e, f, g, and h) represent values that do not exhibit statistically significant differences among *A. mellifera* larvae extracts, while differing letters indicate significant differences. The data were analyzed using One-Way ANOVA followed by Tukey's post-hoc test ( $p < 0.05$ ).