

**Supplementary materials**

**Table S1.** Characterization results of all nanoparticles.

Nanoparticle samples (mg/mL)	Average hydrodynamic diameter (nm)	Zeta potential (mV)	PDI
3	136.48±3.58	26.69±0.53	0.535±0.069
4	119.56±4.24	24.51±0.45	0.626±0.015
5	122.72±4.88	23.89±0.37	0.473±0.063
10	-	28.96±0.78	> 0.7
15	-	30.7±0.36	> 0.7
20	-	36.93±0.53	> 0.7

**Table S2.** Circle of inhibition diameters of nisin Z, NPC and composites on *S. aureus*.

	<i>S. aureus</i>	Nisin Z	NPC	Gel10- 73/NPC	Gel10- 82/NPC	Gel50- 82/NPC
Circle of inhibition diameters (mm)	0.00	20.20±0. 58	19.70±0. 27	16.59±0. 83	17.06±0. 83	16.91±0. 72

**Table S3.** Volume percentage of each component of hydrogels, NPs and composites.

	Gel <sub>100-73</sub>	Gel <sub>100-82</sub>	Gel <sub>500-82</sub>	5 mg/mL NPs
CS <sub>100</sub> (2%, m/v)	1.4	1.6	-	0.1
CS <sub>500</sub> (2%, m/v)	-	-	1.6	-
HCl (1mol/L)	68.5	78.3	78.3	-
β-GP (45%, m/v)	13.5	9	9	-
H <sub>2</sub> O	16.5	11	11	98.8
Nisin (20mg/mL)	-	-	-	0.5
γ-PGA (4mg/mL)	-	-	-	0.1
Acetic acid (1%, v/v)	-	-	-	0.5