Table 3 Physical properties of the SA, GG, and SA/GG films

	Thickness (μm)	TS (MPa)	EB (%)	WVP ($\times 10^{-11}$ g/(m s Pa))
(a) Thickness, TS, EB and WVP of the SA, GG, and SA/GG films				
SA	33.25 ± 0.62^{d}	33.30 ± 1.31^{b}	8.37 ± 0.40^{d}	7.21 ± 0.16^{b}
GG	51.53 ± 1.19^{a}	26.61 ± 0.73^{c}	15.62 ± 0.35^{a}	11.17 ± 0.56^{a}
S1	35.16 ± 1.08^{cd}	33.34 ± 1.11^{b}	10.13 ± 0.34^{c}	7.32 ± 0.60^{a}
S2	35.14 ± 1.23^{cd}	33.73 ± 1.30^{b}	12.05 ± 0.33^{b}	7.28 ± 0.28^{a}
S3	34.44 ± 0.39^{d}	34.11 ± 0.94^{b}	15.27 ± 0.30^{a}	7.19 ± 0.19^{a}
S4	35.85 ± 0.76^{cd}	34.65 ± 1.06^{b}	9.93 ± 0.50^{c}	7.31 ± 0.33^{a}
S5	37.43 ± 0.93^{b}	37.81 ± 1.11^{a}	8.60 ± 0.34^{d}	7.48 ± 0.29^{a}

Film type	Light transmission (%)							Opacity
	800 nm	600 nm	500 nm	400 nm	350 nm	280 nm	200 nm	
(b) Light transmission and opacity of the SA, GG, and SA/GG films								
SA	89.01	87.49	86.09	82.96	79.25	70.41	0.21	2.01 ± 0.02^{d}
S1	81.73	79.5	78.21	73.78	70.26	59.15	0.27	3.24 ± 0.03^{c}
S2	81.34	76.94	75.08	72.40	66.93	54.95	0.14	3.28 ± 0.04^{c}
S3	79.96	76.28	75.05	71.33	66.26	52.22	0.12	3.32 ± 0.06^{bc}
S4	79.77	75.67	74.43	70.03	64.87	49.50	0.09	3.45 ± 0.06^{ab}
S5	77.78	75.06	72.12	66.31	61.80	47.24	0.07	3.54 ± 0.06^{a}

[a]The same superscript letter in the same column means that the two values are not statistically significantly different ($p > 0.05$) as per the Duncan's multiple range test

[b]Data are given as the mean of three replicates ± standard deviation

[c]Parallel experiments: ten strips were used for each test

Conclusions

In this paper, SA, GG, and SA/GG blend films were prepared by a solvent-casting method. The experimental results show that the performance of the SA/GG blend films are better than that of a single component membrane, especially the SA film is improved in brittleness and flexibility. The mechanical properties showed that, at an SA/GG ratio of 5:1, the EB was 15.27% (an 82.4% increased relative to that of the pure alginate film). The SEM, FTIR-ATR and XRD results revealed that SA has good compatibility with GG, whereby GG is uniformly dispersed in the film structure of SA. The rheological properties confirm the synergy between SA and GG. More importantly, compared to that of the pure SA film, the thermal stability of SA/GG blend films was enhanced. In summary, strong interactions (hydrogen bonding and electrostatic interactions) exist between SA and GG. SA/GG blend films with high mechanical strength, light barrier properties and thermal stability are promising biomaterials and packaging materials with wide application prospects.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

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