CHAPTER 5: RESULTS

5.1 Phase 1

5.1.1 Proximate composition of egg samples

The proximate composition of fresh shell egg, frozen egg pulp, spray-dried egg powder and egg powder mixture samples are shown in Table 4. The ash, protein, fat and carbohydrate contents are expressed on dry matter basis.

The moisture contents of the various egg samples were analyzed to calculate the reconstitution formula (See section 4.3.1) and dry matter basis for all samples. On dry weight basis, the egg powder mixture samples contained more ash than fresh shell egg, frozen egg pulp and spray-dried egg powder samples. There were no significant differences in ash content between fresh shell egg and frozen egg pulp sample on wet basis.

The protein contents differed significantly ($p<0.05$) among the samples. Fresh shell egg samples contained the most protein and the egg powder mixture contained the least protein on dry basis. Fresh shell egg also contained significantly higher protein content than frozen egg pulp on wet basis.

The fat contents varied significantly ($p<0.05$) among the samples. The fresh shell egg and spray-dried egg powder contained the most fat whereas the fat content of the egg powder mixture was the least. However, there were no significant differences in fat content between fresh shell egg and frozen egg pulp sample on wet basis.

Fresh shell egg contained the least carbohydrates whereas egg powder mixture contained the most.

Table 4 Proximate compositions [1] (dry basis) of fresh shell egg, frozen egg pulp, spray-dried egg powder and egg powder mixture samples; Wet basis[2] of fresh shell egg and frozen egg pulp samples

Sample	Moisture %	Ash %	Protein[3] %	Fat %	Carbohydrate[4] %
Fresh Shell Egg	75.76[a] (±0.66)	3.71 [a] (±0.42) [0.90] [x] (± 0.1)	54.38 [a] (±0.18) [13.80] [x] (± 0.04)	35.67 [a] (±0.19) [8.68] [x] (± 0.04)	6.24 [1.51]
Frozen Egg Pulp	72.63[b] (±0.01)	3.15 [a] (±0.42) [0.86] [x] (± 0.11)	44.56 [b] (±0.42) [12.20] [y] (± 0.03)	33 [b] (±1.09) [9.03] [x] (± 0.3)	19.29 [5.28]
Spray-dried Egg Powder	1.86[c] (±0.26)	3.03 [a] (±0.49)	50.68 [c] (±0.03)	35.31 [a] (±1.15)	10.98
Egg Powder Mixture	2.89[d] (±0.32)	7.21 [b] (±0.49)	36.40 [d] (±0.02)	24.35 [c] (±1.21)	32.04

abcd: Values on dry basis in a column with different letters (abcd) are significantly different ($p<0.05$)

xy: Values on wet basis in a column with different letters (xy) are significantly different ($p<0.05$)

1 Values in brackets ( ) are the standard deviations of the measurements

2 Values in brackets [ ] are on wet basis

3 N x 6.25

4 Carbohydrate calculated by difference

5.1.2 pH

Table 5 shows the pH of the various egg samples. The dried egg samples were reconstituted with distilled water (pH 7) before analysis.

Table 5 pH [1] of fresh shell egg, frozen egg pulp, spray-dried egg powder and egg powder mixture samples

Sample	pH
Fresh Shell Egg	7.42 [a] (±0.02)
Frozen Egg Pulp	6.48 [b] (±0.02)
Spray-dried Egg Powder	8.11 [c] (±0.01)
Egg Powder Mixture	6.64 [d] (±0.03)

abcd: Values with different letters are significantly different ($p<0.05$)

[1] Values in brackets are the standard deviations of the measurements

The pH differed significantly for all the samples. Spray-dried egg powder had the highest pH whereas the frozen egg pulp had the lowest pH value.

5.1.3 Foaming Overrun of egg samples

Figure 12 shows the results for foaming overrun of the egg samples which were whipped at room temperature (20 ± 0.5°C). The % foaming overrun of the egg samples differed significantly ($p < 0.05$). The higher the percentages of foaming overrun, the better the whipping ability. Thus, fresh shell egg samples had the best whipping ability whereas the egg powder mixture samples were the worst.

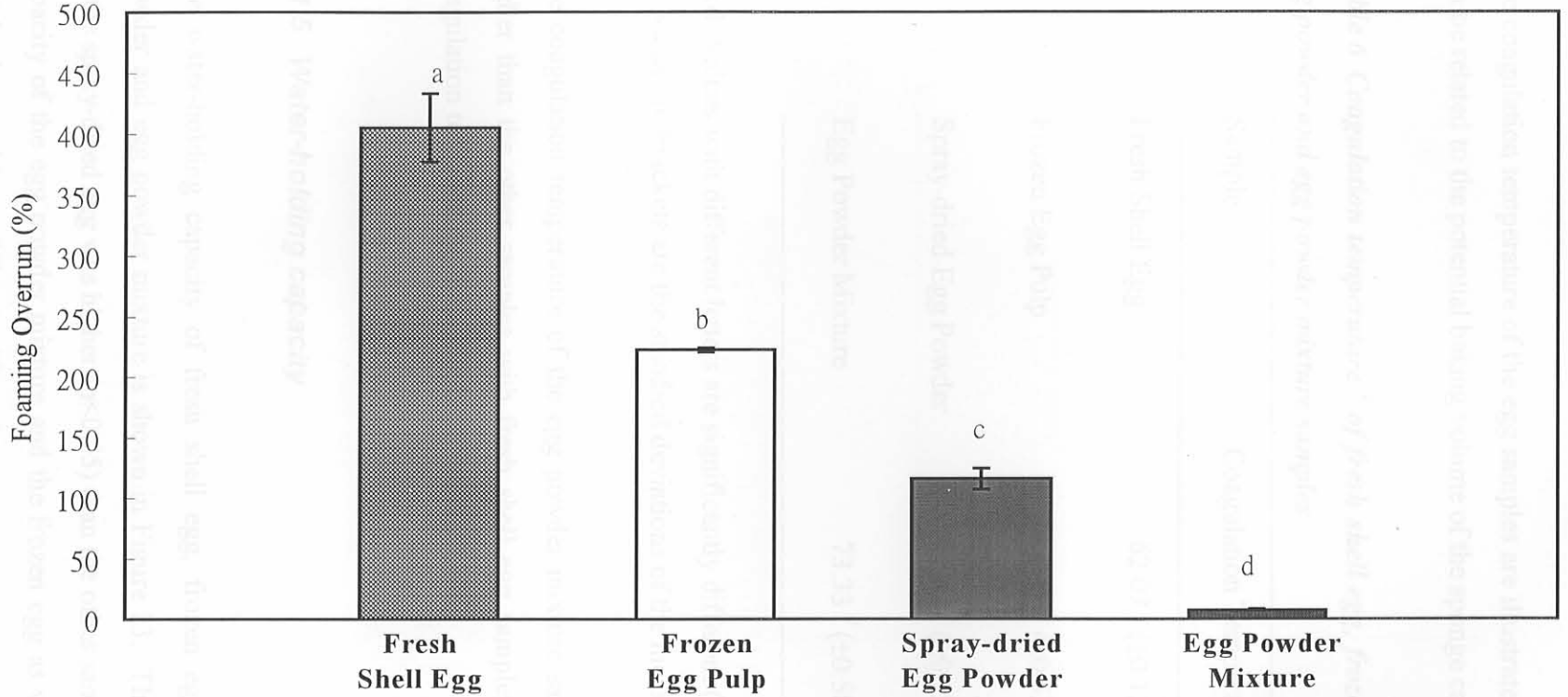

Figure 12 Percentage foaming overrun (± standard deviations) of fresh shell egg, frozen egg pulp, spray-dried egg powder and egg powder mixture samples

abcd: Values with different letters are significantly different ($p<0.05$)

5.1.4 Coagulation temperature

The coagulation temperature of the egg samples are illustrated in Table 6. This result can be related to the potential baking volume of the sponge cakes.

Table 6 Coagulation temperature [1] of fresh shell egg, frozen egg pulp, spray-dried egg powder and egg powder mixture samples

Sample	Coagulation Temperature (°C)
Fresh Shell Egg	62.07 [a] (±0.12)
Frozen Egg Pulp	68.80 [b] (±0.53)
Spray-dried Egg Powder	67.87 [c] (±0.12)
Egg Powder Mixture	73.33 [d] (±0.58)

abcd: Values with different letters are significantly different ($p<0.05$)

[1] Values in brackets are the standard deviations of the measurements

The coagulation temperature of the egg powder mixture samples were significantly higher than the other samples with fresh shell egg samples resulting in the lowest coagulation temperature.

5.1.5 Water-holding capacity

The water-holding capacity of fresh shell egg, frozen egg pulp, spray-dried egg powder and egg powder mixture is shown in Figure 13. The water-holding capacity of the spray-dried egg was higher ($p<0.05$) than the other samples. The water-holding capacity of the egg powder mixture and the frozen egg as well as that of the frozen and fresh egg did not differ significantly.

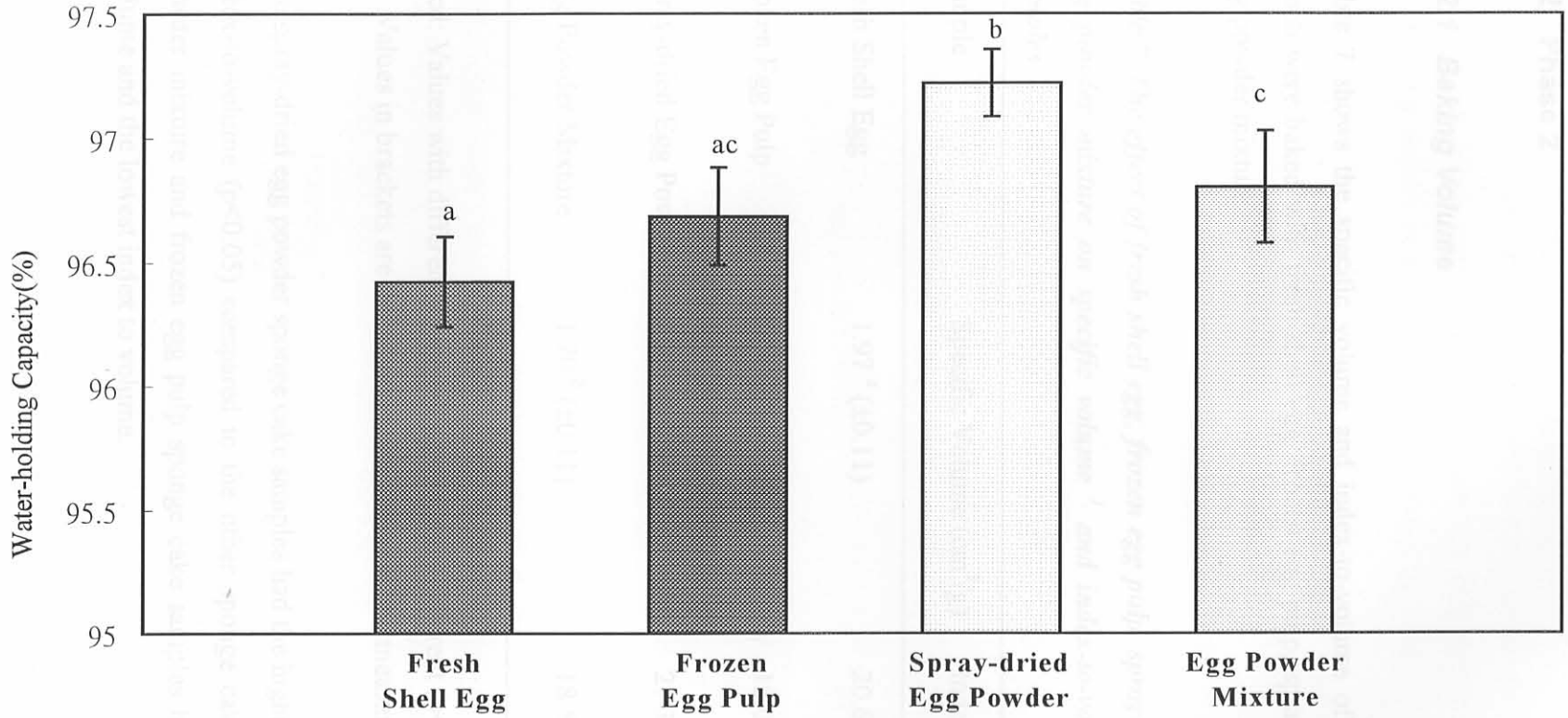

Figure 13 Water-holding capacity (± standard deviations) of fresh shell egg, frozen egg pulp, spray-dried egg powder and egg powder mixture samples

abcd: Values with different letters are significantly different ($p<0.05$)

5.2 Phase 2

5.2.1 Baking Volume

Table 7 shows the specific volume and index-to-volume of sponge cake samples which were baked with fresh shell egg, frozen egg pulp, spray-dried egg powder or egg powder mixture.

Table 7 The effect of fresh shell egg, frozen egg pulp, spray-dried egg powder and egg powder mixture on specific volume [1] and index-to-volume of sponge cake samples

Sample	Specific Volume (cm^3/g)	Index to Volume (cm^2)
Fresh Shell Egg	1.97 [a] (±0.11)	20.63 [a] (±0.52)
Frozen Egg Pulp	1.71 [b] (±0.17)	18.00 [b] (±0.53)
Spray-dried Egg Powder	2.12 [c] (±0.11)	21.38 [c] (±0.44)
Egg Powder Mixture	1.70 [b] (±0.11)	18.50 [b] (±0.46)

abcd: Values with different letters are significantly different ($p<0.05$)

[1] Values in brackets are the standard deviations of the measurements

The spray-dried egg powder sponge cake samples had the highest specific volume and index-to-volume ($p<0.05$) compared to the other sponge cake samples. The egg powder mixture and frozen egg pulp sponge cake samples had the lowest specific volume and the lowest index to volume.

5.2.2 Water Activity

Water activity of the various sponge cake samples is shown in Table 8. The sponge cake samples which were baked with frozen egg pulp had the highest water activity whereas egg powder mixture had the lowest water activity.

Table 8 The effect of fresh shell egg, frozen egg pulp, spray-dried egg powder and egg powder mixture on water activity of sponge cake samples

Sample	Water Activity
Fresh Shell Egg	0.87
Frozen Egg Pulp	0.88
Spray-dried Egg Powder	0.84
Egg Powder Mixture	0.83

5.2.3 Yeast and mould counts

Table 9 shows the yeast and mould counts of the sponge cake samples which were stored at 21 and 31°C for 12, 16, 21 and 24 days, respectively. Positive yeast and mould counts were found on fresh shell egg and frozen egg pulp sponge cake samples from Day 16 at 31°C in fresh shell egg and frozen egg pulp. Frozen egg pulp sponge cake samples had the highest counts on Day 20 and Day 24 at both storing temperatures. However, the sponge cake samples baked using egg powder mixture had yeast and mould counts only on Day 24 at 21°C. Thus, the egg powder mixture sponge cake samples had the longest shelf-life at 21°C which were between 21 days and 24 days. Yeast and mould counts were found on fresh shell egg and frozen egg pulp sponge cake samples from Day 16 at 31°C. Therefore, the sponge cake samples which were stored for 16 days at 31°C, 20 days at 21°C or 24 days at 31°C were not evaluated by a sensory panel.

Table 9 Yeast and mould counts (cfu/g) of fresh shell egg, frozen egg pulp, spray-dried egg powder and egg powder mixture sponge cake samples

Sponge cake sample	°C	Day 12	Day 16	Day 20	Day 24
Fresh Shell Egg	21	ND	ND	10	700
	31	ND	10	>1000	>1000
Frozen Egg Pulp	21	ND	ND	60	>1000
	31	ND	10	>1000	>1000
Spray-dried Egg Powder	21	ND	ND	55	210
	31	ND	ND	130	600
Egg Powder Mixture	21	ND	ND	ND	20
	31	ND	ND	20	440

ND = Not detected at levels <10 cfu/g

5.2.4 Texture analysis

Figure 14 shows the texture measurements of fresh shell egg, frozen egg pulp, spray-dried egg powder and egg powder mixture sponge cake samples from Day 0 to Day 24. Temperature of storage (i.e. 21°C and 31°C) did not have a significant effect on the texture measurements of the sponge cakes. The results of 21°C and 31°C storage temperature are therefore combined.

The crumb softness as evaluated by the texture analyser with compression force differed significantly ($p<0.05$) among the storage days for all egg samples. In general, the crumb texture of spray-dried egg powder sponge cake samples was the softest, followed by fresh shell egg, frozen egg pulp and egg powder mixture. For fresh shell egg, spray-dried egg powder and egg powder mixture sponge cake samples, a softening of the crumb texture was noticed on Day 4.

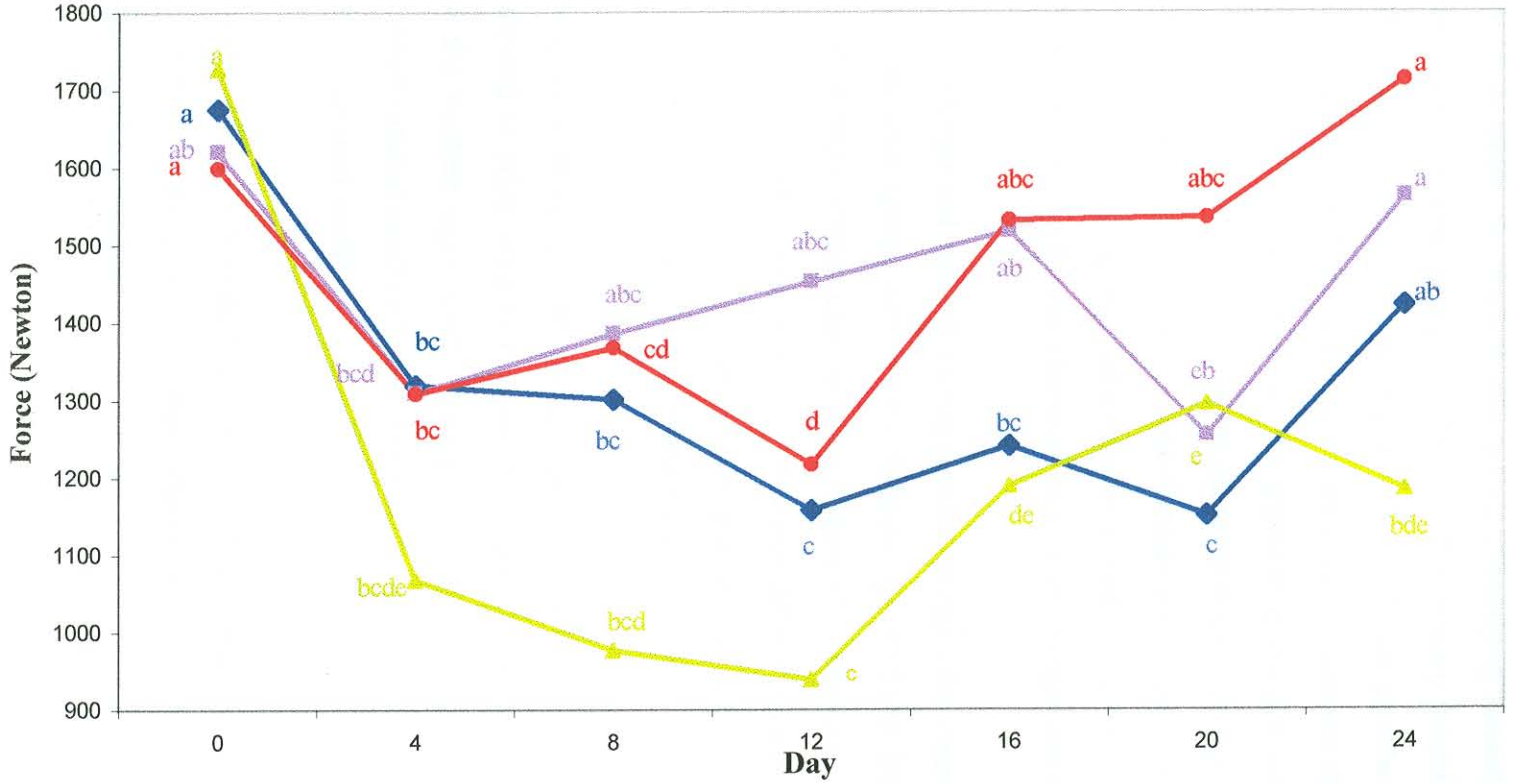

Figure 14 Texture analysis of fresh shell egg (◆), frozen egg pulp (■), spray-dried egg powder (▲) and egg powder mixture (●) sponge cake samples stored from Day 0 to Day 24

abcde: Values for each treatment with different letters are significantly different ($p<0.05$)

5.2.5 Sensory Analysis

The factors, temperature (i.e. 21°C and 31°C) and period (from Day 0 to Day 16) of storage, respectively, did not differed significantly in sensory characteristics of the sponge cake samples, except "rubbery". The sensory properties of fresh shell egg, frozen egg pulp, spray-dried egg powder and egg powder mixture sponge cake samples which were assessed by a trained sensory panel are shown in Figures 15, 16, 17, 18 and 19. Figure 15 shows the appearance characteristics of the sponge cake samples. Figure 16 shows the aroma characteristics of the sponge cake samples. The texture characteristics of sponge cake samples are shown in Figure 17. The changes in rubbery texture of sponge cake samples stored over 16 days are shown in Figure 18. Figure 19 shows the flavour characteristics of the sponge cake samples.

Fresh shell egg and spray-dried egg powder sponge cake samples had the least brown crust and least specks which were different ($p< 0.05$) to frozen egg pulp and egg powder mixture sponge cake samples (Figure 15). However, fresh shell egg sponge cake samples had a more yellow crumb which differed significantly ($p<0.05$) from all the other samples. Egg powder mixture sponge cake samples had the brownest crust, most specks and the least yellow crumb colour ($p<0.05$).

The spray-dried egg powder sponge cake samples had a stronger eggy smell ($p<0.05$) compared to other samples (Figure 16). Egg powder mixture sponge cake samples had the weakest eggy smell. Egg powder mixture sponge cake samples had the strongest caramel smell ($p<0.05$). Fresh shell egg and spray-dried egg powder had the weakest caramel smell.

Fresh shell egg, frozen egg pulp and spray-dried egg powder sponge cake samples had the strongest baking powder smell whereas the egg powder mixture sponge cake samples had the weakest.

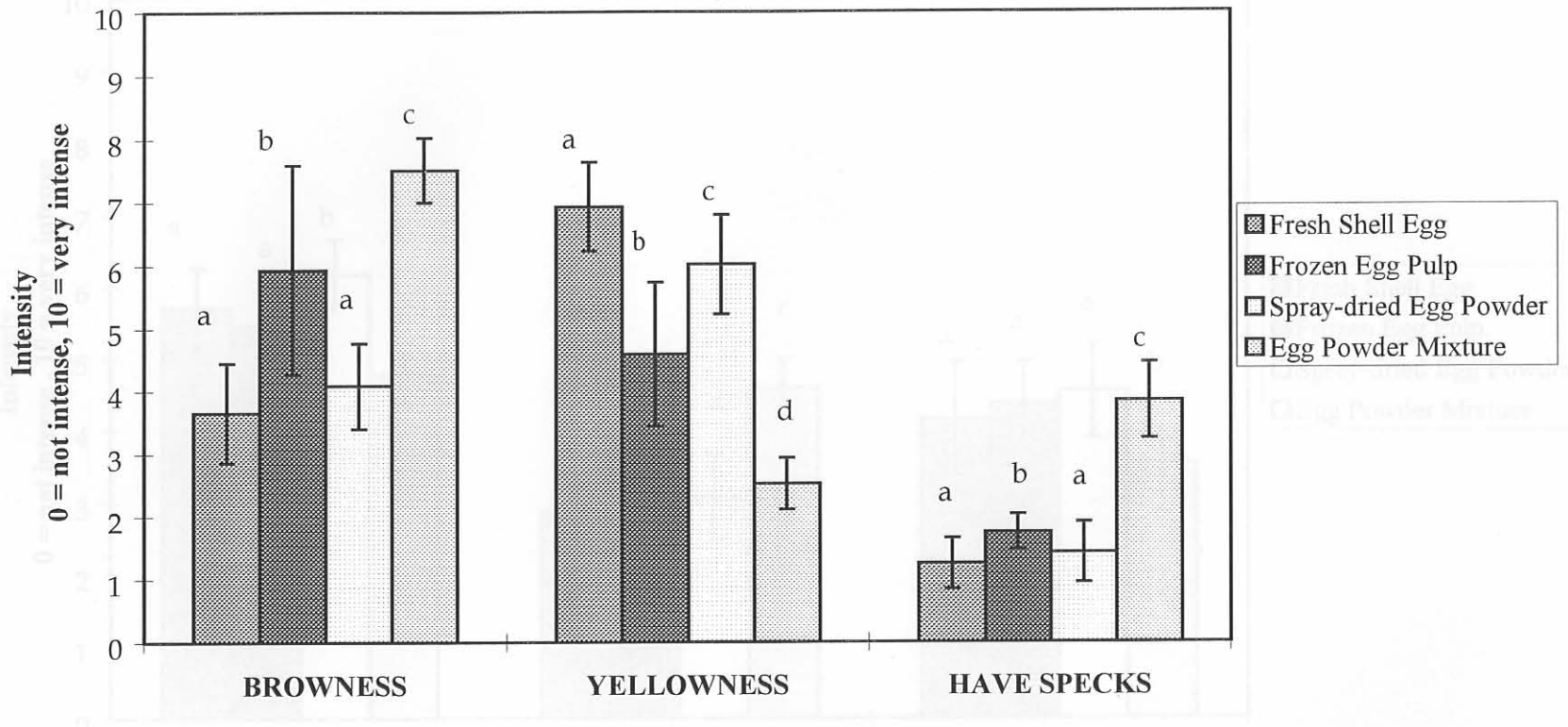

Figure 15 Average ratings (± standard deviations) of appearance characteristics of fresh shell egg, frozen egg pulp, spray-dried egg powder and egg powder mixture sponge cake samples as assessed by a trained sensory panel

abcd: Values for a sensory characteristic with different letters are significantly different ($p<0.05$)

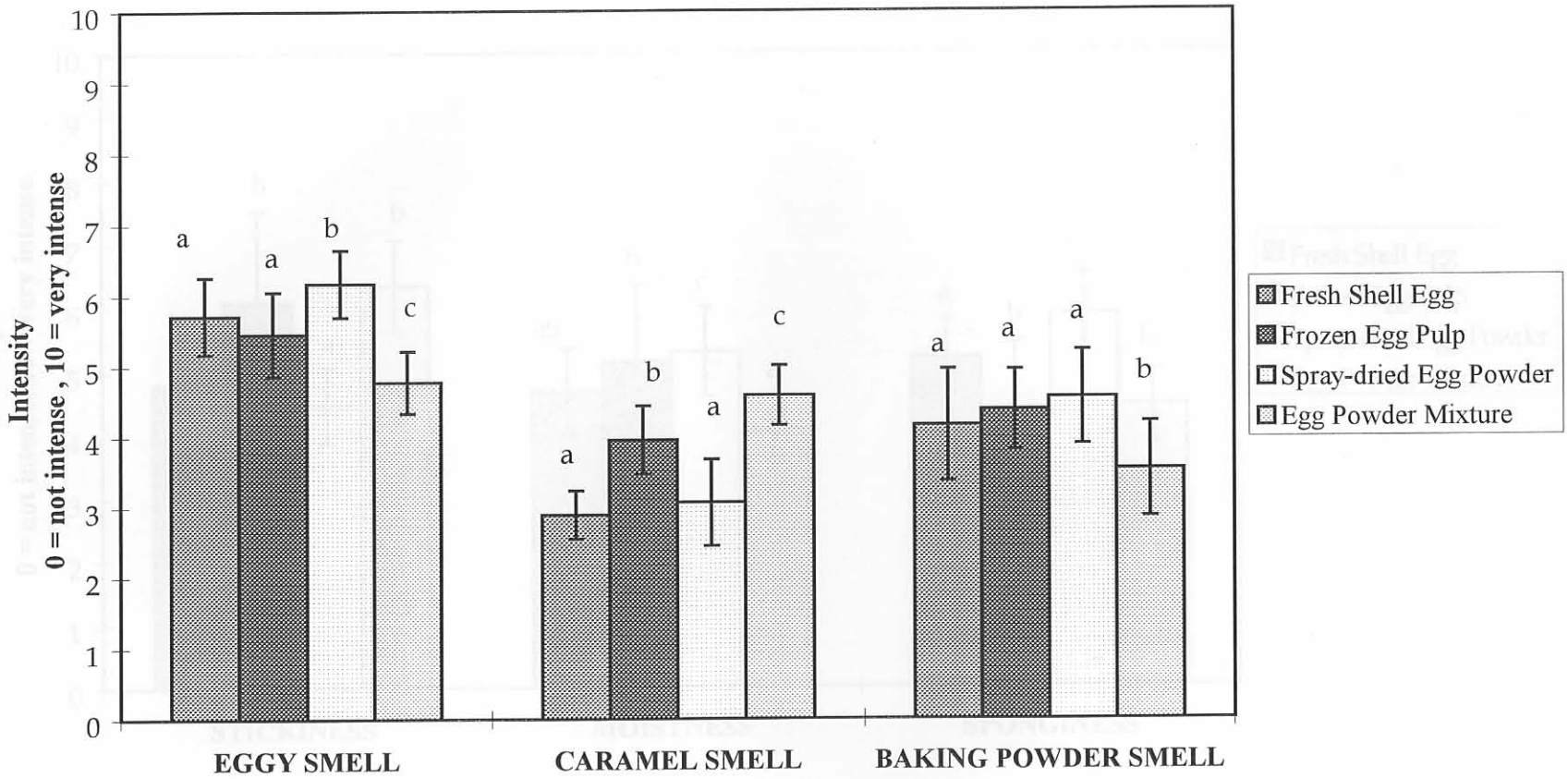

Figure 16 Average ratings (± standard deviations) of aroma characteristics of fresh shell egg, frozen egg pulp, spray-dried egg powder and egg powder mixture sponge cake samples as assessed by a trained sensory panel

abcd: Values for a sensory characteristic with different letters are significantly different ($p<0.05$)

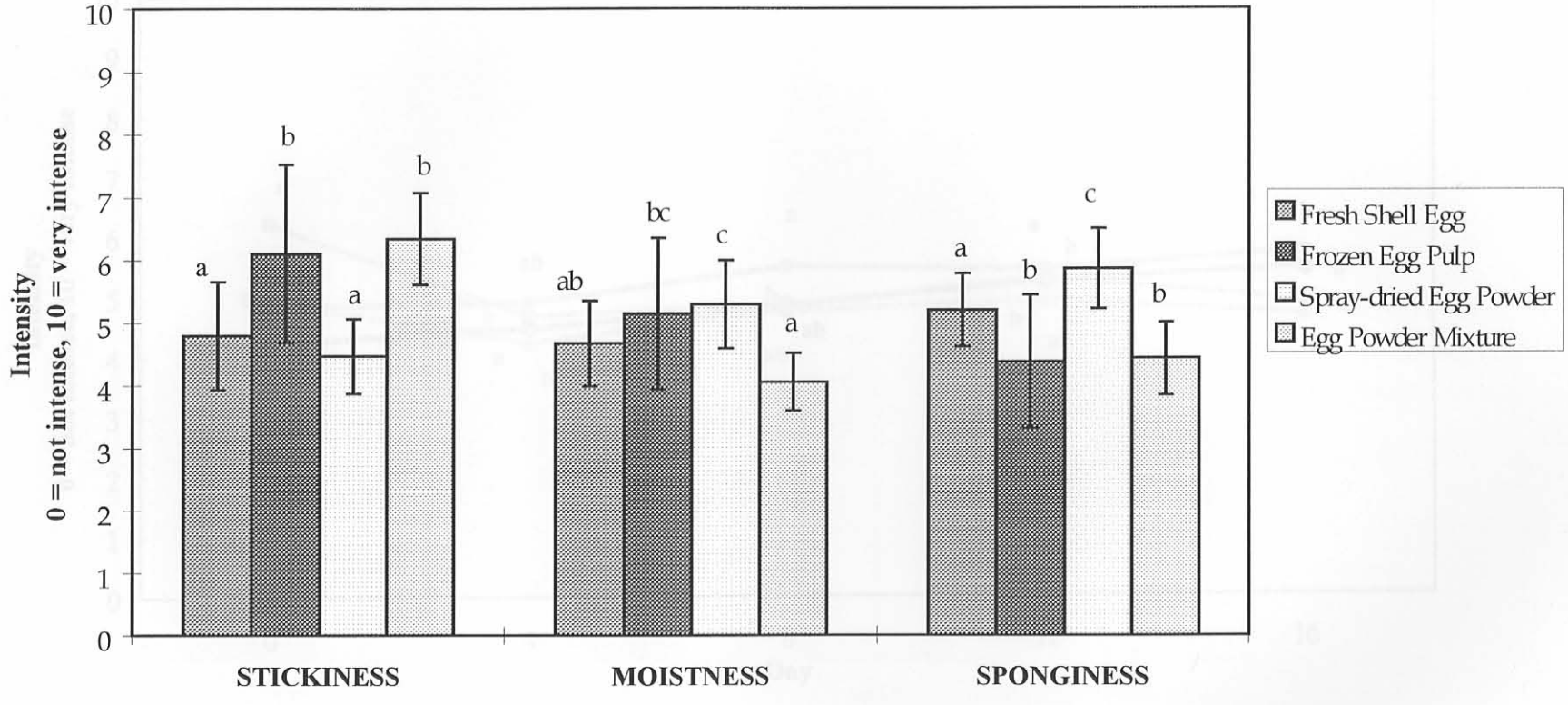

Figure 17 Average ratings (± standard deviations) of texture characteristics of fresh shell egg, frozen egg pulp, spray-dried egg powder and egg powder mixture sponge cake samples as assessed by a trained sensory panel

abcd: Values for a sensory characteristic with different letters are significantly different ($p<0.05$)

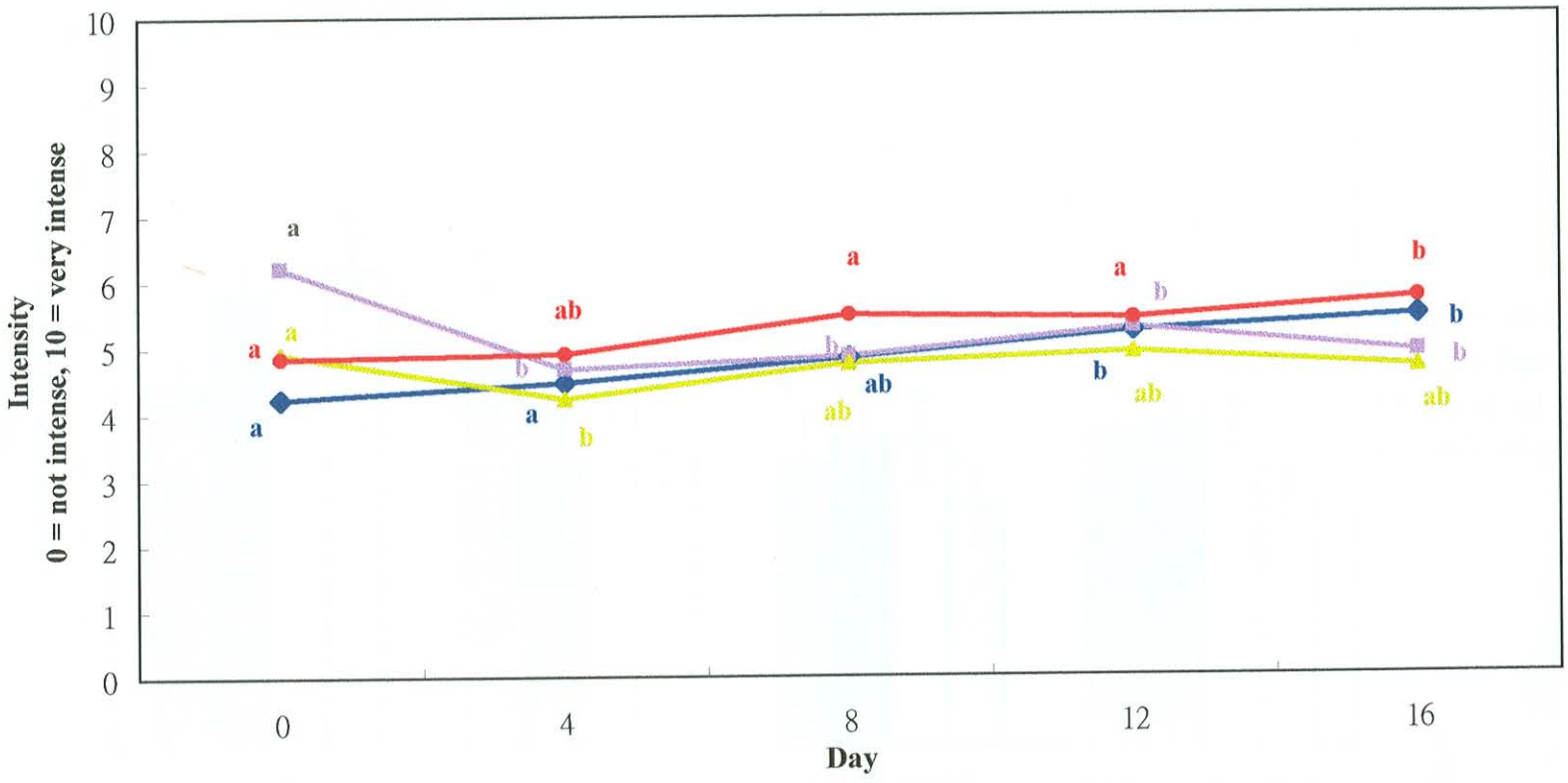

Figure 18 Average ratings of rubberiness for fresh shell egg (♦), frozen egg pulp (▩), spray-dried egg powder (▲) and egg powder mixture (●) sponge cake samples as assessed by a trained sensory panel

abcd: Values for a specific treatment with different letters are significantly different ($p<0.05$)

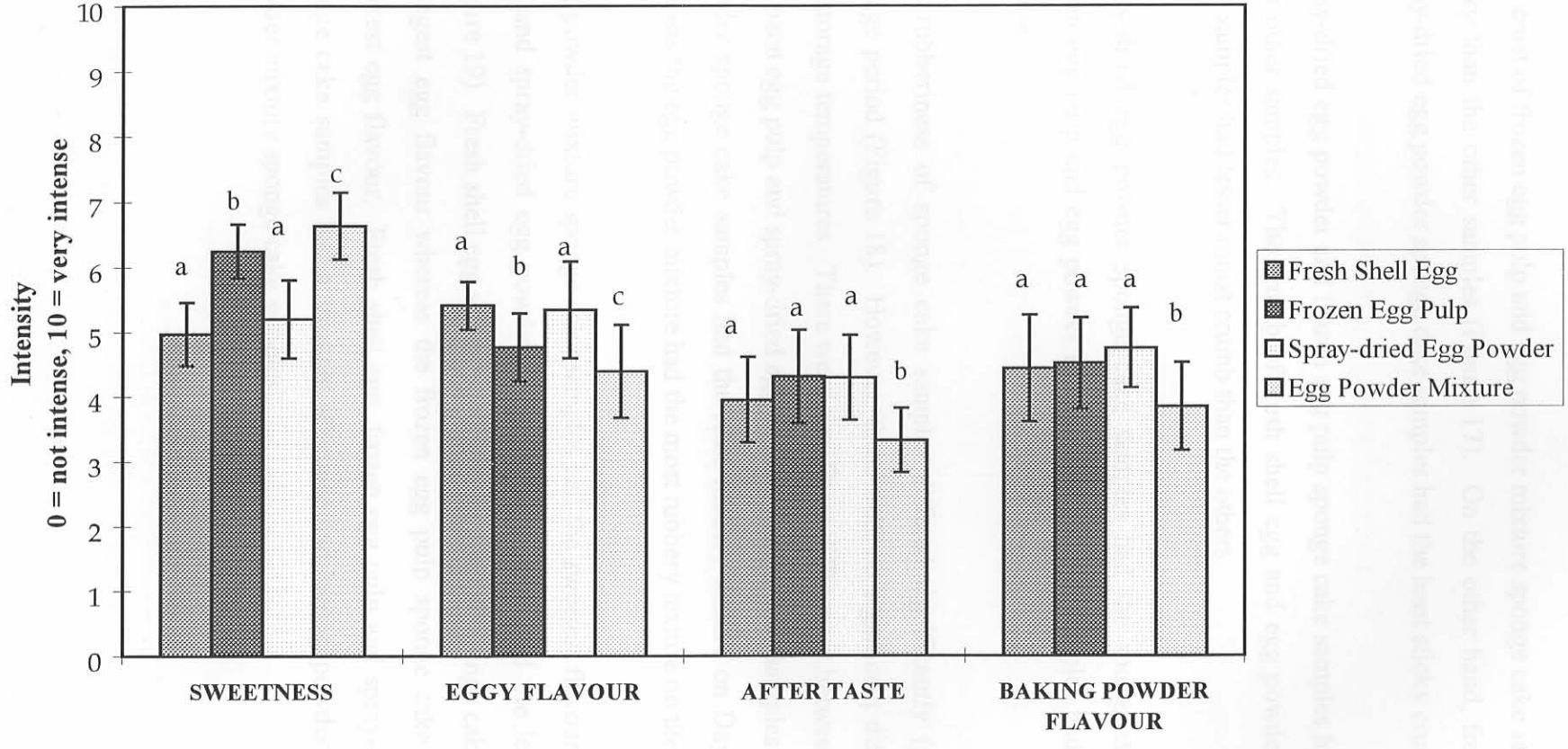

Figure 19 Average ratings (± standard deviations) of flavour characteristics of fresh shell egg, frozen egg pulp, spray-dried egg powder and egg powder mixture sponge cake samples as assessed by a trained sensory panel

abcd: Values for a sensory characteristic with different letters are significantly different ($p<0.05$)

The crust of frozen egg pulp and egg powder mixture sponge cake samples were more sticky than the other samples (Figure 17). On the other hand, fresh shell egg and spray-dried egg powder sponge cake samples had the least sticky crust.

Spray-dried egg powder and frozen egg pulp sponge cake samples had moister crumb than other samples. The crumb of fresh shell egg and egg powder mixture sponge cake samples had lesser moist crumb than the others.

Spray-dried egg powder sponge cake samples had the spongiest texture whereas frozen egg pulp and egg powder mixture sponge cake samples had the least spongy texture.

The rubberiness of sponge cake samples differed significantly ($p<0.05$) over the storage period (Figure 18). However, there were no significant differences between the storage temperatures. There were significant differences between Day 0 to Day 4 in frozen egg pulp and spray-dried egg powder sponge cake samples. Spray-dried egg powder sponge cake samples had the least rubbery texture on Day 4, 8, 12 and 16 whereas the egg powder mixture had the most rubbery texture on these days.

Egg powder mixture sponge cake samples had the sweetest flavour while fresh shell egg and spray-dried egg powder sponge cake samples had the least sweet flavour (Figure 19). Fresh shell egg and spray-dried egg powder sponge cake samples had the strongest egg flavour whereas the frozen egg pulp sponge cake samples had the weakest egg flavour. Fresh shell egg, frozen egg pulp and spray-dried egg powder sponge cake samples had a stronger aftertaste and baking powder flavour than egg powder mixture sponge cake samples.