

Gluten protein quality: Some recent observations



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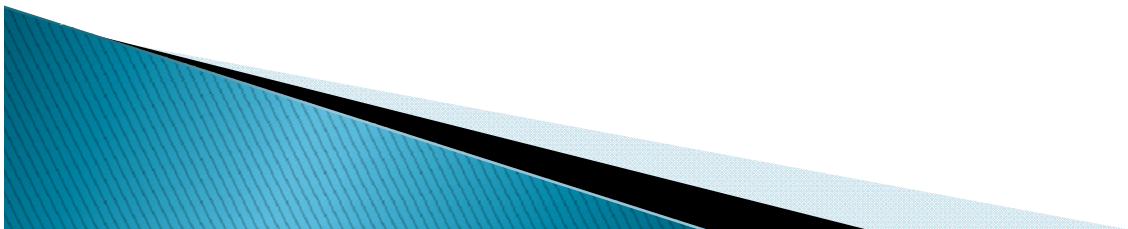
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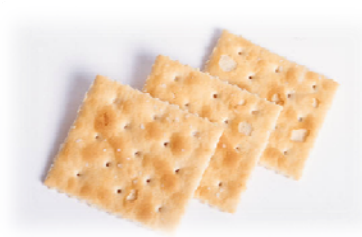
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Gluten Quality

- ▶ High quality flour refers to the ability of gluten to form efficiently and contribute characteristics essential for a high quality product
- ▶ Two important factors
 - Gluten Content/Composition
 - Processing Parameters



Processing Conditions



Dough Prep Temp (°C)	20–30	25	20–30	25–30
Dough Mix Time	Min–hours	18h ferment	6–24h dry time	10–20min
Flour (% Protein)	Hard Wheat (10–12%)	Hard and Soft (8.5–10%)	Semolina (14–15%)	Hard (8–11%, salted), (9–13%,alkaline)
Moisture (% based on flour mass)	60–75%	~30%	25–30%	30–38%
Preparation	Dough mixing, proof, bake	Mix and ferment sponge, mix in dough, laminate, sheet, bake	Dough mix, extrusion/ sheeting, drying	Dough mixing, sheeted through rollers, stretch, cut
Gluten Development	Resting (proofing)	Lamination and reduction	Extrusion	Sheeting
Ingredients	2% salt, yeast, sugar	1.5% salt, yeast, shortening, chemical leavening agent	Salt	2–8% NaCl (salted), 0.5–1% Na ₂ –, K ₂ CO ₃ (alkaline)

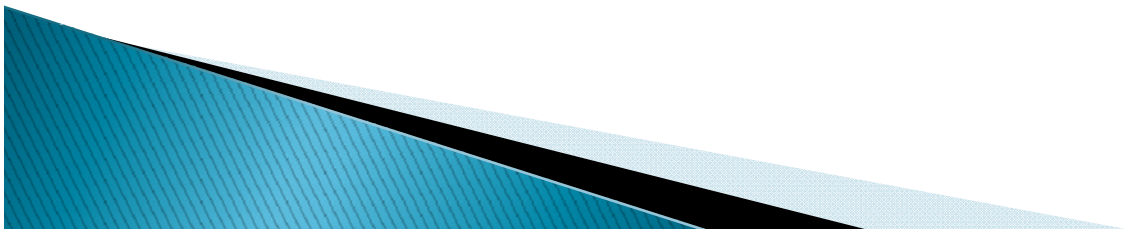
Gluten

- ▶ Gliadin
 - Different proteins (α , β , γ , ω)
- ▶ Glutenin
 - Different proteins (LMW B, LMW C, LMW D, HMW1, HMW2)
- ▶ In the presence of water and energy forms network/aggregates, i.e., Gluten
- ▶ What defines gluten functionality?
 - Protein structure: LMW vs gliadin?
 - # of S-S bonds?
 - Degree of folding/unfolding?
 - Soluble/insoluble?



Gluten Peak Test

- ▶ Prototype gluten quality testing instrument developed by Brabender GmbH & Co. (Germany)
- ▶ Torque based method that measures the torque value upon gluten network formation
- ▶ Three important parameters observed
 - Lift Off Time (LOT)
 - Peak Maximum Time (PMT)
 - Maximum Torque (BEM)



Gluten Peak Test



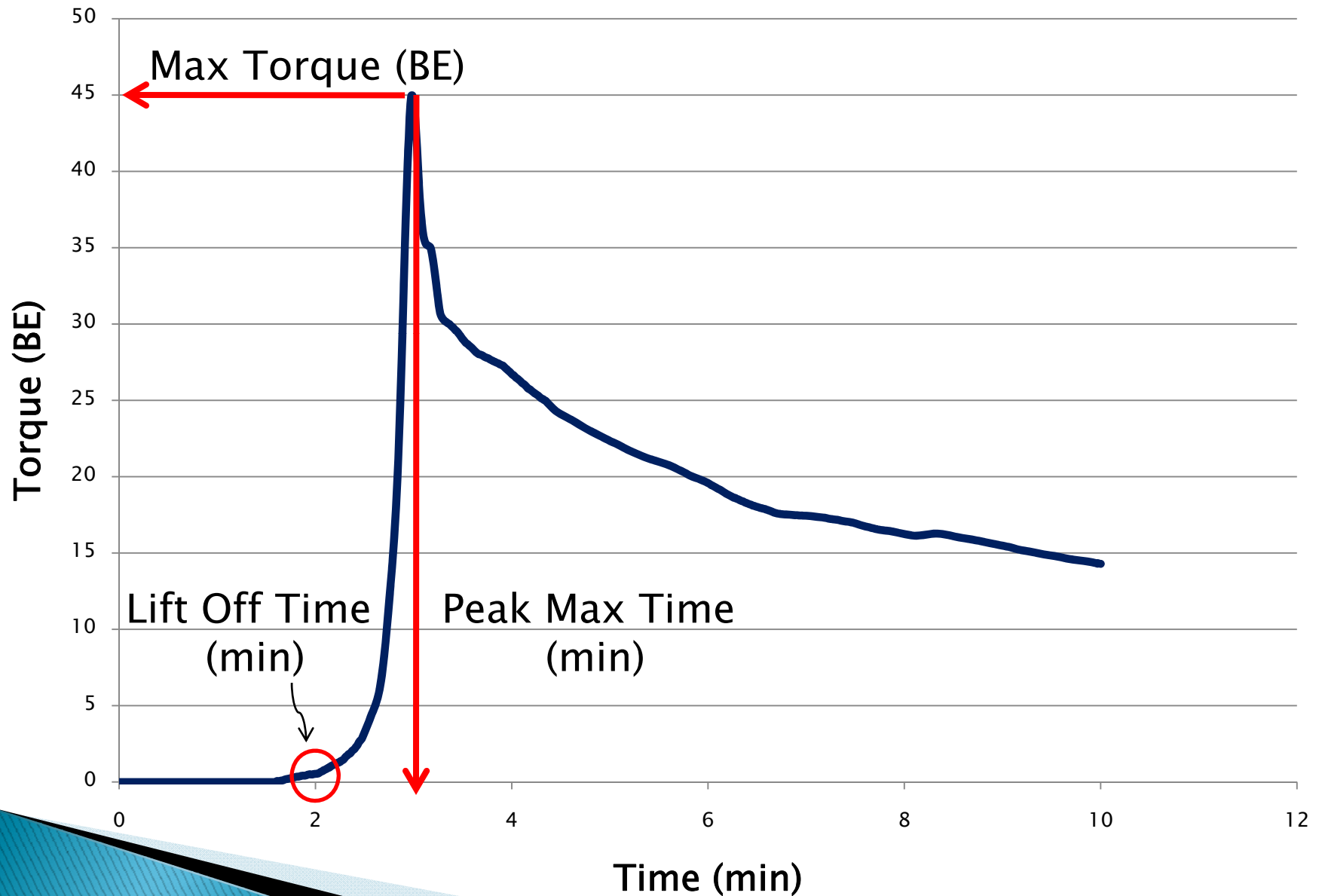
Paddle

Sample Cup

Paddle

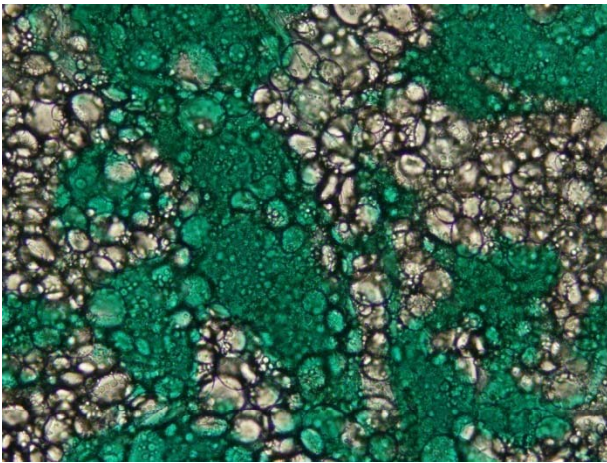


Sample GPT Curve

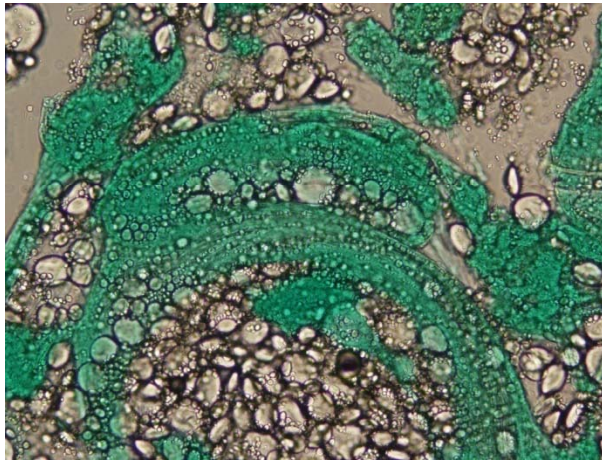


Gluten Network at Various Stages of GPT Run

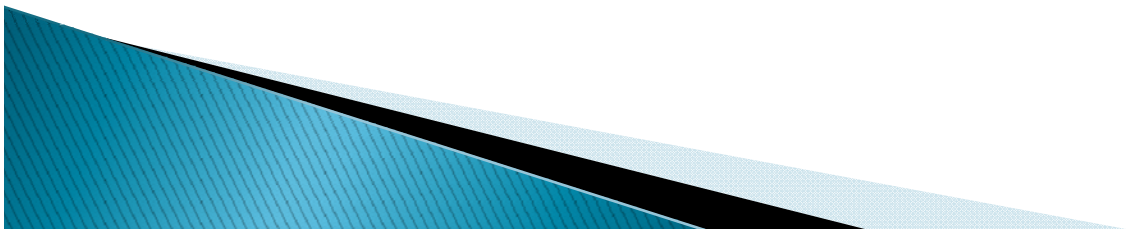
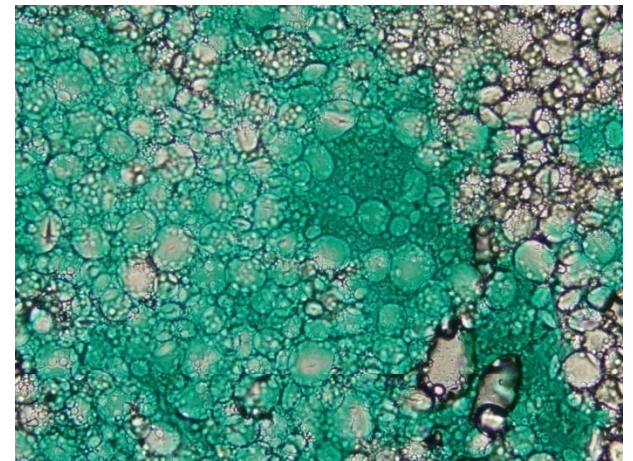
Lift Off (30 s)



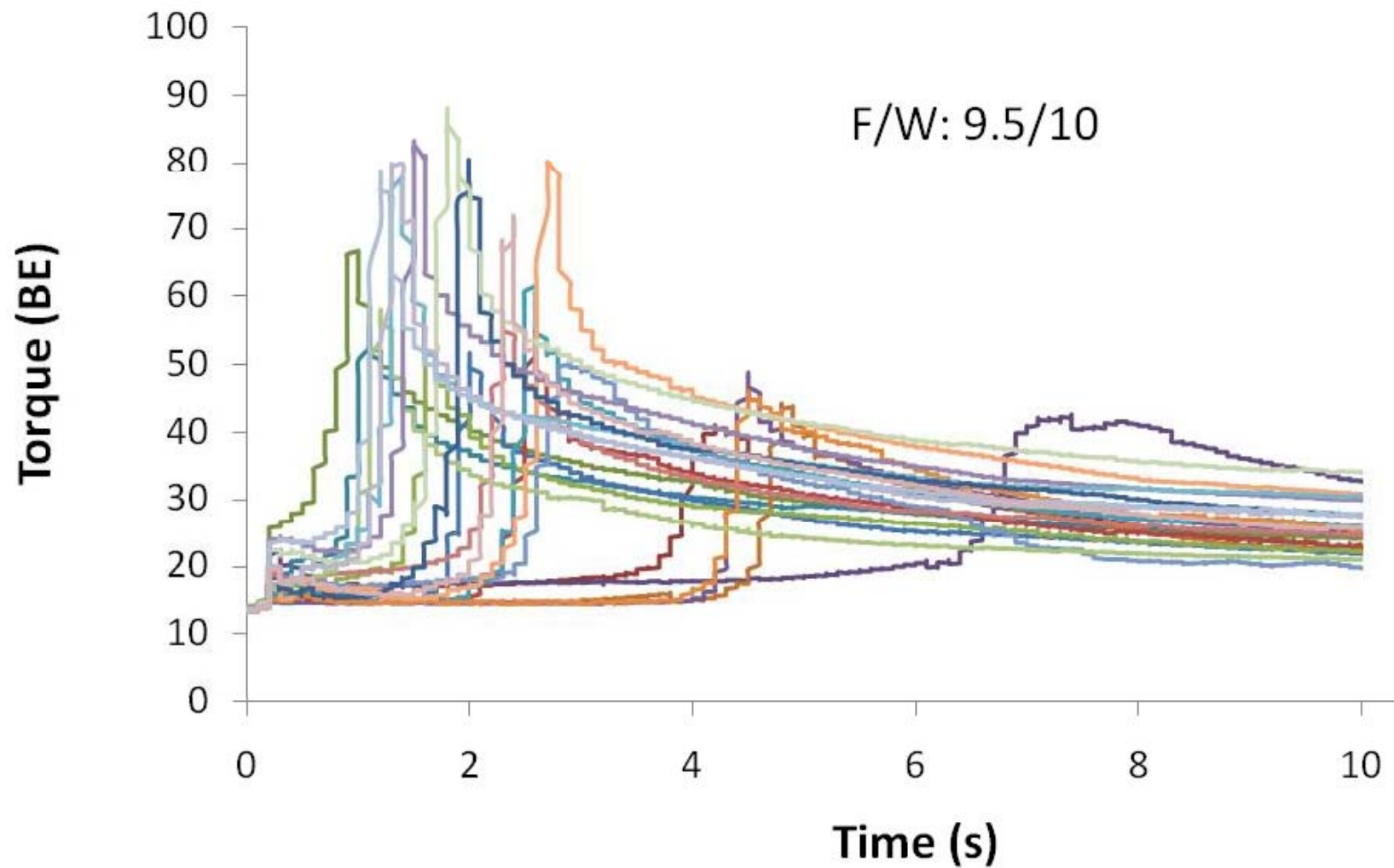
Max Peak (180 s)



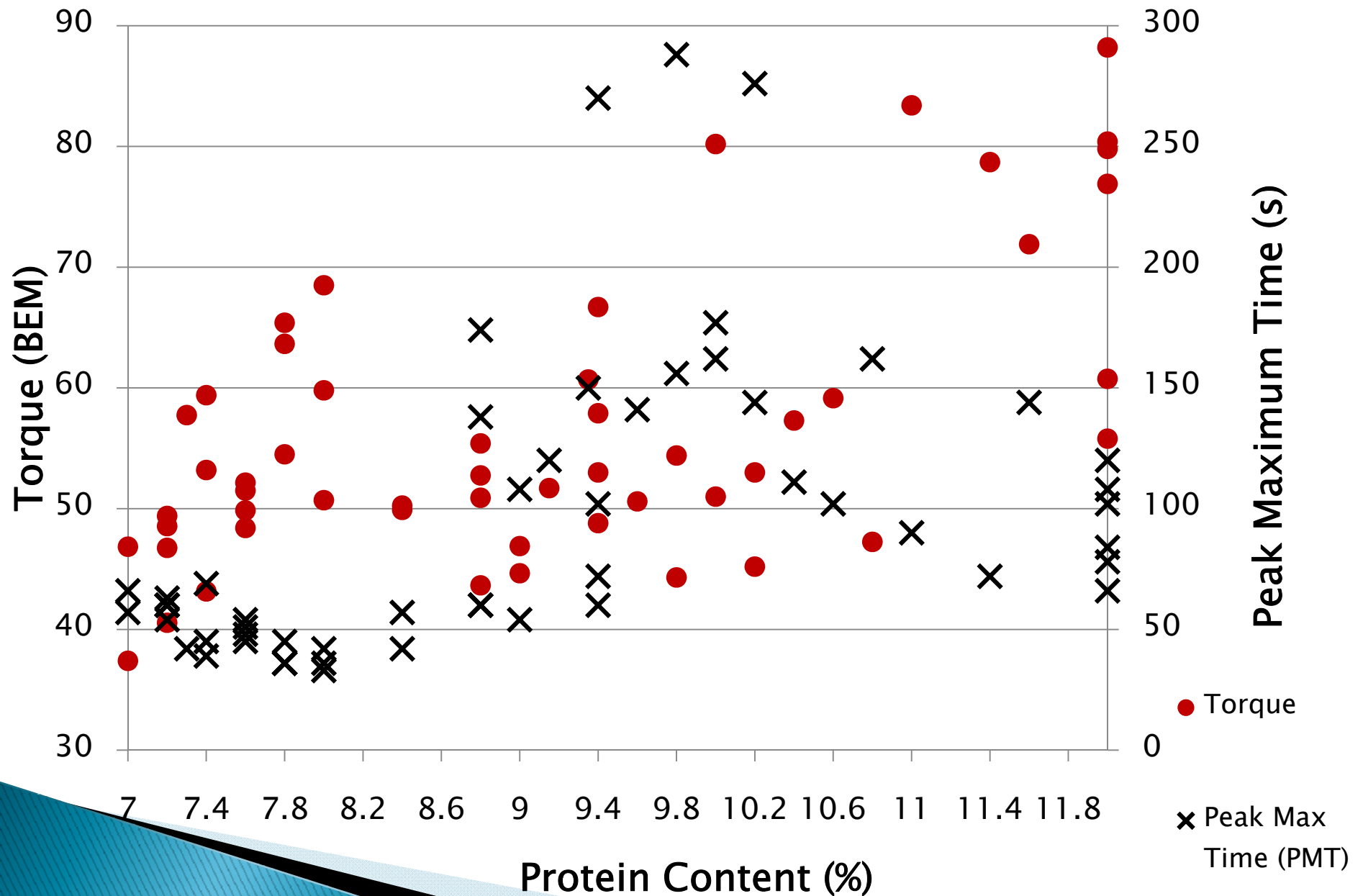
Breakdown (300 s)



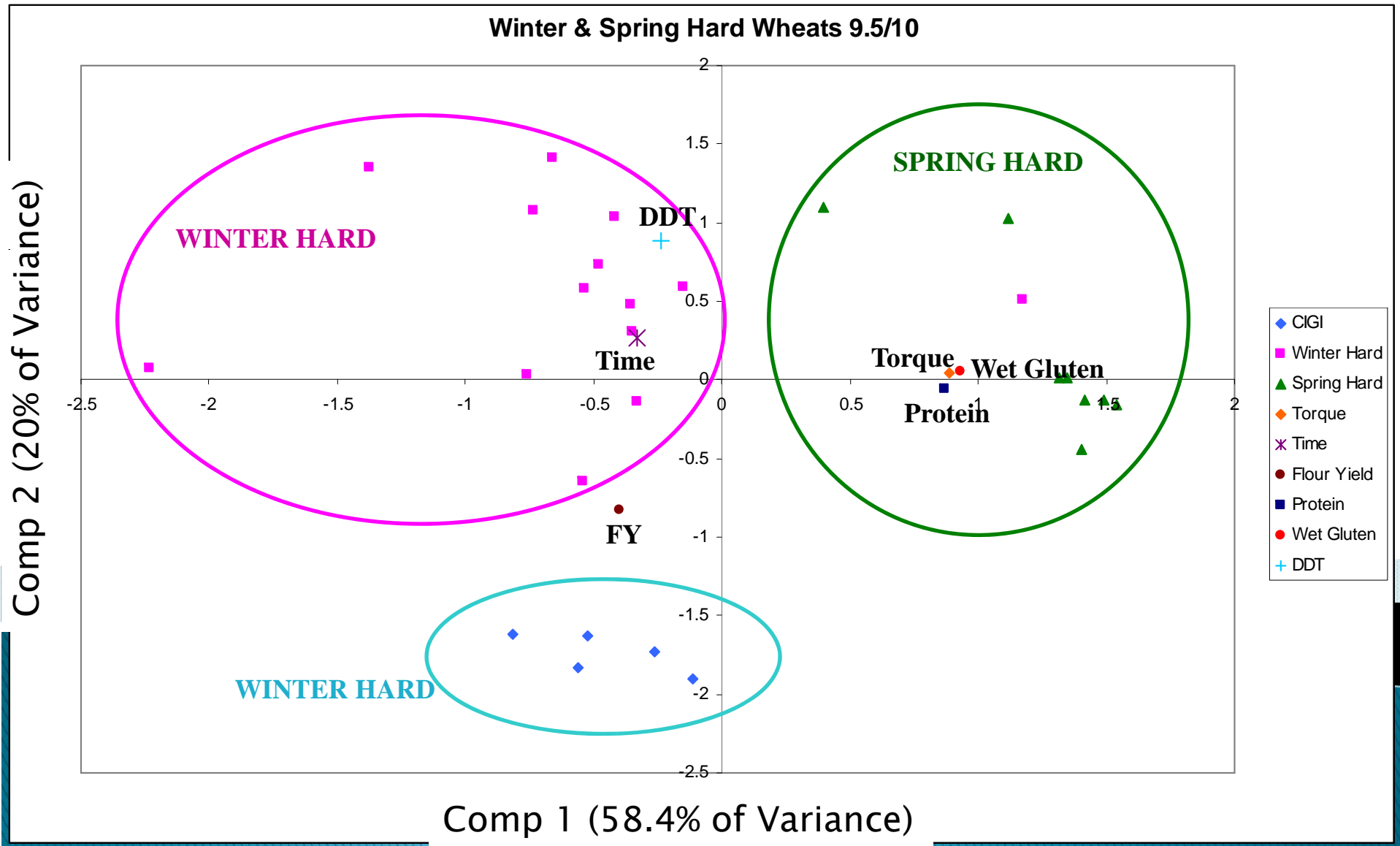
GPT Curves of Hard Wheats



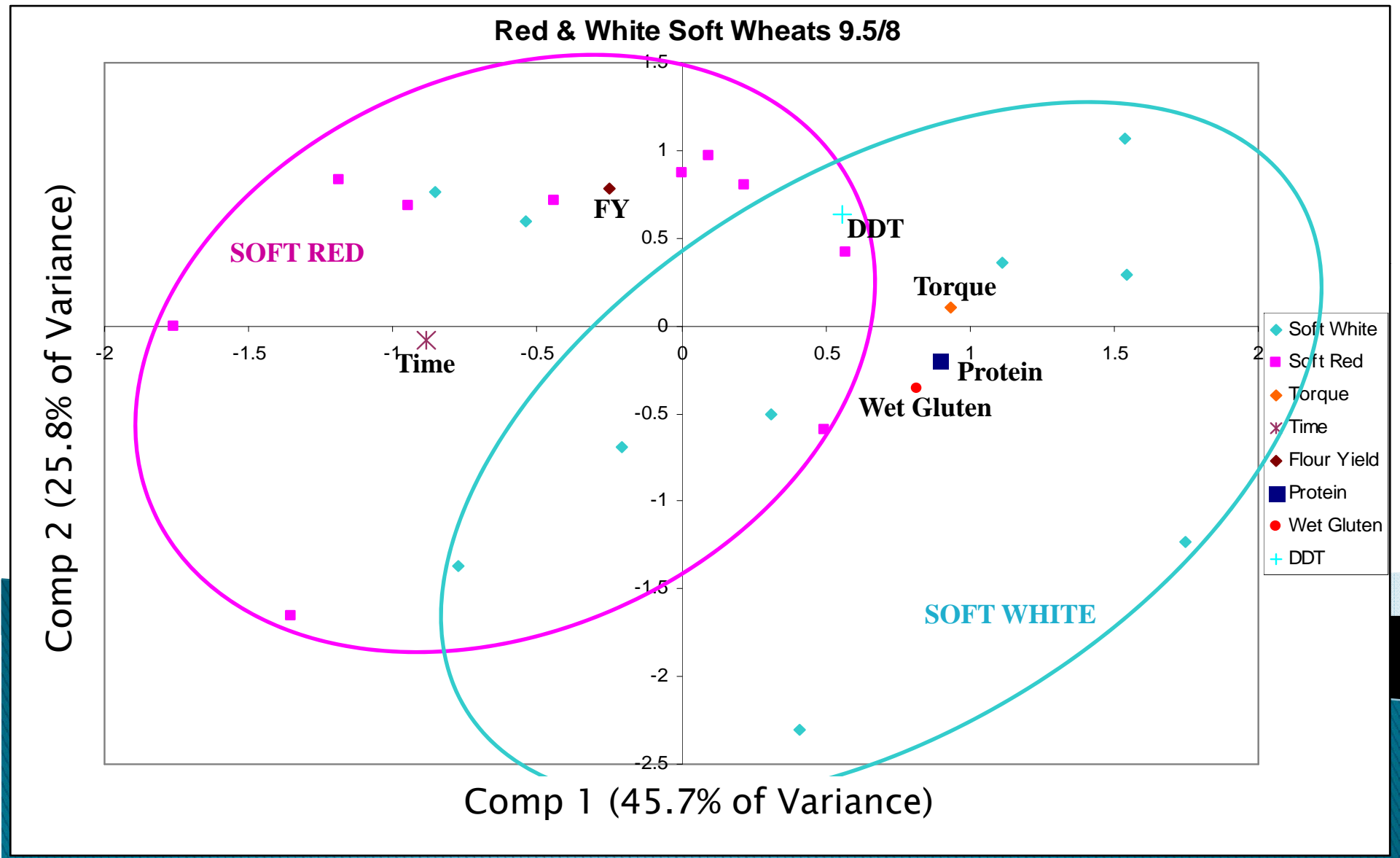
PMT and Torque of Various Flour Samples



PCA of hard wheat samples based on quality parameters

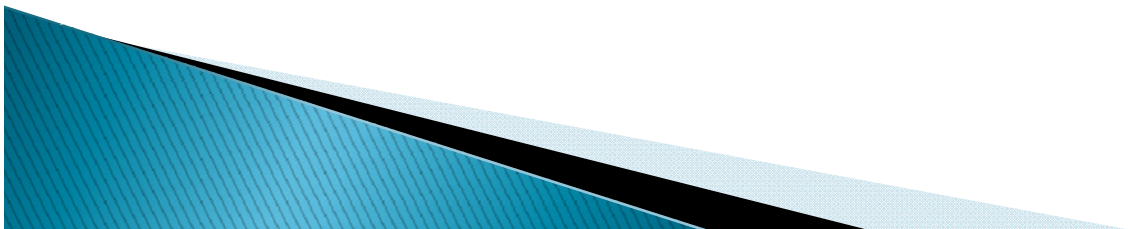


PCA of soft wheat samples based on quality parameters



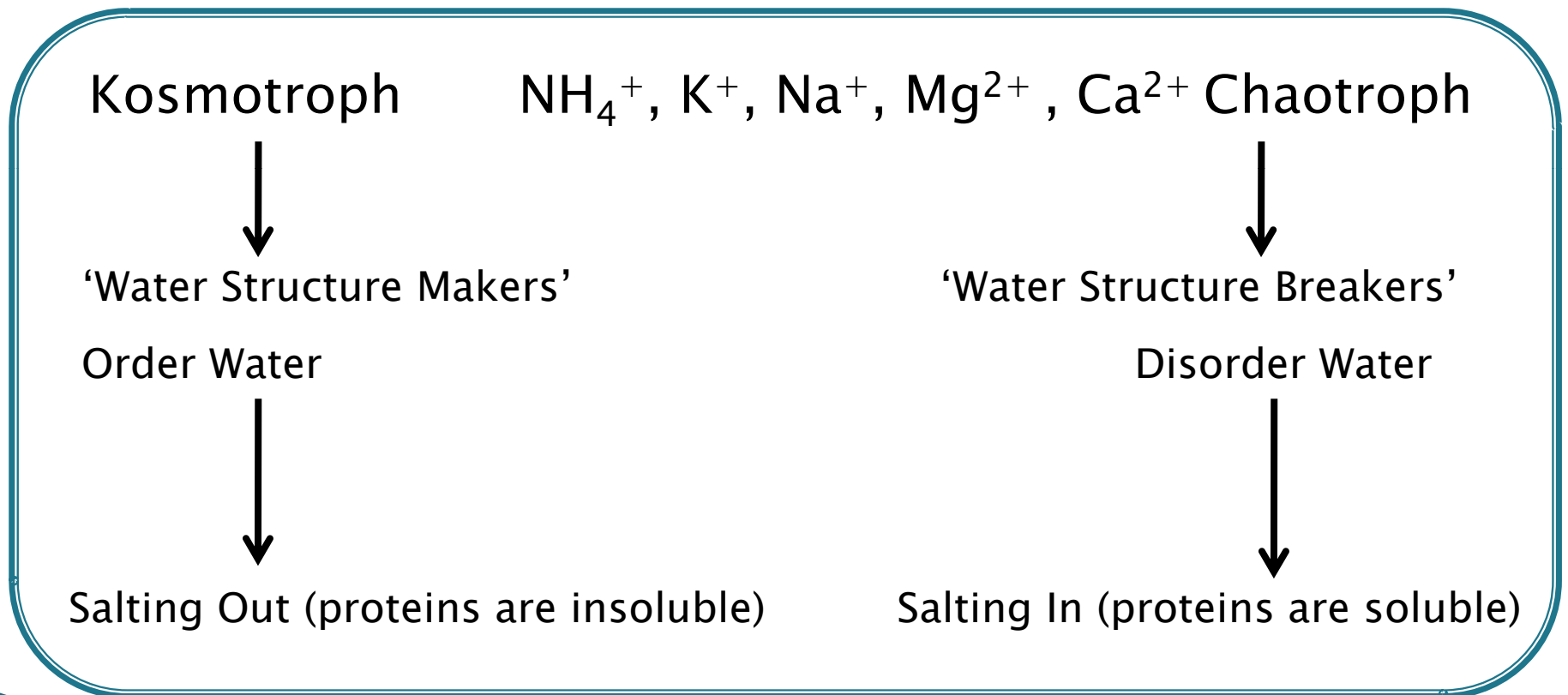
Some thoughts...

- ▶ There are differences among the wheat flours
- ▶ What does this mean?
 - Need more data for better correlation analyses
- ▶ Some limitations
 - Soft and hard wheat flours require different flour:water ratios
 - Some flours do not present any peaks
 - How do these relate to flour performance?



Hofmeister Series

The Hofmeister series characterizes ions based on the effect they have on water structure, and therefore protein solubility.



Limitations of Previous Salt/Protein Work

- ▶ Only studied fractions and amount of solubilized/aggregated protein
- ▶ Did not study time for development
- ▶ Did not study strength of gluten network
- ▶ Did not study differences between 2 or more flours of different protein contents
- ▶ Have not helped with understanding of LMW-GS behaviour
- ▶ Clements (1973), Preston (1981, 1984, 1989), He (1992), Fu (1996), Wellner (2003), Ukai (2008)



Method

Energy

Spindle = 2750 rpm
Temperature = 35 °C

Flour (8 g)

Ibis (15.1% protein)
Diamant (10.6% prot.)

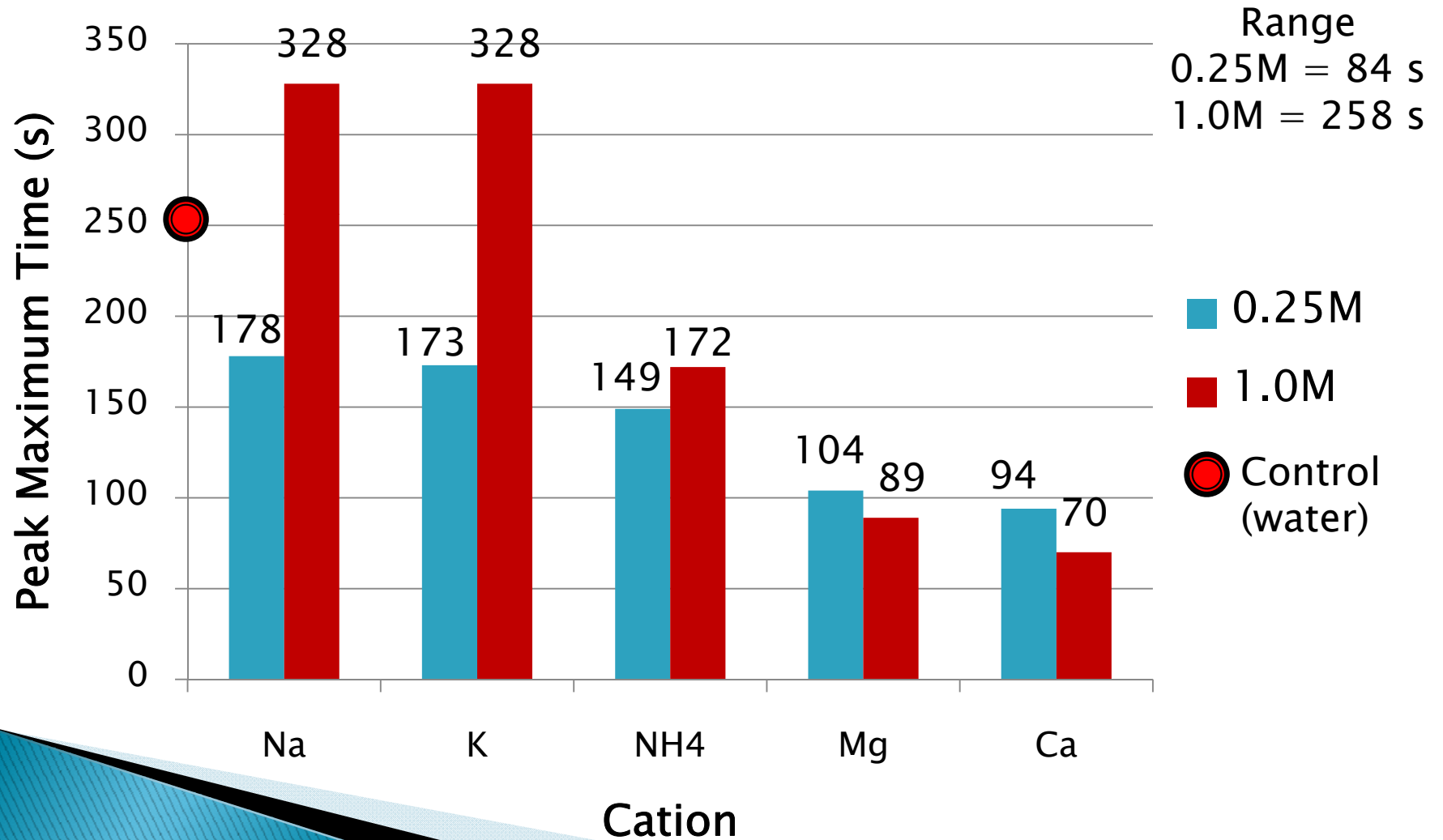


Chloride Salt Solutions (10 g)

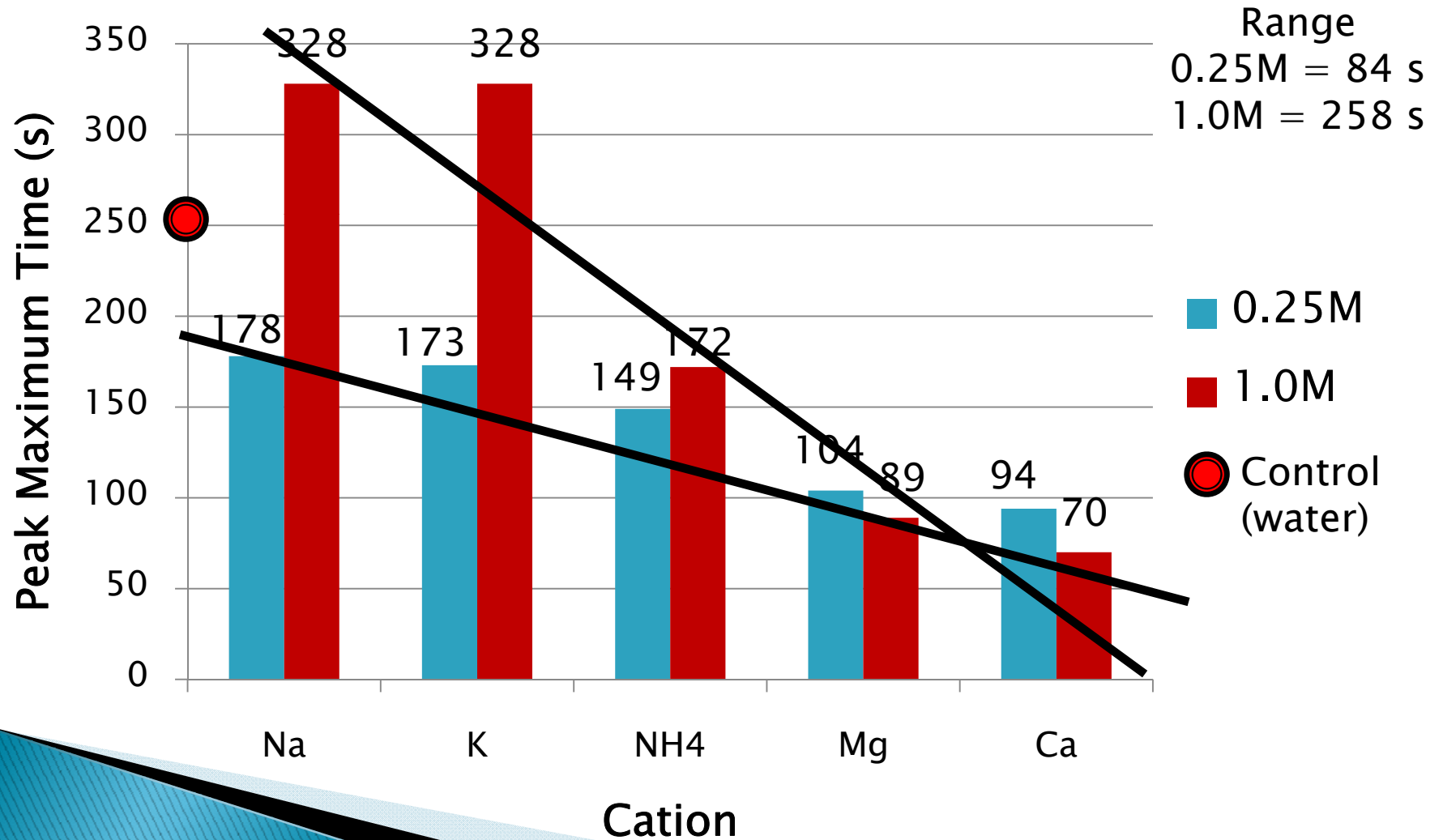
NH_4^+ 1M
 K^+ 0.5M
 Na^+ @0.25M
 Mg^{2+} 0.125M
 Ca^{2+} 0.0625M

Alcohol
Buffer
Dilute Acids

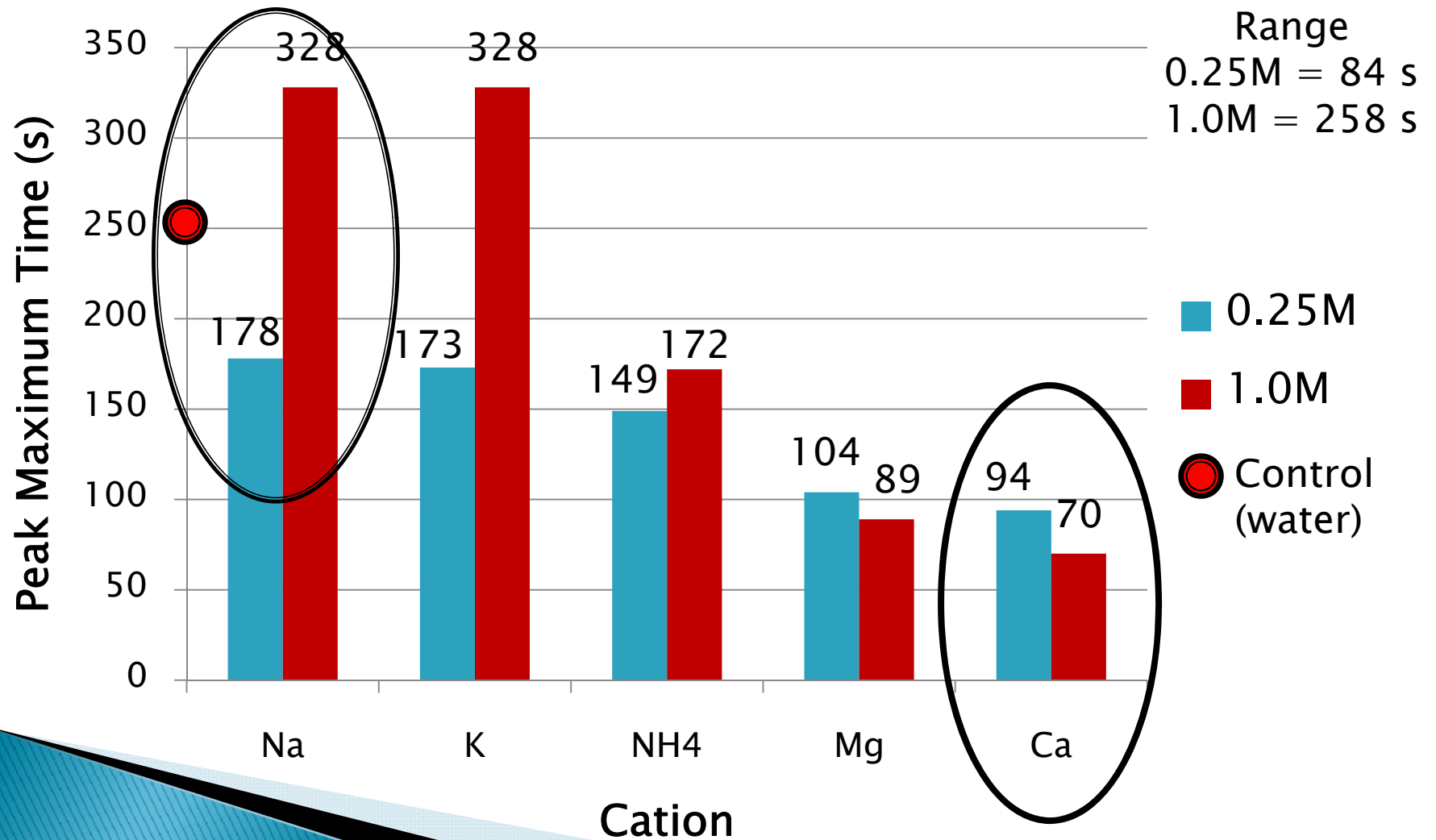
Effect of Cations



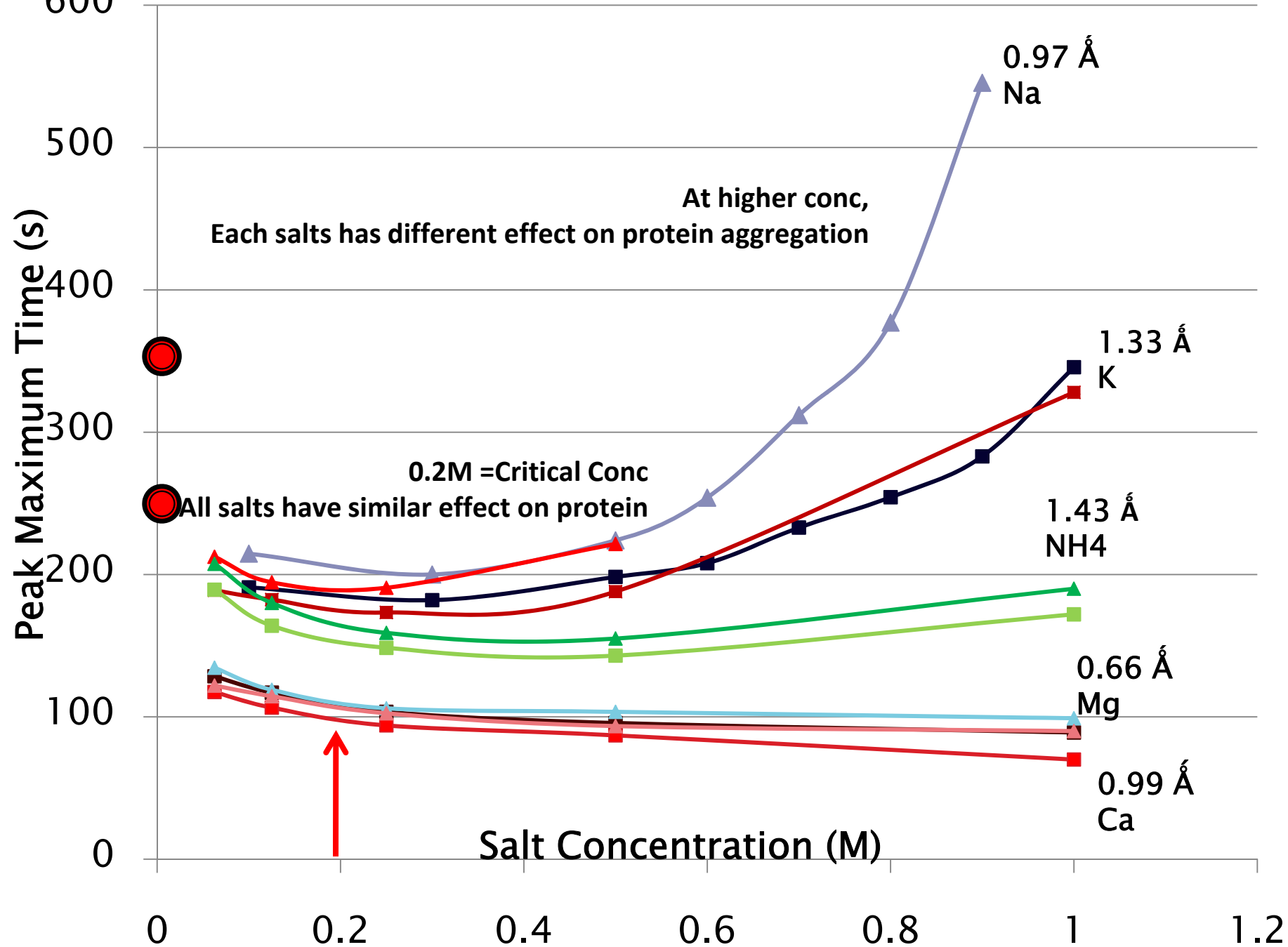
Effect of Cations



Effect of Cations



Effect of all ions at all concentrations on PMT of Ibis and Diamant

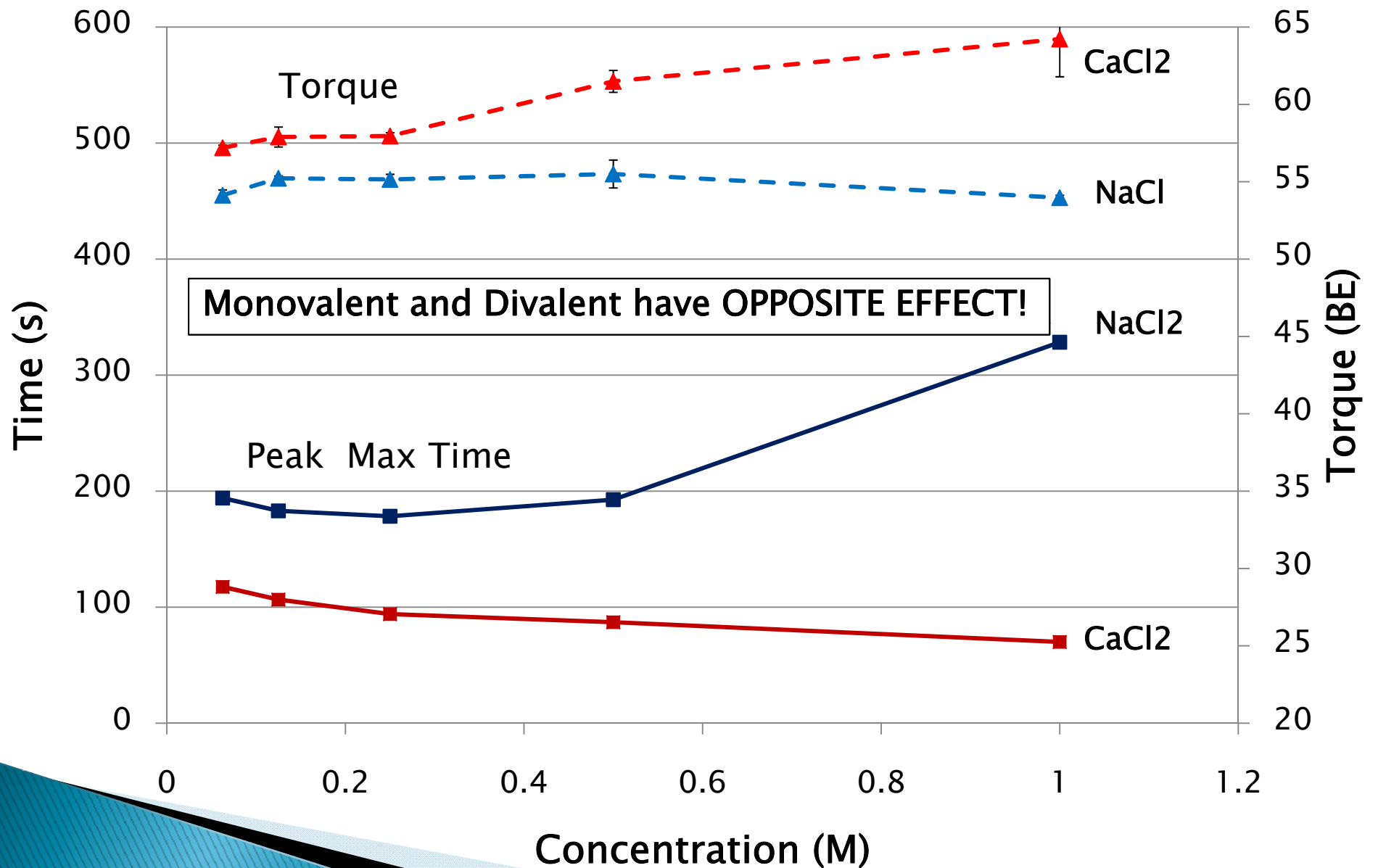


Summary of Trends

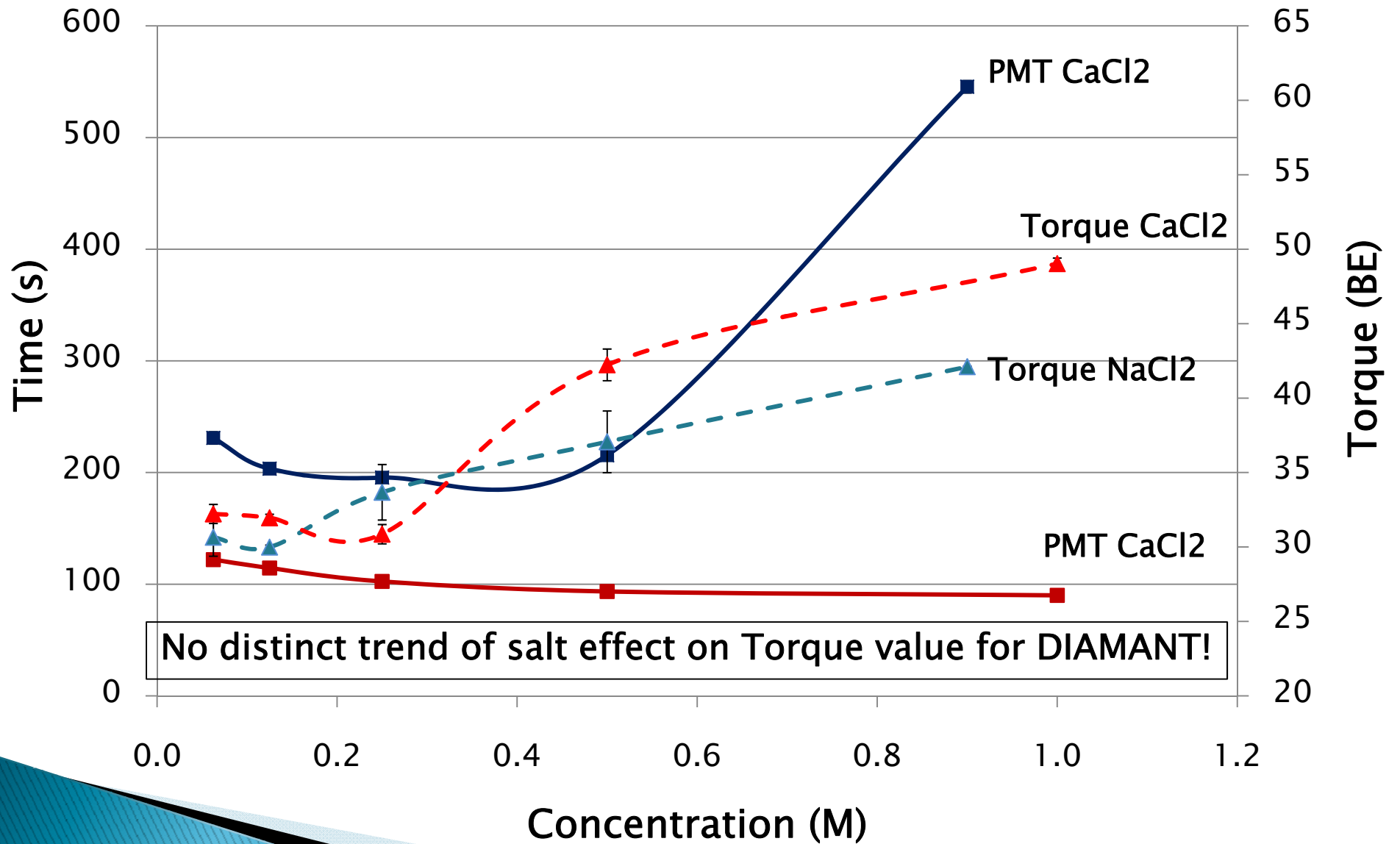
- ▶ Peak Max Time follows the Hofmeister Series (except for NH_4^+) with PMT decreasing from Kosmotrophic to Chaotrophic
- ▶ At low salt concentration all ions have similar effect on PMT, but as concentration increases, differences between PMT increases
- ▶ Monovalent ions result in later PMT than Divalent ions
- ▶ Within mono/divalent ions, as ion size increases, PMT decreases
- ▶ Monovalent ions increase PMT with increasing concentration, while divalent ions decrease PMT with increasing ion concentration



Effect of Salt on IBIS

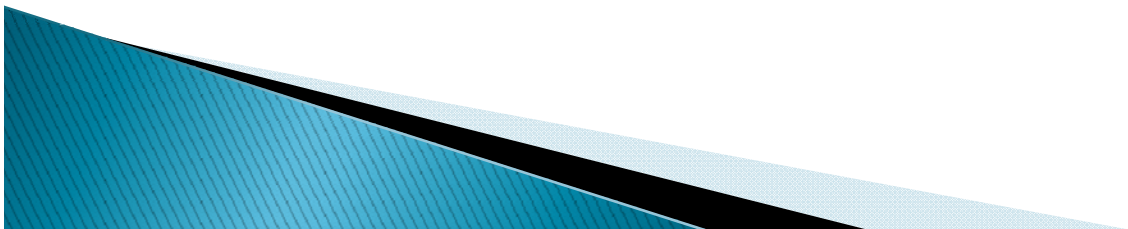


Effect of Salt on DIAMANT



Some thoughts on salts...

- ▶ GPT creates high shear and strong forces pushing protein together – electrostatic repulsion at low salt concentration is negligible and strong hydrophobic interactions can occur
- ▶ NH_4^+ does not follow Hofmeister Series (should have strongest salting out effect)
- ▶ Hofmeister theory suggests kosmotrophs force gliadins to remain in native form and interact hydrophobically
 - This should hinder glutenin network formation and a peak at high kosmotrophic conc., however a peak (although late) is still observed



At LOW Salt Concentration,

- ▶ Ions affect gliadins in a way that allows gluten formation (either through solubilization or a conformational change).
 - Ukai (2008) found that gluten prepared with salts at low conc. (0.25M) allowed for gliadinsolubilization in water after salt removal– suggests a change in gliadin structure since native gliadin is not soluble in water.
- ▶ Approximately 0.2M is critical salt concentration – all salts have similar effect on gliadins (supported by similar PMT for all salts at 0.25M).
 - Preston (1981) found that gluten treated with a kosmotroph and chaotroph resulted in solubility of same protein fractions at low salt concentration (gliadin-like properties).



At HIGH Salt Concentration,

- ▶ Gluten formation is highly dependant on salt type.
 - highlighted by large variability in PMT
- ▶ Each salt has different effect on water structure, which affects protein unfolding and glutenin network formation
- ▶ New studies suggest glutenin network formation is highly dependent on LWM-GS forming intermolecular S-S bonds
 - Cauvain (2003) suggests LMW-GS are smaller, can diffuse into dough more easily, and are therefore chemically more reactive and form inter S-S bonds with HMW-GS



Thank you

