

# Pickled Beer: Tandem Fermentation of Flemish Sour Ale

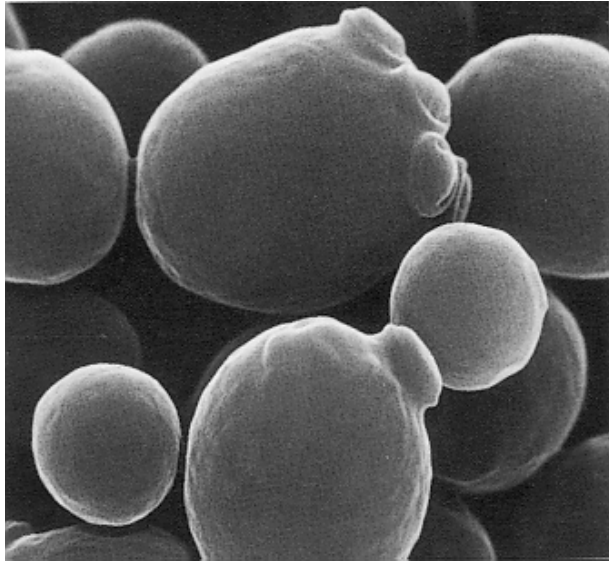
*Raj B Apte*

*Matadero Creek Brewery*

# Outline

- What is Flemish Sour Ale
- Cast of Characters
- Fermentation: microbes, substrates, environments; we can drink poison
  - Brewing: malting, mashing, wort
    - Spit beer, sake, California v. Bordeaux
  - Pickling
  - Vinegar
- Flemish Sour Ale
  - Steps: Alcohol, Lactic Acid, Brettanomyces, Acetic Acid
  - Comparison with red wine
- Tasting, courtesy of New Belgium Brewing Co.

# Cast

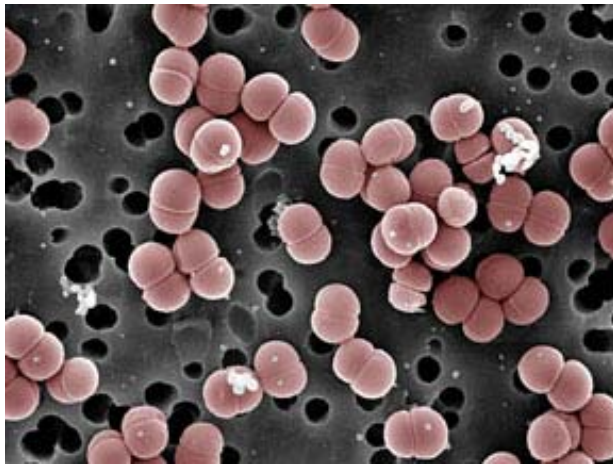
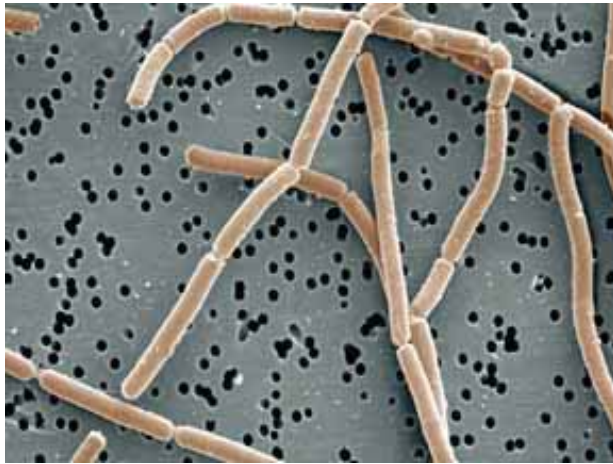


- **Saccharomyces**
  - sugar fungus
  - aerobic or anaerobic
  - produces alcohol
  - bakers, brewers, vintners; hundreds of strains



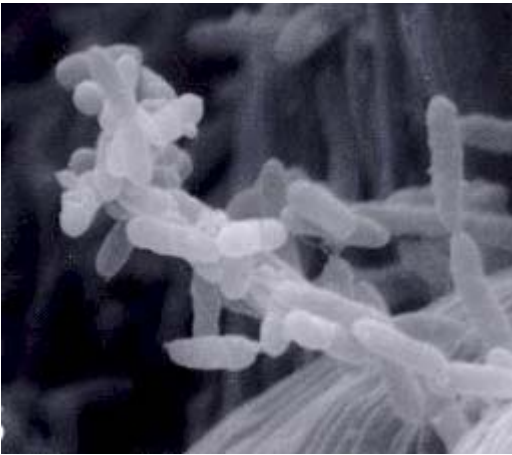
- **Brettanomyces**
  - british fungus; british flavor
  - aerobic or anaerobic
  - Bordeaux v. Davis
  - produces alcohol or acetic acid
  - several species; dozens of strains

# Lactic Acid Bacteria



- **Lactobacillus**
  - basis of yoghurt, cheese
  - lactic acid
  - many strains
  - salt resistant
  - hop sensitive
- **Pediococcus**
  - anaerobic
  - lactic acid
  - slow
  - hop resistant
  - secrete amylase

# Acetic Acid Bacteria

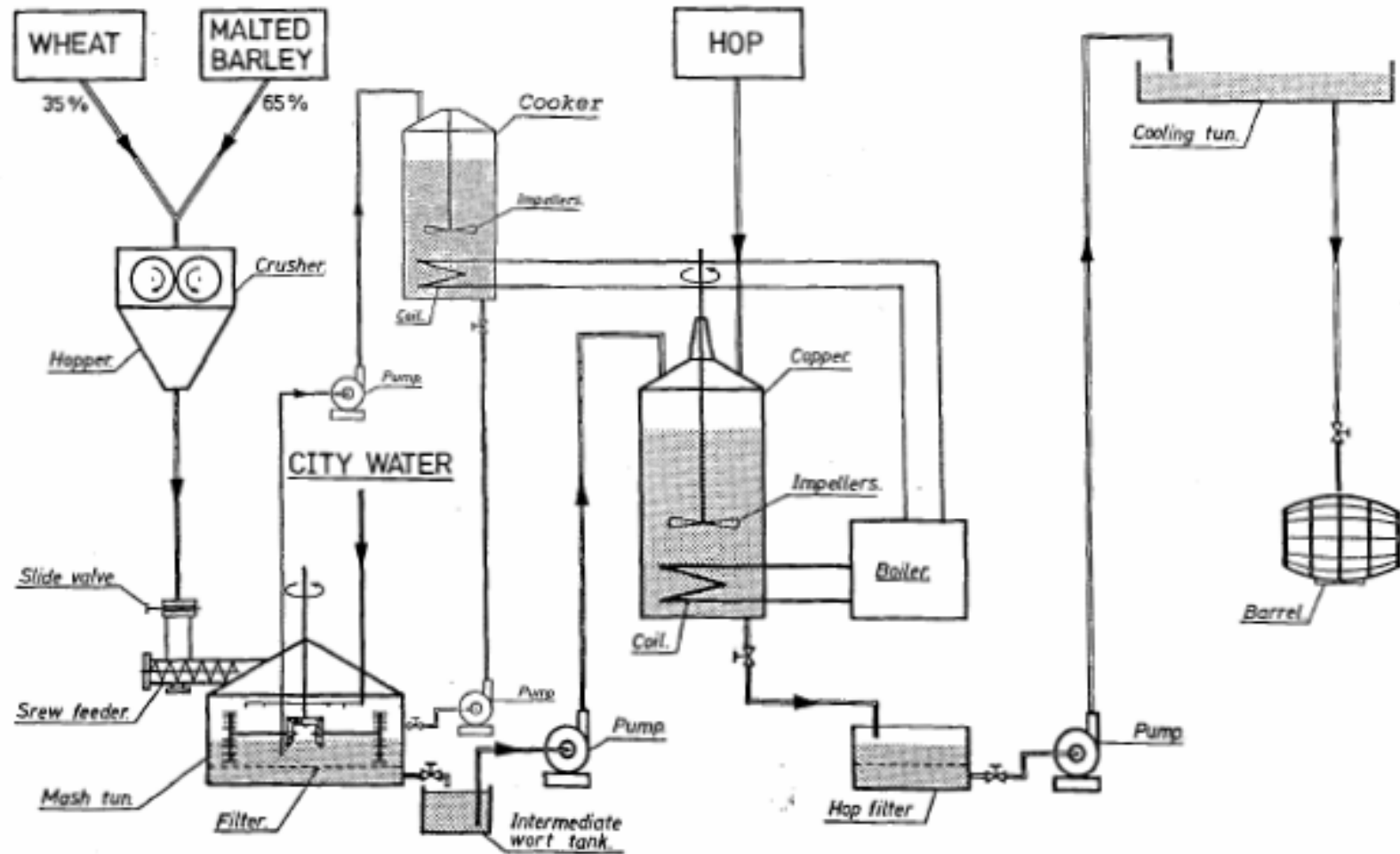


- Acetobacter
  - aerobic
  - mother of vinegar
  - inhibited by salt

# Fermentation

- Microbes—many species, many strains
  - pathways: oxidation of ethanol to acetic acid
- Substrate—the food and nutrition of the microbes.
  - sugar & starch
  - nitrogen
- Environment
  - exogenous: oxygen, moisture, temperature, acidity, and salt
  - acidity
  - alcohol
    - 3% no pathogens survive (beer—refrigeration)
    - 7-15% capable of aging (wine—cellar; oxygen)
    - 20% shelf stable (fortified wines & spirits)
- Tandem fermentations

# Brussels' Gueuze Museum



" LAMBIC " production process diagram.

# Introduction to Beer

- Malting
  - rejuvelac
- Mashing
  - milling, steeping.
  - enzymes: spit beer, sake
- Wort
  - fermentable or in fermentable sugars; mouthfeel
  - other nutrition (bacteria v. yeast)
  - hops
    - bitterness is bacteriostatic
    - taste is anti-oxidative
    - aroma is art—grapefruit
    - IPA
- Yeast: *Saccharomyces cerevisiae*
  - anaerobic
  - attenuation
  - aroma: 10-100 identifiable strains





# Lactic and Acetic Preservation

- Sauerkraut & Lactic Cucumbers
  - wild *Lactobacillus*
  - 1.5% brine, similar to animal fluids
  - anaerobic
  - produce 0.1-2% lactic acid
- Vinegar and Brine
  - inoculated *Acetobacter* in wine
  - salt toxic to *Acetobacter*; brined only after acetic fermentation is done.
  - produce 5-15% acetic acid
  - aerobic
  - re-use
  - Shao Xing cooking wine



# General Fermentation

	salt	Alcohol tolerance	Lactic acid	Acetic acid	starch	time	oxygen	temp, F
Saccharomyces	-	20%, P		-	-	2		40-95
Brettanomyces	-	P		P		100		40-95
Lactobacillus	8%	10%	1% P	-		4		60-150
Pediococcus			2% P		+	100	--	
Acetobacter	-	18%		10% P		30	++	70-110
molds		-	-	--		5	++	<100
pathogens		-	-	-		2		<240

P produces  
-- toxic

++ requires  
- inhibits

# Outline of Flemish Sour Ale

- Beer 1500-1900
  - Fresh ale: cheap, common
  - Lager: more expensive, very clean and smooth
  - Aged beer: very expensive, 2 years
    - 5% sour ale. Today: Flemish sour ale
    - 10% stock ale. Today: Barleywine, Imperial Stout
- Porter: consistency v. complexity. Guinness
- Flemish sour ale
  - Unfermentable wort
  - Aged hops: bacteriostatics and anti-oxidants
  - “Spontaneous” or collateral inoculation
  - Wood: the role of oxygen
  - Time
  - Lambic; Flemish Red; Oud Bruin
  - Kriek; Framboise; Peche; Oudbeitje, apricots, grapes, honey
- Sequence
  - Saccharomyces: alcohol
  - Lactobacillus: lactic acid
  - Pediococcus & Brettanomyces: lactic & acetic acid, funk
  - Acetobacter: rising oxygen levels
- Non-sour Brettanomyces ales: Orval, Biere de Mars, Reinaert’s Flemish Wild Ale



# Fermentation Dynamics

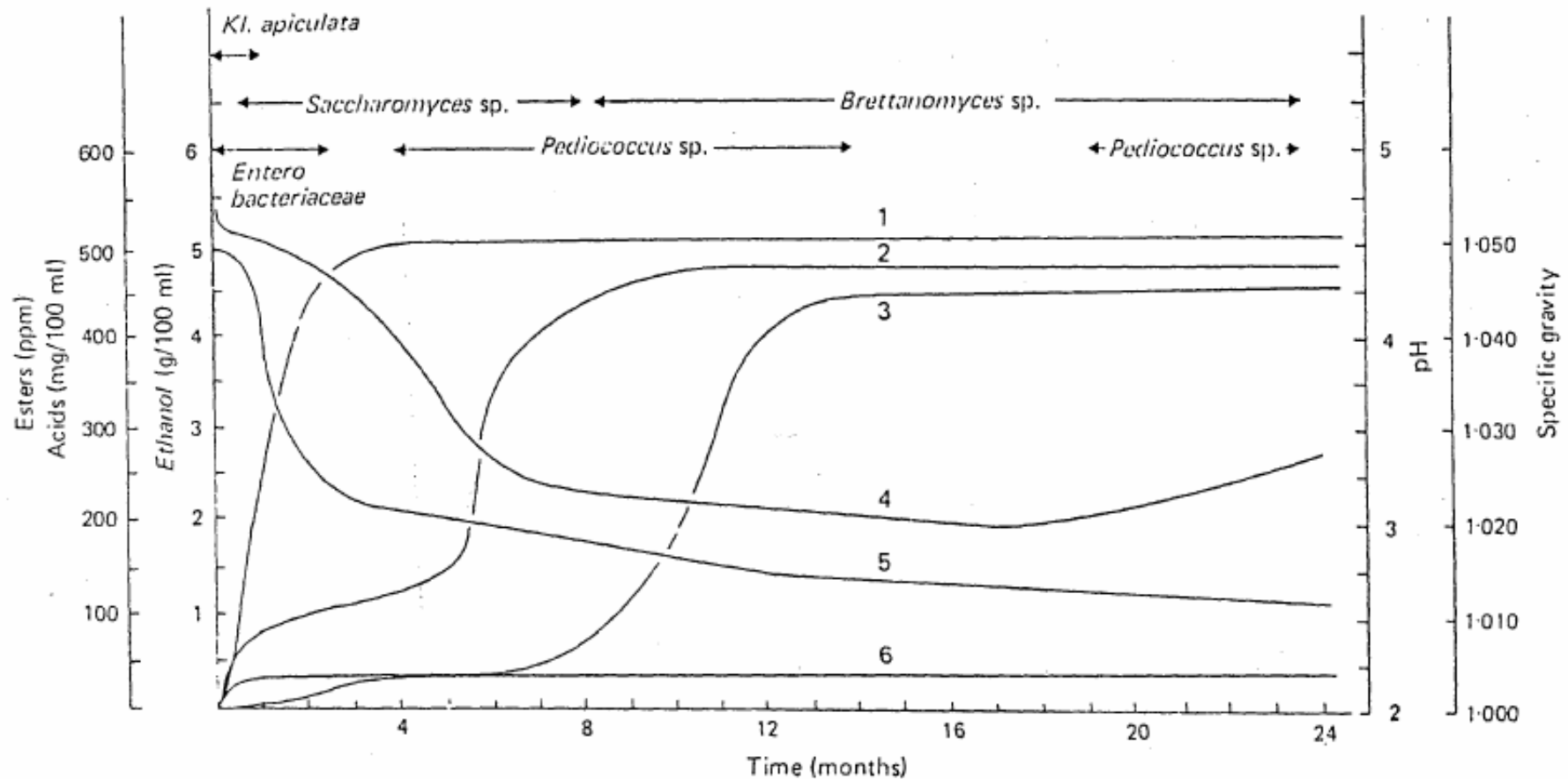


Figure 3. Evolution of some important parameters of spontaneous lambic fermentation: 1 = ethanol; 2 = lactic acid; 3 = ethyl lactate; 4 = pH; 5 = real extract; 6 = acetic acid, and sequence of microorganisms involved (Reprinted from Van Oevelen *et al.* 1977. *J. Inst. Brew.* 83:356-360).

# Red Wine Fermentation

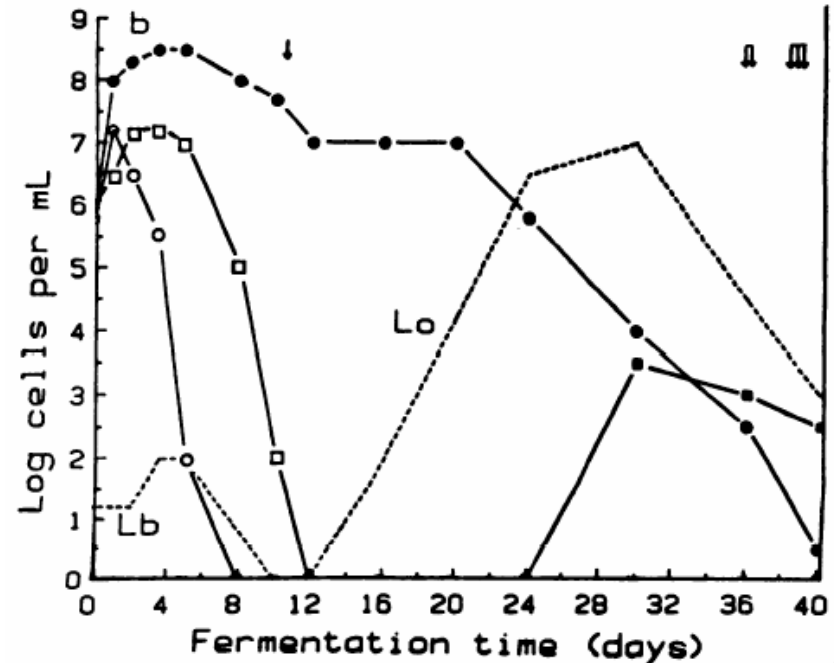
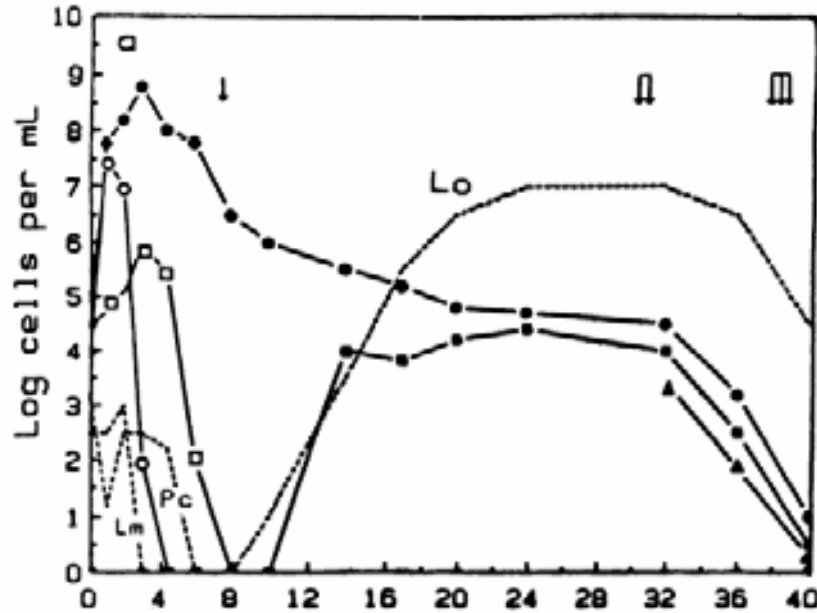


FIG. 1. Evolution of yeasts and lactic acid bacteria during vinyfication of red wine A (a) and red wine B (b). Symbols: (●) *S. cerevisiae*; (○) *K. apiculata*; (□) *T. stellata*; (■) *P. membranaefaciens*; (▲) *S. bayanus*; (---) growth of lactic acid bacteria *L. mesenteroides* (Lm), *P. cerevisiae* (Pc), *L. oenos* (Lo), and *Lactobacillus* spp. (Lb); (↓) finish of alcoholic fermentation and transfer of wine from fermentor to barrels; (⇓) remixing of barreled wines in fermentor; (⇓⇓) return of wine to barrels and addition of 30 to 50 mg of SO<sub>2</sub> per liter.

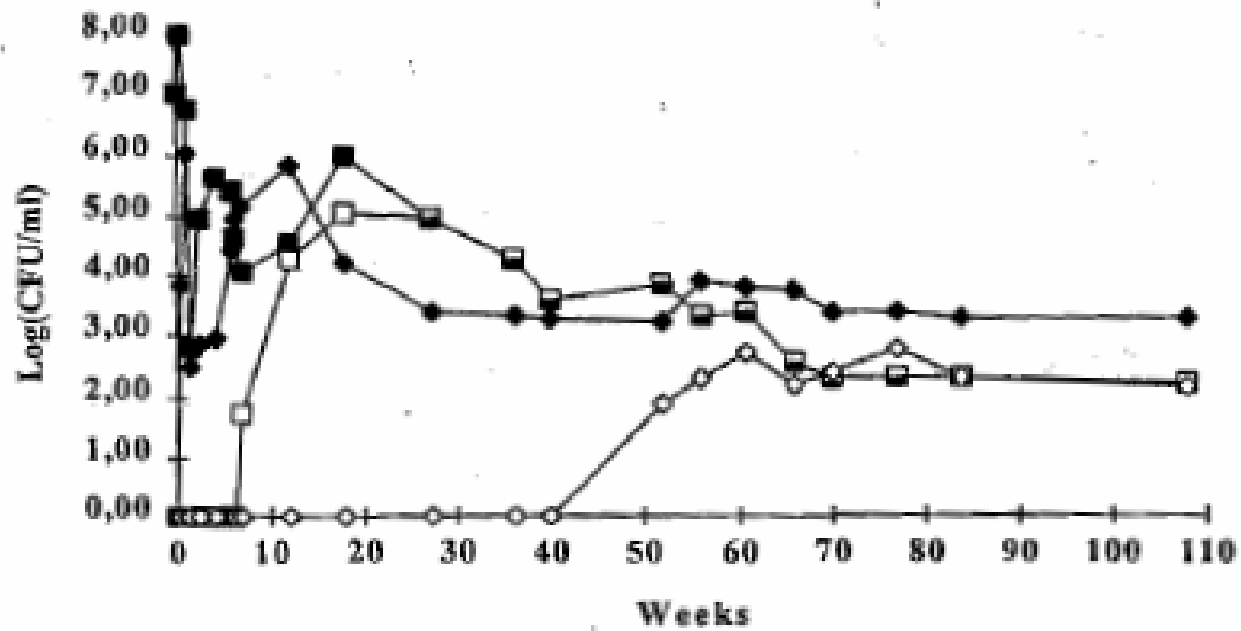
Tandem: alcoholic, acidic

Very fast

Process variation: art of blending



# Population Dynamics



**Figure 2.20:** Evolution of the microbial populations during the fermentation of 'heavy' brew B (■ : total yeasts; □ : actidione-resistant yeasts; ◆ : lactic acid bacteria; ◇ : acetic acid bacteria).