Principles of Sparkling Winemaking

SARAH MIDGLEY

11 APRIL 2023

EST 1926
PLUMPTON
COLLEGE

TO START WITH

- Paper work - Student learner agreements
- How to find your way around
- Aims and objectives of the course
- Who you are
- What we hope to achieve today

HOUSEKEEPING

Housekeeping issues:

Emergency exits, what to do in case of emergency, toilets, refreshments, parking

General layout of the College:

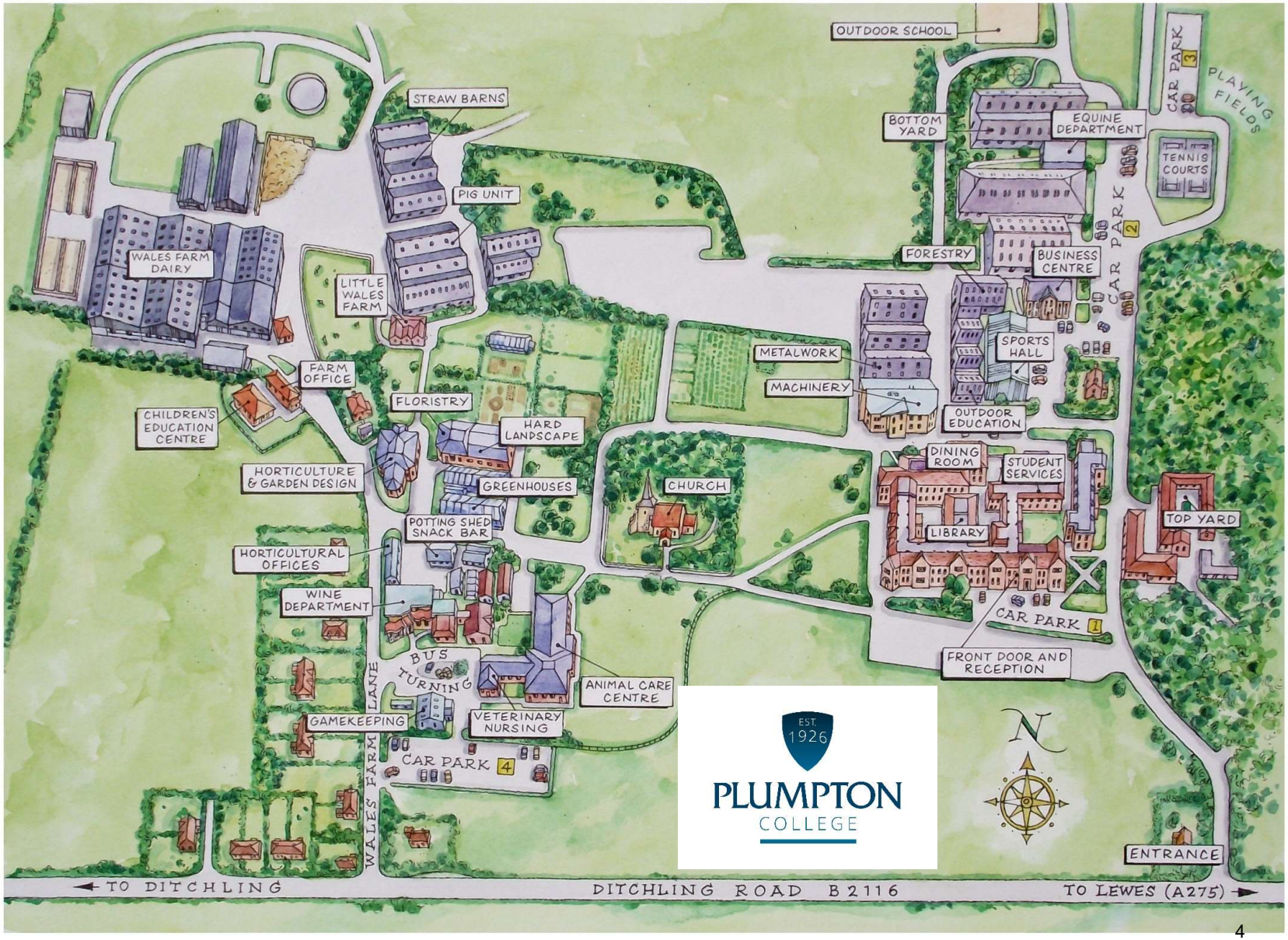
HE common room, dining room and dining arrangements, snack bar, library, reception & student services (if an emergency)

WiFi:

Network: Plumpton Visitor

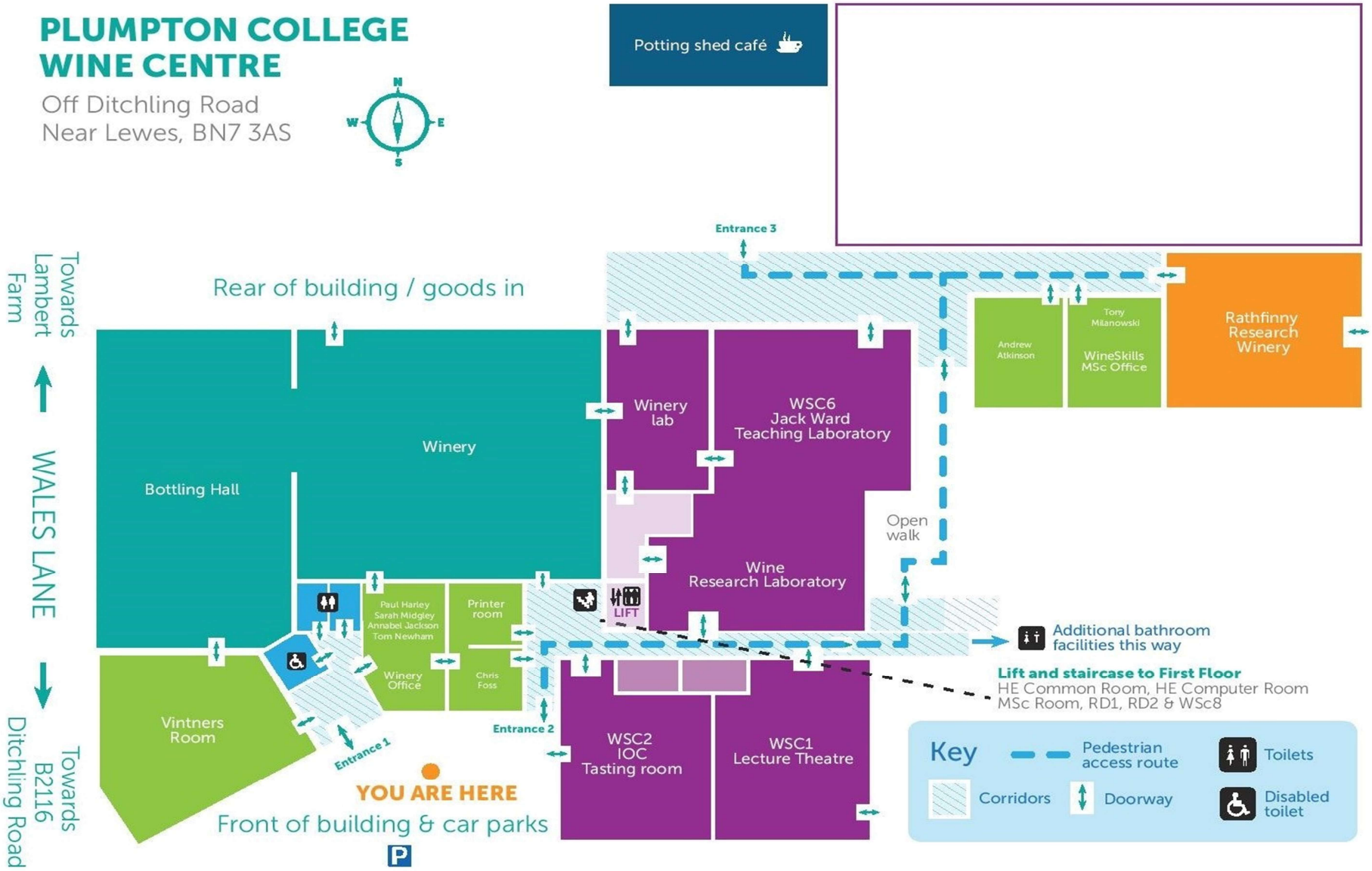
Password: Tuesday14$

PLUMPTON COLLEGE



PLUMPTON COLLEGE WINE CENTRE

Off Ditchling Road
Near Lewes, BN7 3AS



COURSE OUTLINE

Principles of Sparkling Winemaking

- This course focuses on production traditional method sparkling wine, from tirage to disgorging

Tutors

- Lectures – Sarah Midgley
- Practical – Deepika Koushik

Format

- Day 1 is lecture based
- Day 2 + 3 are demonstration based, in the winery

Assessment will be a 30 question multiple choice test at the end of the lectures

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COURSE FORMAT

Time	Tuesday	Wednesday	Thursday
9.15 – 12.00	• Introductions • Tirage & secondary fermentation • Maturation & lees aging	• Yeast culture preparation • Use of adjuvants	• Prepare liquer d'expedition • Dosage trials
13.00 – 16:15	• Disgorging, dosage, corking • Riddling and disgorging • Dosage	• The bottling process	Visit: Wiston Estate, RH20 4BB (optional minibus) • Disgorging process

Who Are We?

- Sarah Midgley, Winemaker and wine lecturer
- BSc. (Hons) in Biochemistry – University of Manchester
- Grad Dip. in Viticulture & Oenology – Lincoln University, NZ
- Worked vintages in Marlborough (NZ), Hunter Valley (Aus), California (USA)
- Assistant winemaker at Camel Valley Vineyard, Cornwall 2010-2014
- Winemaker at Plumpton 2014-2021
- Now part time lecturer / course designer and working to make the wine industry more sustainable
- Chair of SWGB Technical Winemaking group

Who Are We?

- Deepika Koushik, Winemaker
- BSc. (Hons) in Chemistry, Zoology and Microbiology – Bangalore University, India
- MSc. (Dist) In Fermentation Sciences – University of Westminster, UK
- MSc. In Viticulture and Enology – University of California, Davis (USA)
- Taught Microbiology for undergraduate students (India)
- Worked vintages in California (USA), Bourgogne (France) and East Sussex (UK)
- Now based in the UK and working to help students develop unique perspectives on winemaking by helping them build up a strong academic and vocational foundation.

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WHO ARE YOU?

Please turn to the person next to you and interview them

In next 5 minutes find out

- Their name or how they like to be called
- Occupation, home town
- Why they are doing the course
- What was the last bottle of wine they drank and was it any good

Then you will report back your findings to the class

Principles of Sparkling Wine

11th April 2023

1. Tirage and secondary fermentation
2. Maturation and lees aging
3. Riddling and disgorging
4. Dosage

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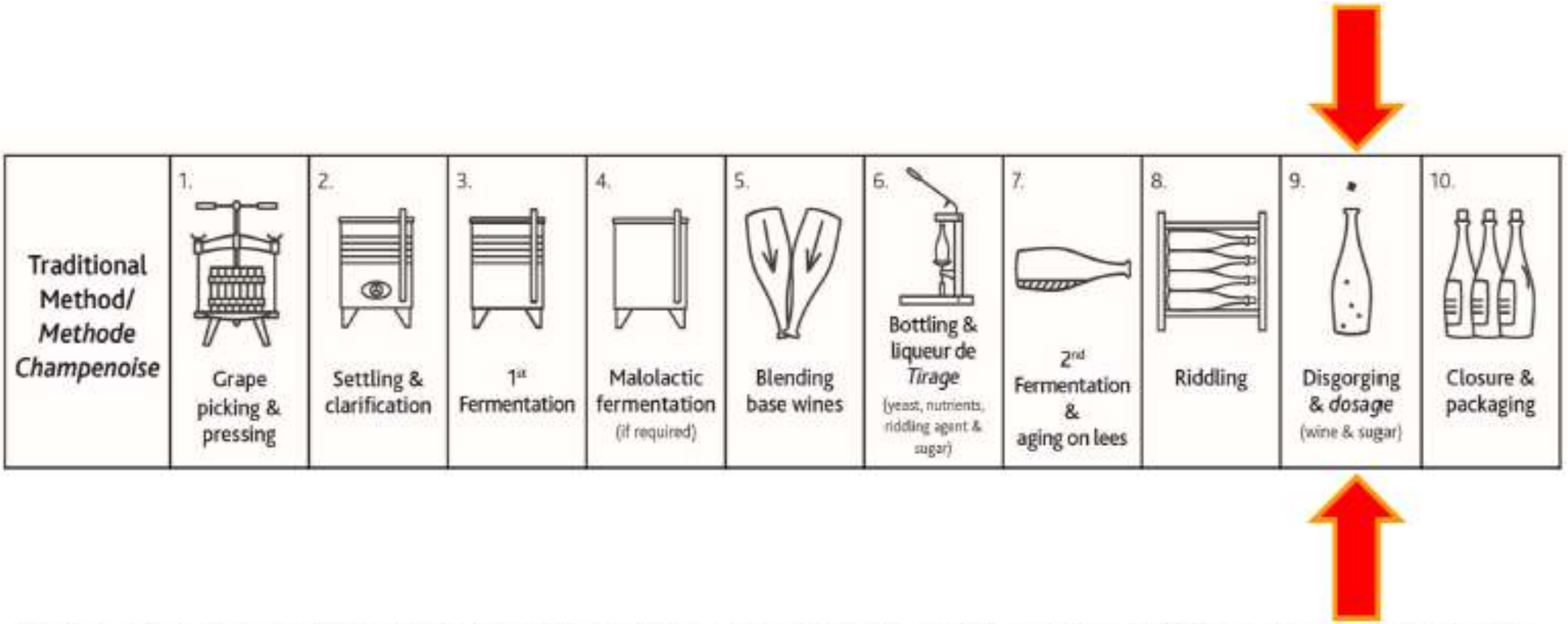
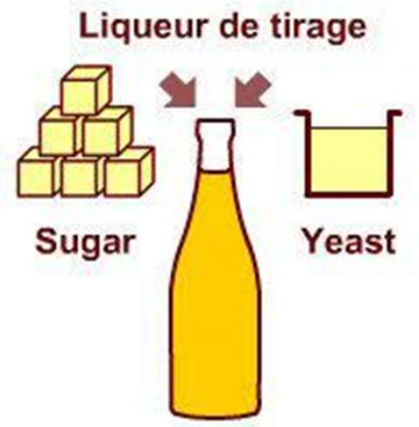
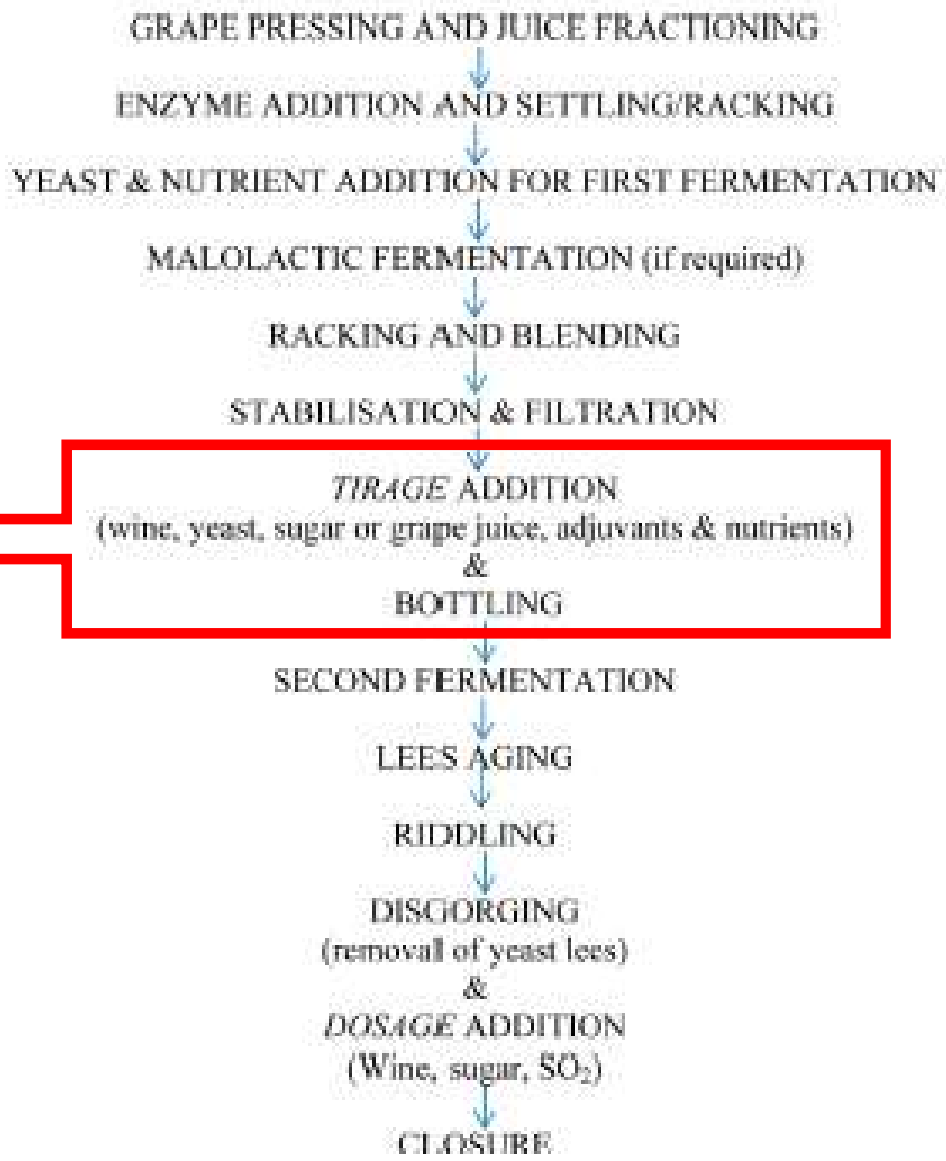


Figure 1. Schematic representation of the Traditional method of sparkling wine production

Tirage
and
secondary fermentation



Tirage preparation for bottling



What is tirage?

- Bottling of base wine for traditional method sparkling wine.

Wine is first mixed with sugar, yeast and riddling agents and yeast nutrients

Wine + Sugar + Yeast + riddling agents

Tirage

Tirage solution, composed of sugar (Sucrose), yeasts, grape must or wine, in the correct proportion to produce the desired CO_2 pressure, is added.

- Sugar addition. 22-24 g/L is used in tirage
- This gives 5-6 Bar atmosphere pressure at 12-15°C
- From sugar cane or beet, but recently also RCGM.
- Sugar is firstly diluted in wine (= liquor)
- Liquor: 500-700 g/L sugar, generally 500-615 g/L (= 1kg sugar in 1 L of wine)

Bottling requirements

1. A base wine blend
2. A yeast strain for 2nd fermentation
3. Sugar as base wine is dry. Named liquor as sugar is generally dissolved in wine
4. Riddling (rémuage) adjuvants to help with lees elimination
5. Fermentation aid (optional)
6. A bottle
7. A bidule to seal it and facilitate the deposit recovery
8. A closure
9. A cool cellar

1. A base wine blend

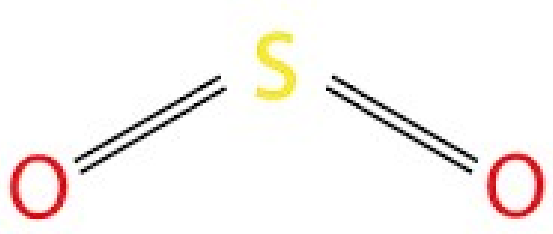
Base wine chemical characterises in NV Champagne after MLF (Tusseau 2008)

Analytical parameter	1996	2001	2003	2005	2007
Alcohol (%vol)	11,0	10,9	11,2	11,1	11,0
Total acidity (g/L tartaric acid)	7,80	6,88	5,81	7,42	6,73
Volatile acidity (g/L acetic acid)	0,29	0,24	0,21	0,31	0,31
pH	3,03	3,03	3,12	3,06	3,07
Tartaric acid (g/L)	3,6	3,0	2,6	2,4	2,9
Malic acid (g/L)	0,2	0,2	0,1	0,2	0,1
Gluconic acid (g/L)		0,11	0,04	0,09	0,11
Potassium (mg/L)	289	326	344	304	333
Calcium (mg/L)	81	78	72	68	70
Sodium (mg/L)	8	7	10	6	7
Magnesium (mg/L)	64	65	69	66	61
Copper (mg/L)	0,13	0,09	0,10	0,08	0,05
Iron (mg/L)	1,8	1,6	1,2	1,2	1,2

- Stabilised base wine with specific characteristic
- Wine composition variable with vintage
- Differences in potential alcohol in juices are not in wines due to chaptalisation to the same level
- Acidity varies with the vintage
- Gluconic acid (from botrytis) changes
- Sometimes MLF so low malic

SO_2 addition ahead of tirage

- Generally total SO_2 needs to be:
  - between 40 and 50 mg/L if MLF was conducted
  - Between 60-80 mg/L if MLF was not done
- Free SO_2 < 10 mg/L to avoid inhibition of yeast, but also check pH for Molecular SO_2 reference



Sulphur Dioxide

2. Yeast for secondary fermentation

- In 1890, IOC (Institute Oenologique de Champagne) started yeast selection for tirage
- Now ADY used, all *Saccharomyces cerevisiae* Development of Hybrid yeast looks promising

Selected yeasts for tirage need to work:

- in high alcohol environment (11%)
- at low pH (3.0-3.2)
- with 5-15 mg/L of free SO_2
- at a low temperature (11-15°C)
- With high pressure
- Poor nutrition & in presence of inhibitory chemicals

- Except for the temperature, the other criteria are fixed and the success of *prise de mousse* depends on the yeast preparation and the ability to cope with them.

IOC
Révélons votre différence

A good yeast for PDM should also…

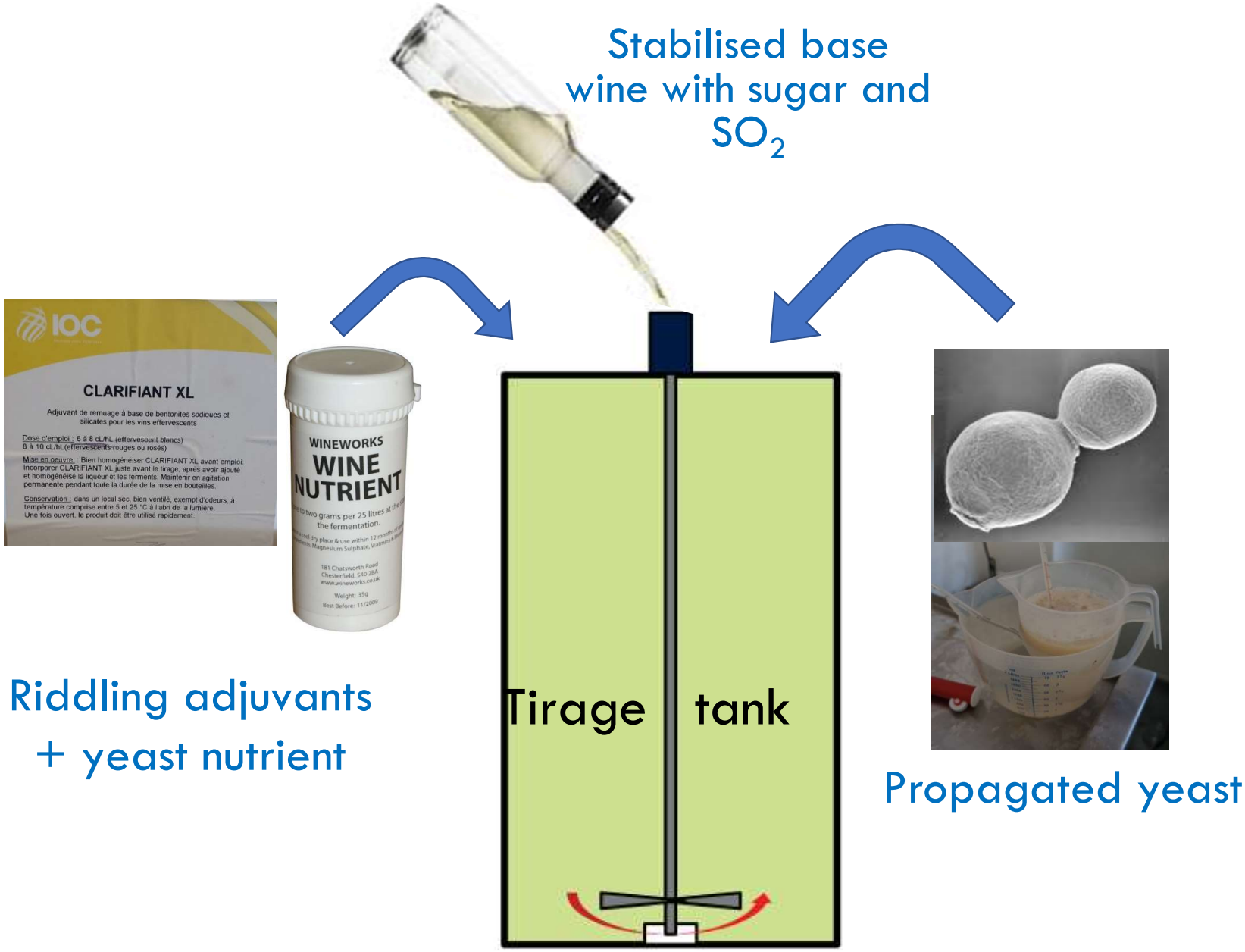
- Be quick in multiplying in the culture tank
- Not produce off-flavours, such as H_2S, Volatile Acidity, ethyl acetate
- Autolyse rapidly but also agglomerate and flocculate
- Improve sensory properties, including foam (autolysis)
- Be neutral
- Most common is IOC18-2007, EC1118, PDM, Davis 595, Red star pasteur champagne
    - Others include DV10, Spark

Yeast propagation

- Yeast cultures are usually prepared in advance of bottling
- Grown in mixture wine, water, sugar (sucrose, RCGM, juice)
- Grown with aeration
- Aim to produce very healthy culture 100-150 million CFU/ml
- Takes several days to achieve
- Then used at appropriate rate, to achieve a finally cell count of 1-1.5 million CFU/ml in bottle
- Any residual sugar in the culture needs to be considered in calculations

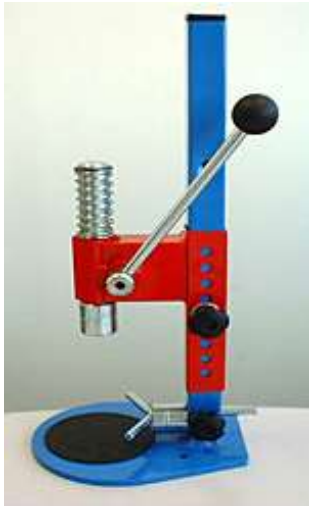
3. Sugar requirements: 16.83g/L = 1% Alc This means that 25g/L will give 1.5% Alc and result in 6 bar of pressure if it all ferments

Alcohol % ABV	5 bar g/l sugar req.	5.5 bar g/l sugar req.	6.Bar g/l sugar req.
9	19	21	23
10	20	22	24
11	21	23	25
12	22	24	26


Stabilised base wine with sugar and SO_2
IOC
CLARIFIANT XL
Adjuvant de remuage à base de bentonites sodiques et silicates pour les vins effervescents
Dose d'emploi : 6 à 8 cL/hL (effervescent blancs)
8 à 10 cL/hL (effervescents rouges ou rosés)
Mise en œuvre : Bien homogénéiser CLARIFIANT XL avant emploi. Incorporer CLARIFIANT XL juste avant le tirage, après avoir ajouté et homogénéisé la liqueur et les ferments. Maintenir en agitation permanente pendant toute la durée de la mise en bouteilles.
Conservation : dans un local sec, bien ventilé, exempt d'odeurs, à température comprise entre 5 et 25 °C à l'abri de la lumière. Une fois ouvert, le produit doit être utilisé rapidement.
WINEWORKS
WINE NUTRIENT
the fermentation.
181 Chatsworth Road
Chesterfield, S40 2BA
www.wineworks.co.uk
Weight: 35g
Best Before: 11/2009
Tirage tank
Riddling adjuvants
+ yeast nutrient
Propagated yeast

Bottling

- Different products for bottling (base wine and tirage) are pre-mixed in a mixing tank to minimise differences among bottles (so constant mixing)
- Possible also to use dosing pumps rather than mixing everything in advance
- Bottling lines have:
  - Washing system for bottles
  - Filling
  - Machine to place the bidule
  - Crown capping

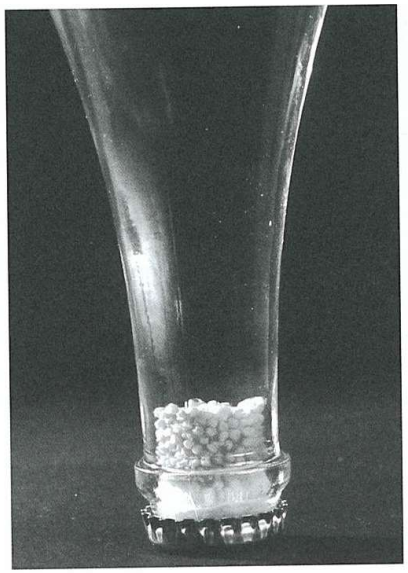


240,000 bottles blending tank at Billecart-Salmon

The tirage addition of yeast, sugar and adjuvants must be well mixed into the tank for blending to ensure an even distribution into each bottle

In big Champagne houses they may have the ability to dose each bottle precisely on the bottling line, but more common is to ensure the tanks are actively mixing whilst bottling.

4/5 Riddling adjuvants + nutrients



Common adjuvants are:

- Bentonite, bentonite + alginate, bentonite + tannin. Dosage = 1-3 g/hL. These favour the compactness of the deposit and prevent sediments sticking to the glass.
- Tannins
- Immobilised yeast in alginate matrix – this is a completely different protocol!
- Fermentation aids (nitrogen max 20 g/hL, optional)

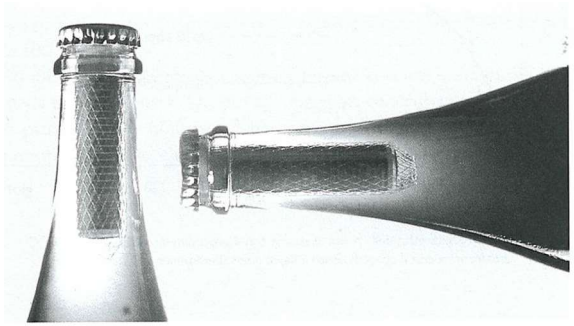


Illustrazione 10.5: cartuccia Millispark® nel collo della bottiglia ©Millipore.

Bentonite for riddling

- Bentonite and Alginate: the alginate makes the complex more slimy and so it will slip better during riddling. Used particularly with automatic riddling (gyropallets)
- Bentonite: 1-3 g/hL. Favour the compactness of the deposit.
  - Its use was studied in Cava (Vanrell, et al., 2007) and found to decrease foam height and stability in 4 varieties including Chardonnay (protein removal).
  - Negative effects on aroma compounds (Pozo-Bayon et al 2003)

6. A bottle

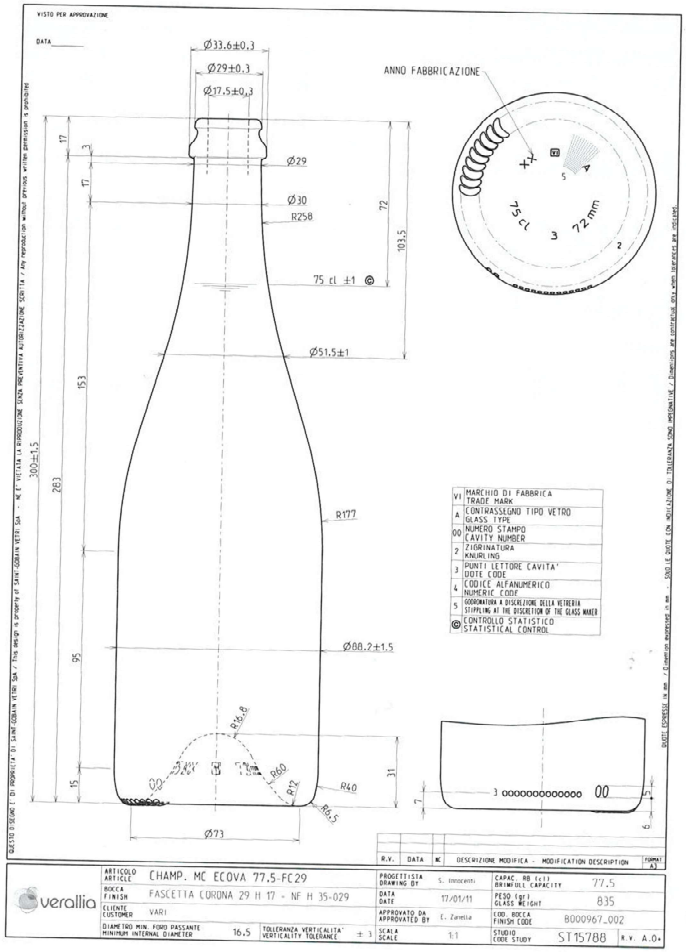


Figura 8.2: disegno tecnico di una bottiglia ecosostenibile per champagne/metodo classico ©Verallia.

- Thick to withstand pressure (normally 20 bar certified) 900g, double a normal bottle – the standard now is 835g
- Shapes influence riddling manual/machine
- Different sizes, some need transfer method to be filled but magnum and Jeroboams can be done traditionally

7/8. Closures

- Bidules (polyethylene cup usually 17mm Ø and 14 mm high) are used as:
  - they aid in disgorging
  - can be combined bidules/crown caps
  - separate bidules provide better ageing than combined
- Stainless steel crown caps are rust free but very springy.
- They come with different

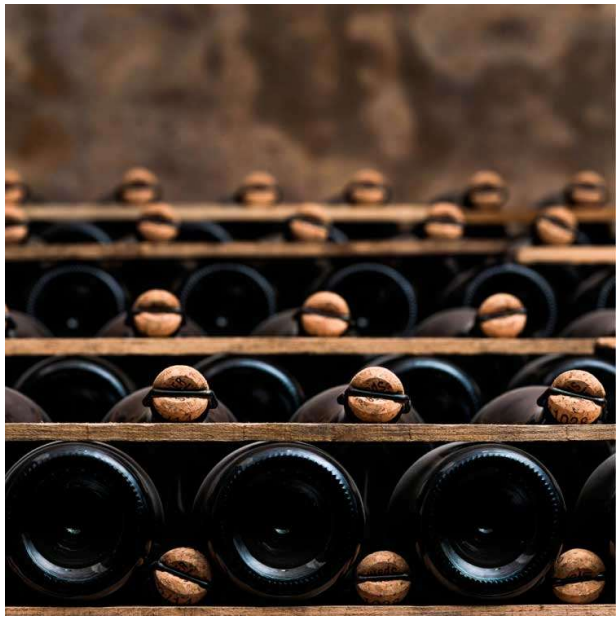
  O_2 permeability → suited to

  different wine styles

Blanc de Blancs may be aged for many more years compared to a Rosé

Cork Closures

- Due to crown seal permeability, which allows fixed amount of gas transfer per year
- Some producers favour cork seals for secondary ferment
- Provide a lot of oxygen to wine initially (during ferment) then less as the bottles age
- Requires different equipment for disgorging. More difficult to mechanise



9. Cellar for storage

- The second fermentation (prise de mousse) temperature and storage temperatures have great effects on quality
- Optimum is 10 - 14°C average temperature with high humidity

Post-harvest, post-ferment, post-MLF

- Your base wines have settled and been racked
- You start putting together the blending plan for each wine style
- Make the blends in the winery – planning for partial tanks being left
- Cold-stabilise – either CMC, chilling, metatartaric acid, etc.
- Filtration post cold stab
- Storage until bottling
- Analysis required
- Book the bottling line
- Order stillage cages and bottles

4+ weeks in advance

- Dry goods
- Staffing
- Yeast and adjuvants
- Check cages and bottles are on schedule
- Double check bottling line booked (if necessary)
- Double check volumes
- SUGAR!
- Forklift and driver

2-3 weeks out

- Samples of final base wines to lab for analysis – highlight any problems
- Confirm staffing and all PPE required
- Start your tirage plan
- Account for RS in the wines and ensure enough sugar/RCGM

1 week out

- Clean winery floor, tirage tanks, all kit required
- Empty out space to work
- Confirm transport, forklifts, drivers
- Gas? Diesel? Power?
- Check all kit such as forklifts
- Arrange skip or waste collection for debris from bottling
- Set temperature of all wines to at least 15 degrees C
- Think about adding the first sugar towards end of the week

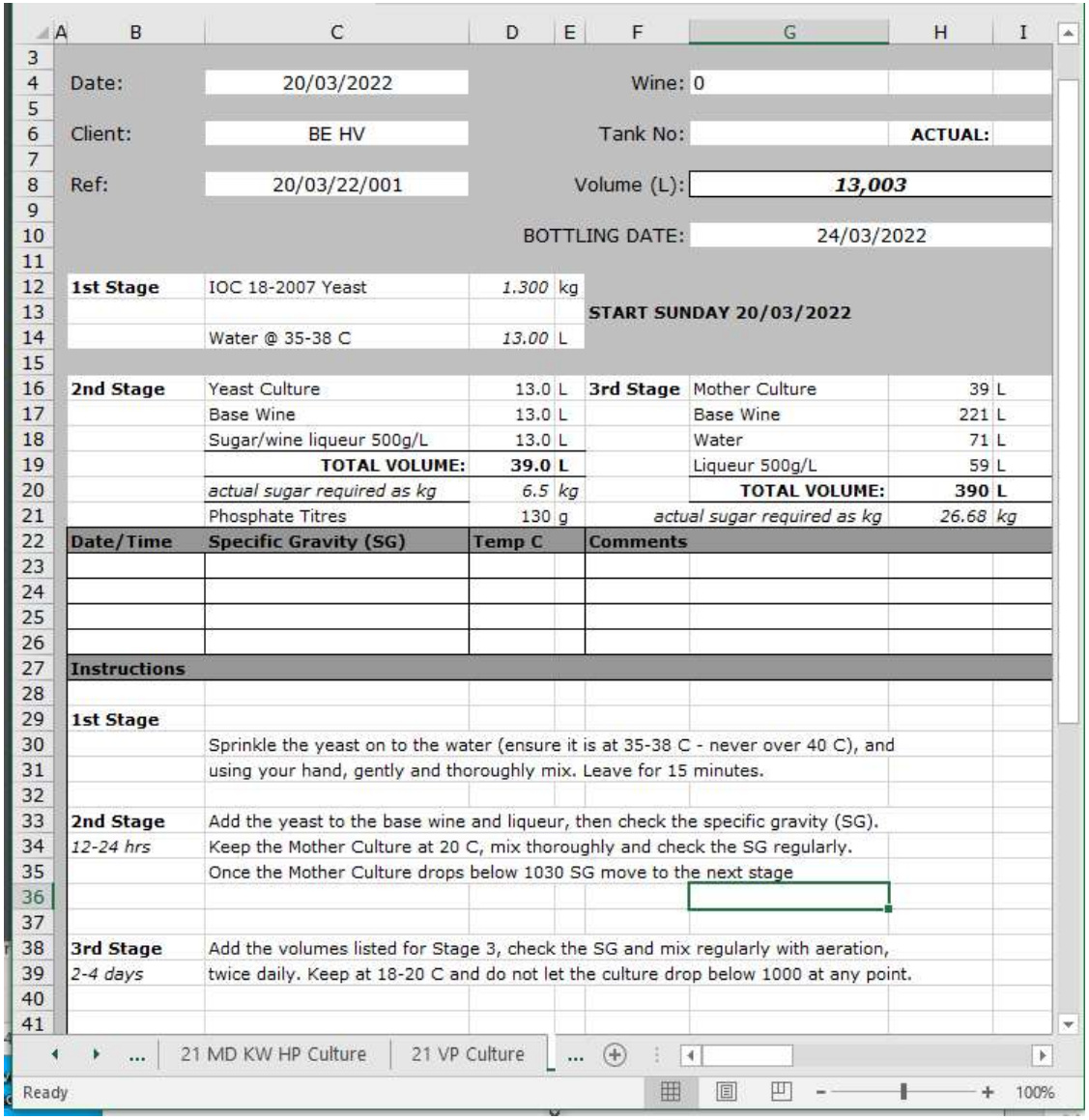
2-5 days before

- Start cultures for each wine or batches of wine
- Keep a close eye on them (daily SG + temperature monitoring + cell counts if possible)
- Organise adjuvants, crown caps, bidules, etc. for easy access
- Isolate any problem wines to be dealt with

Culture Plan

	A	B	C	D	E
1			Sat AM: JR/		
2	**Hattingley Valley TIRAGE MARCH 2022**		Sat PM: JM/VK		
3	**Date**		Sun AM: ER/JM	Completed?	
4			Sun PM: JR/	AM	PM
5	**Friday 18/3/23**	**21 BS HP GF Culture**	Stage 1& 2		
6	**Saturday 19/3/22**	**21 BS HP GF Culture**	Stage 3		
7		**21 MD KW Culture**	Stage 1& 2		
8		**21 VP Culture**	Stage 1& 2		
9	**Sunday 20/3/22**	**21 BS HP GF Culture**	Mix and check		
10		**21 MD KW Culture**	Stage 3		
11		**21 VP Culture**	Stage 3		
12		**21 BE HV Culture**	Stage 1& 2		
13	**Monday 21/3/22**	**21 BS HP GF Culture**	Mix and check		
14		**21 MD KW Culture**	Mix and check		
15		**21 VP Culture**	Mix and check		
16		**21 BE HV Culture**	Stage 3		
17	**Tuesday 22/3/22**	**21 BS HP GF Culture**	Use for bottling		
18		**21 MD KW Culture**	Mix and check		
19		**21 VP Culture**	Mix and check		
20		**21 BE HV Culture**	Mix and check		
21	**Wednesday 23/3/22**	**21 MD KW Culture**	Use for bottling		
22		**21 VP Culture**	Use for bottling		
23		**21 BE HV Culture**	Mix and check		
24	**Thursday 24/3/22**	**21 BE HV Culture**	Use for bottling		
25					
26					

Individual Culture



Date:	20/03/2022			Wine:	0			
Client:	BE HV			Tank No:		ACTUAL:		
Ref:	20/03/22/001			Volume (L):		13,003		
				BOTTLING DATE:		24/03/2022		
1st Stage	IOC 18-2007 Yeast	1.300	kg					
				START SUNDAY 20/03/2022				
	Water @ 35-38 C	13.00	L					
2nd Stage	Yeast Culture	13.0	L	3rd Stage	Mother Culture	39	L	
	Base Wine	13.0	L		Base Wine	221	L	
	Sugar/wine liqueur 500g/L	13.0	L		Water	71	L	
	TOTAL VOLUME:	39.0	L		Liqueur 500g/L	59	L	
	actual sugar required as kg	6.5	kg		TOTAL VOLUME:	390	L	
	Phosphate Titres	130	g		actual sugar required as kg	26.68	kg	

Date/Time	Specific Gravity (SG)	Temp C	Comments

Instructions

1st Stage

Sprinkle the yeast on to the water (ensure it is at 35-38 C - never over 40 C), and using your hand, gently and thoroughly mix. Leave for 15 minutes.

2nd Stage *12-24 hrs*

Add the yeast to the base wine and liqueur, then check the specific gravity (SG). Keep the Mother Culture at 20 C, mix thoroughly and check the SG regularly. Once the Mother Culture drops below 1030 SG move to the next stage

3rd Stage *2-4 days*

Add the volumes listed for Stage 3, check the SG and mix regularly with aeration, twice daily. Keep at 18-20 C and do not let the culture drop below 1000 at any point.

1 Kg of yeast IOC 18-2007 to make 300 litres of yeast culture (10g/hl) = for 100hl wine

Stage 1 - Rehydration : time = 15 to 20 minutes

Put 1 Kg of yeast IOC 18-2007 into 10L of lukewarm water (35/38°C) – never go over 40°C ! – mix thoroughly to avoid the formation of lumps.

Leave for 15 minutes then homogenize properly before going to the next stage.

Stage 2 - Mother culture : time = 12 to 24 hours

- 10L of rehydrated yeasts
- 10L of base wine
- 10L of liqueur (sugar + wine – concentration 500 g/l) = 5 kg of sugar
- Total : 30 L of mother culture

Homogenize properly and check the specific gravity. The loss of specific gravity will show the good activity of the yeast culture – in fact, the consumption of sugar shown by the evolution of specific gravity is a good way of checking the yeast culture.

Keep at 20°C. Mix and check the specific gravity regularly, then go to next stage, as soon as the specific gravity has gone under 1030.

Stage 3 – Yeast culture : time = 2 to 4 days

- 30L of mother culture
- 170L of base wine
- 50L of water
- 50L of liqueur (= 25 kg of sugar)
- 100g of Phosphates titres
- Total : 300L of yeast culture

- Keep at 18 / 20°C. Mix with aeration twice a day and check specific gravity daily.
- The loss of specific gravity is normally around 10 points a day. Make sure that the yeast culture is over 1000 of specific gravity during all time of elaboration.
- Make a microscopic examination before use, if possible.

Feeding a Yeast Culture – keeping it alive!

Always aiming to be between 1000-1010 at the point of addition of YC to cuvee, each evening add sugar based on assumption that 10 points of SG = 25g/L

(0.4 SG = 1 g/L)

i.e. if YC of 2,000 L is at 1000 SG on evening before next day's bottling, I would want to bring this to at least 1010 immediately, so I would add 2,000 L x 25g = 50kg.

Or, if I felt the YC was moving quickly as ambient temp higher than 20C, or SG is lower than 1000 (danger zone), then maybe add up to 15 points SG so 2,000 L x 37.5g =75kg

Now, it is important that whenever you add sugar to a YC, you also add some water, so you can dilute the medium a little. A good rule of thumb is half the weight of the sugar in water, i.e. if 50 kg sugar add 20-30 L water. Additionally, as the week progresses, there is no harm in adding more Phosphate Titres (DAP) to the culture.

On day of bottling:

Check SG Yeast culture – and allow for any residual sugar
Re-check SO2 level in wine – ideally to be below 12mg/L
Re-check alcohol level – 10% vol. for 24g/L tirage sugar

	Per hL	Per 1000L (10hL)	
Yeast Culture	4L	40L	
Sugar	2.4kg	24kg	
Cleanspark	60ml	600ml	Prepare a solution of 25% Cleanspark in cold water (1L cleanspark for 3L water) mix with yeast culture
Tanspark	30ml	300ml	mix with wine (before cleanspark)
Fresharom (Blush only)	20g	200g	mix with wine
Thiazote PH	10g	100g	mix with wine

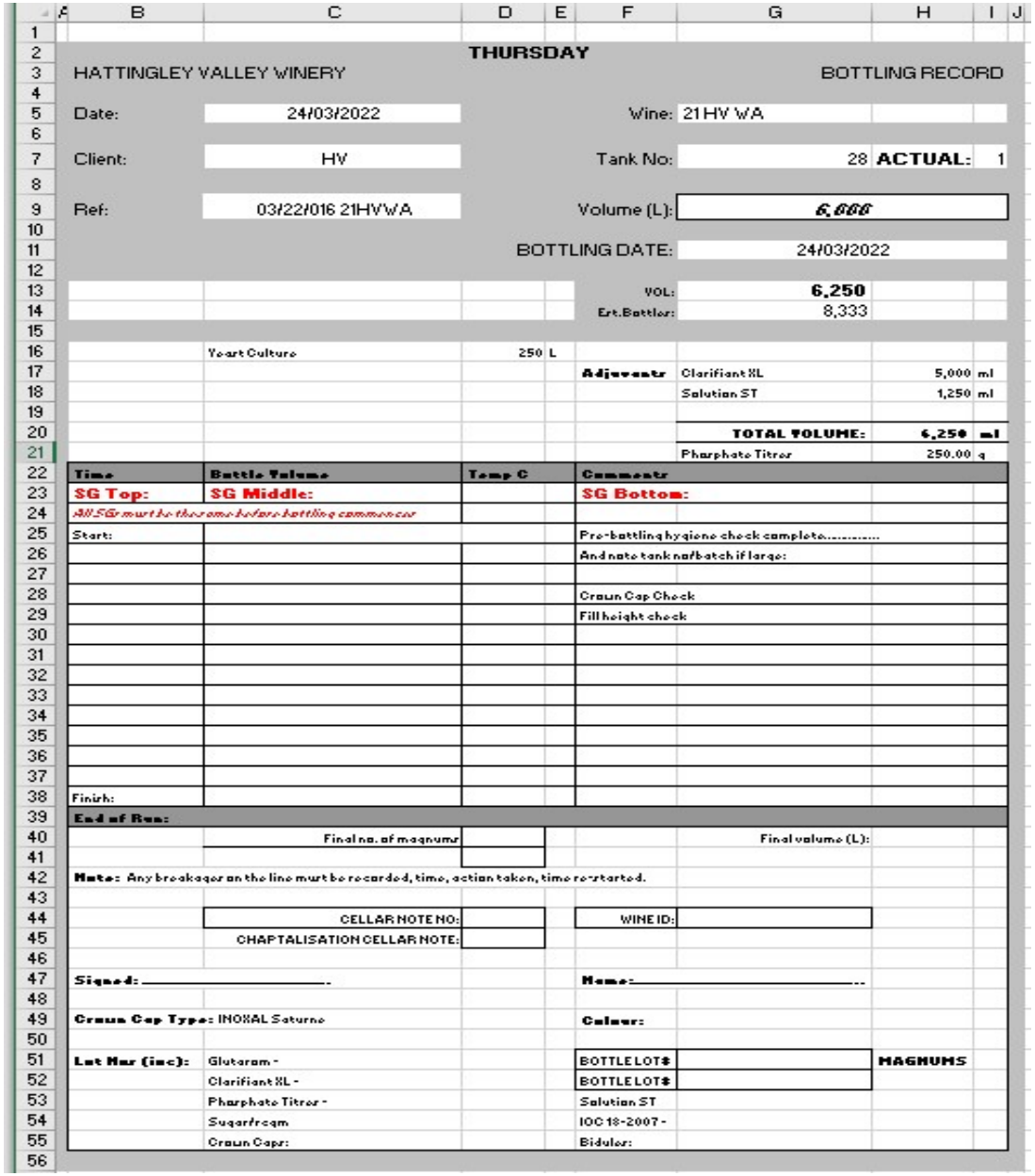
Blend ***all**** together in batches and pump over and/or rouse to mix.

Bottling Day

- Check, check and check again

- SG on wines, yeast cultures, do you have everything to hand and ready?
- How are you marking the cages?
- Keeping count? Taking library/QC bottles as you go?
- Once the line is going you cannot stop!
- Any hold-ups just mean a later night!

Day/Wine bottling record



THURSDAY

HATTINGLEY VALLEY WINERY — BOTTLING RECORD

Date:	24/03/2022	Wine:	21 HV WA
Client:	HV	Tank No:	28 ACTUAL: 1
Ref:	03/22/016 21HVWA	Volume (L):	6,000
		BOTTLING DATE:	24/03/2022
		VOL:	6,250
		Ext.Bottler:	8,333

Yeast Culture	250 L		
		Adjuvants	Clarifiant XL 5,000 ml
			Solution ST 1,250 ml
			TOTAL VOLUME: 6,250 ml
			Phosphate Titrer 250.00 g

Time	Bottle Volume	Temp C	Comments
SG Top:	SG Middle:		SG Bottom:
All SG must be the same before bottling commences			
Start:			Pre-bottling hygiene check complete.....
			And note tank no/batch if large:
			Crown Cap Check
			Fill height check
Finish:			

End of Run:

Final no. of magnums: | Final volume (L):

Note: Any breakages on the line must be recorded, time, action taken, time re-started.

CELLAR NOTE NO: | WINE ID:

CHAPTALISATION CELLAR NOTE:

Signed: _____ **Name:** _____

Crown Cap Type: INOXAL Saturno **Colour:**

Lot Nos (inc):	Glutaram -	BOTTLE LOT$		MAGNUMS
	Clarifiant XL -	BOTTLE LOT$		
	Phosphate Titrer -	Solution ST		
	Sugar/cream	IOC 18-2007 -		
	Crown Caps:	Bidular:		

Food safety

- It is advisable to have a HACCP (Hazard analysis of critical control points) in place for food safety and to analyse the risk of different operations.
- Bottling and disgorging are critical control points (CCP's) meaning that problems in the bottle at this point pose a risk to consumers health or to wine quality.
- Glass – glass breakage policy in place
- Foreign bodies in bottle – workers to wear hair nets and overalls
- Final check – Before selling the wine a sample should be analysed by an independent lab for safety – sulphite and alcohol levels.

Troubleshooting

What can and does go wrong?

Potential problems and how to avoid them

- Yeast culture failing before tirage commences:

1. Yeast health
2. Cell counts
3. Temperature and speed of ferment (oxygen & nutrition)

- Considerations for both yeast at both culture and tirage:

1. Free SO_2 – too high on base wine? What pH? Molecular SO_2 levels for protection
2. Total SO_2 – too high? What are you aiming for <100ppm preferably less
3. Temperature – in tank and ambient – then storage for ferment
4. Nutrition in the base wines

Problems, cont…

- Failure to mix tank properly before tirage

1. Sugar or RCGM – much heavier than the wine – must be mixed thoroughly
2. Check top, middle and bottom of each tank several times and then immediately before seeding and tirage commences

- This could be a very expensive and time-consuming problem to fix!

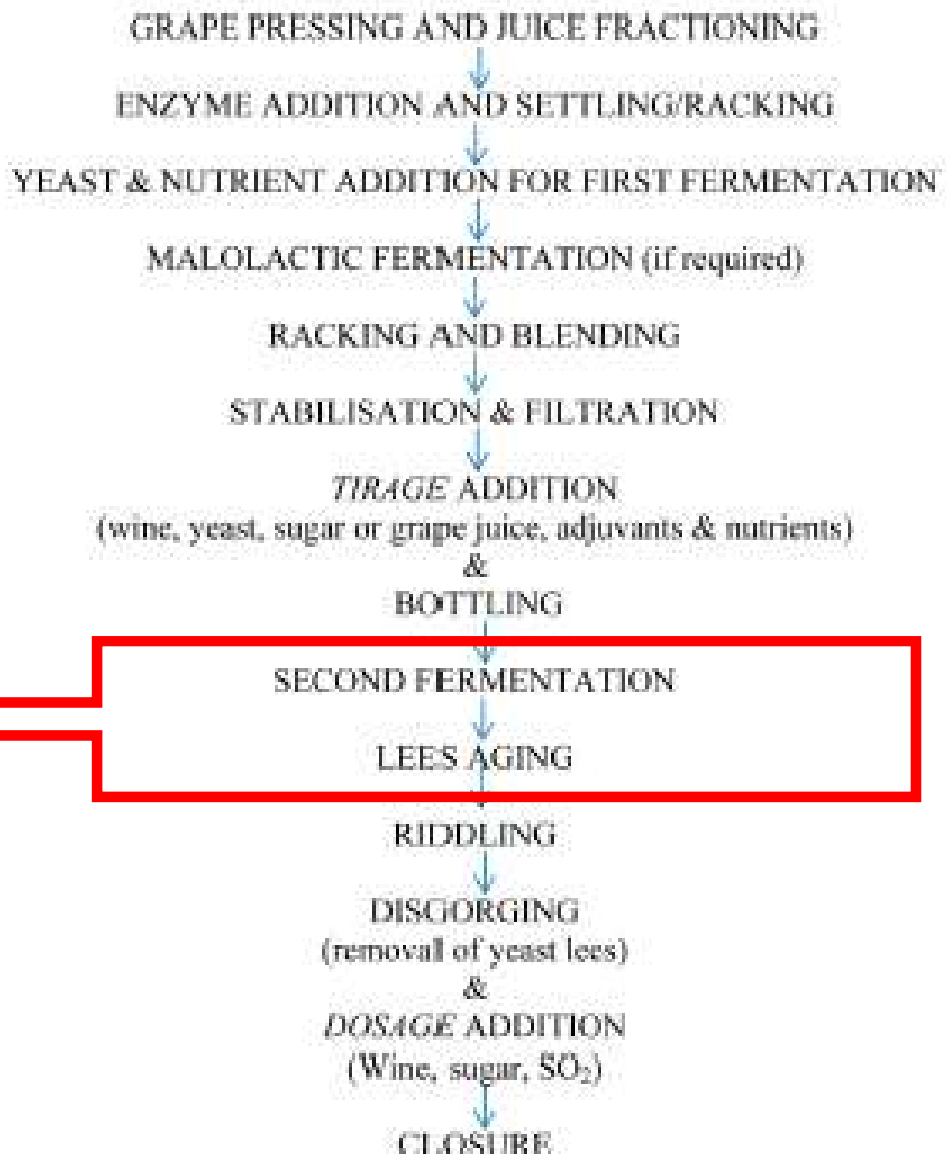
Problems, cont….

- Undetected instabilities, calcium, tartrates, *Brettanomyces*, poor hygiene generally
- Lack of protein – over-fining base wines
- QA on the line, fill-height, foaming, bidule insertion, crimping of crown cap check, forgetting adjuvants

Secondary fermentation and parameters affecting it

Yeast, O_2, CO_2, ethanol, pH, SO_2, temperature

2nd AF and lees aging



Prise de mousse (PDM)

- Alcoholic fermentation is very slow: 3-6 weeks duration during which 20-24 g/L of sugar will be fermented (in primary 170-180 g/L sugar in 6-12 days)
- Anaerobic conditions slow it down

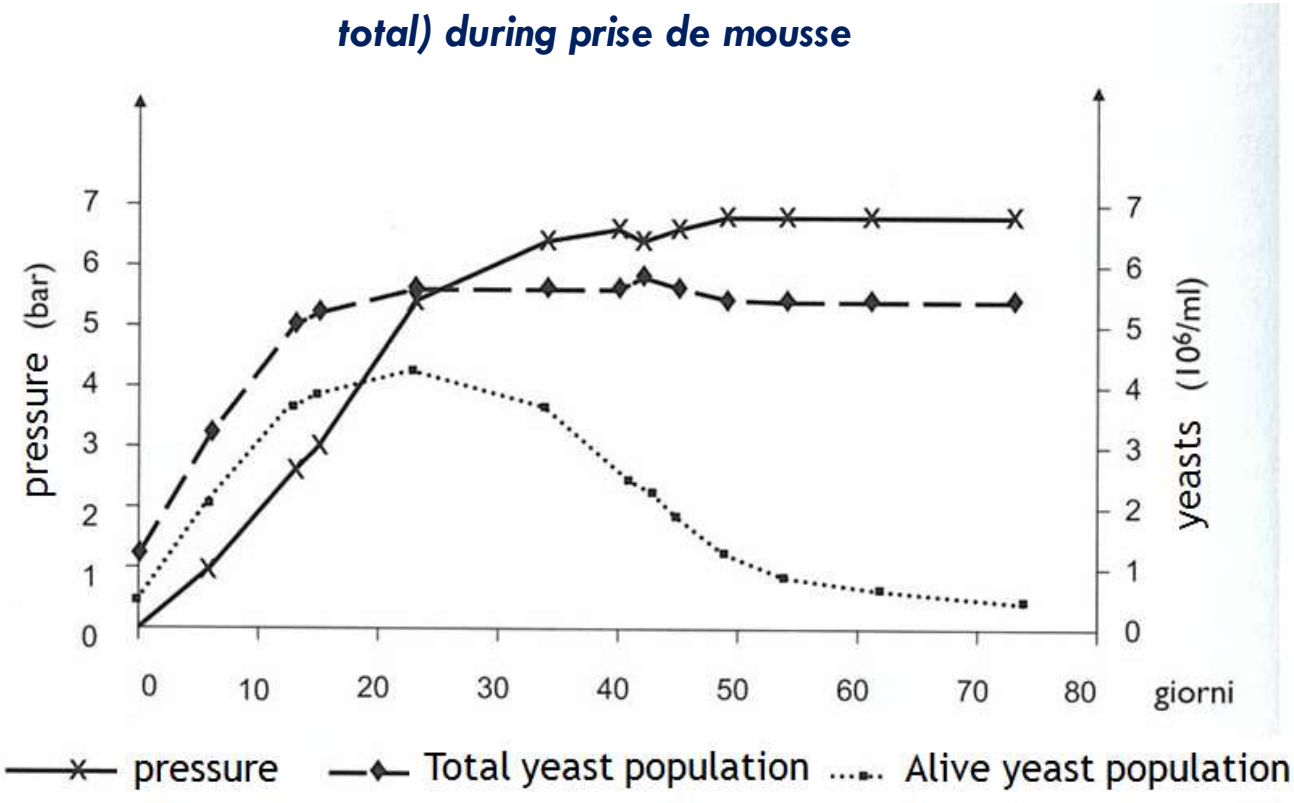
Kinetics of fermentation can be monitored in different ways:

- ATR-FTIR spectroscopy
- Laser
- Afrometer

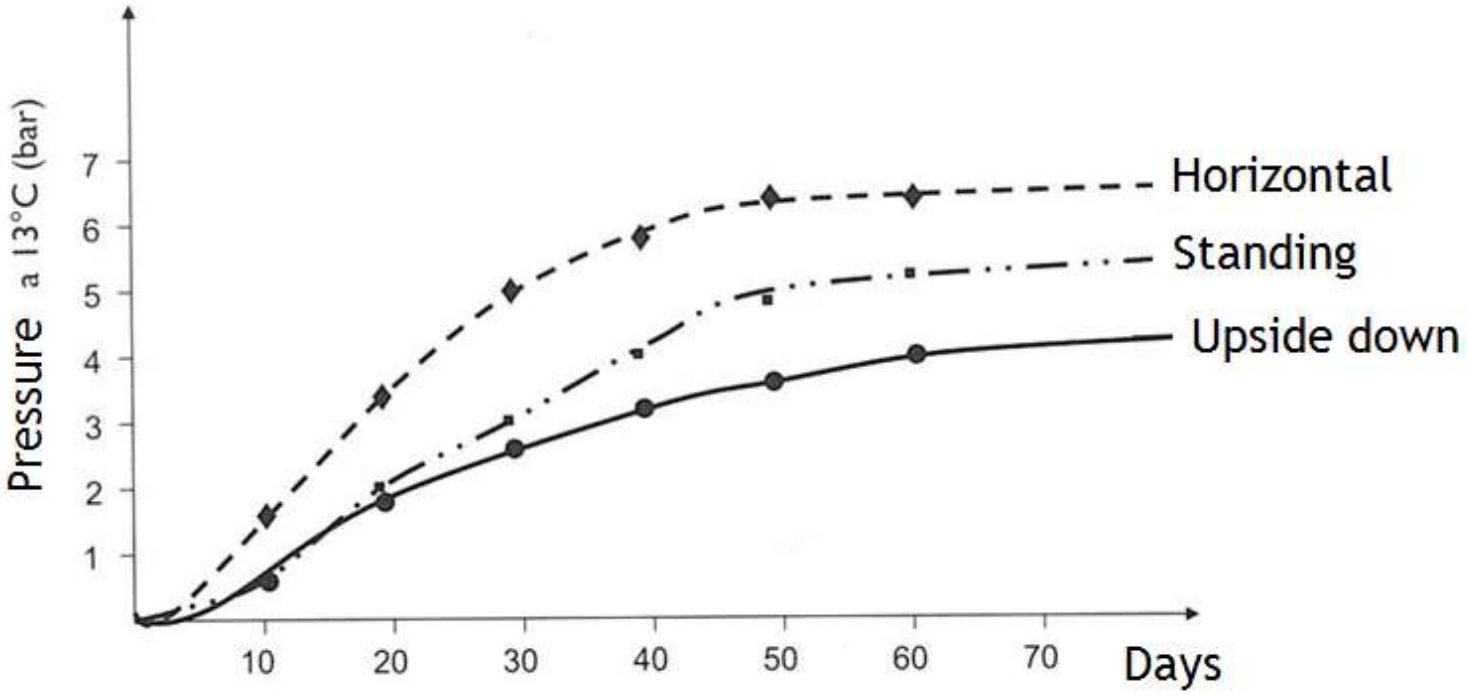
Secondary fermentation (prise de mousse - PDM)

Much slower than primary fermentation (anaerobic conditions): 20-30 days duration vs. 6-12 days

Evolution of pressure, of yeast population (alive and total) during prise de mousse



Effect of bottle position on PDM



Redrawn from Vadane and Laurent, 1999

Factors affecting secondary fermentation

- Oxygen: quite anaerobic conditions unless some oxygen is picked up at bottling
- SO_2: 10 mg/L of free at bottling should not negatively affect yeast development
- CO_2 content in base wine: if high it can hinder the correct prise de mousse kinetic
- Ethanol: from 11% to 12.5% during prise de mousse → inhibitive effect on yeast
- pH: below 2.9 series risks for prise de mousse to happen correctly
- Temperature: generally between 12 and 14°C.
  - <10°C = difficult to achieve prise de mousse
  - > 20°C = combined with low pH and high ethanol risk of viable yeast to decrease rapidly with possible stuck secondary fermentation.
    In addition, at high temperature the wine will age faster

Bottle ageing & yeast autolysis

Bottles in horizontal position maximises contact between wine and yeast sediment

➢ leading to a slow release of yeast compounds

Lees aging in wine

Still wine lees composition	Sparkling wine lees composition
▪ tartaric acid salts ▪ organic residues ▪ cells of various species of yeasts and bacteria	▪ mainly cells from a single species of yeast ▪ Co-adjuvants

- Other differences
- Aging in sparkling is longer (several months/years)
- Aging occurs under pressure

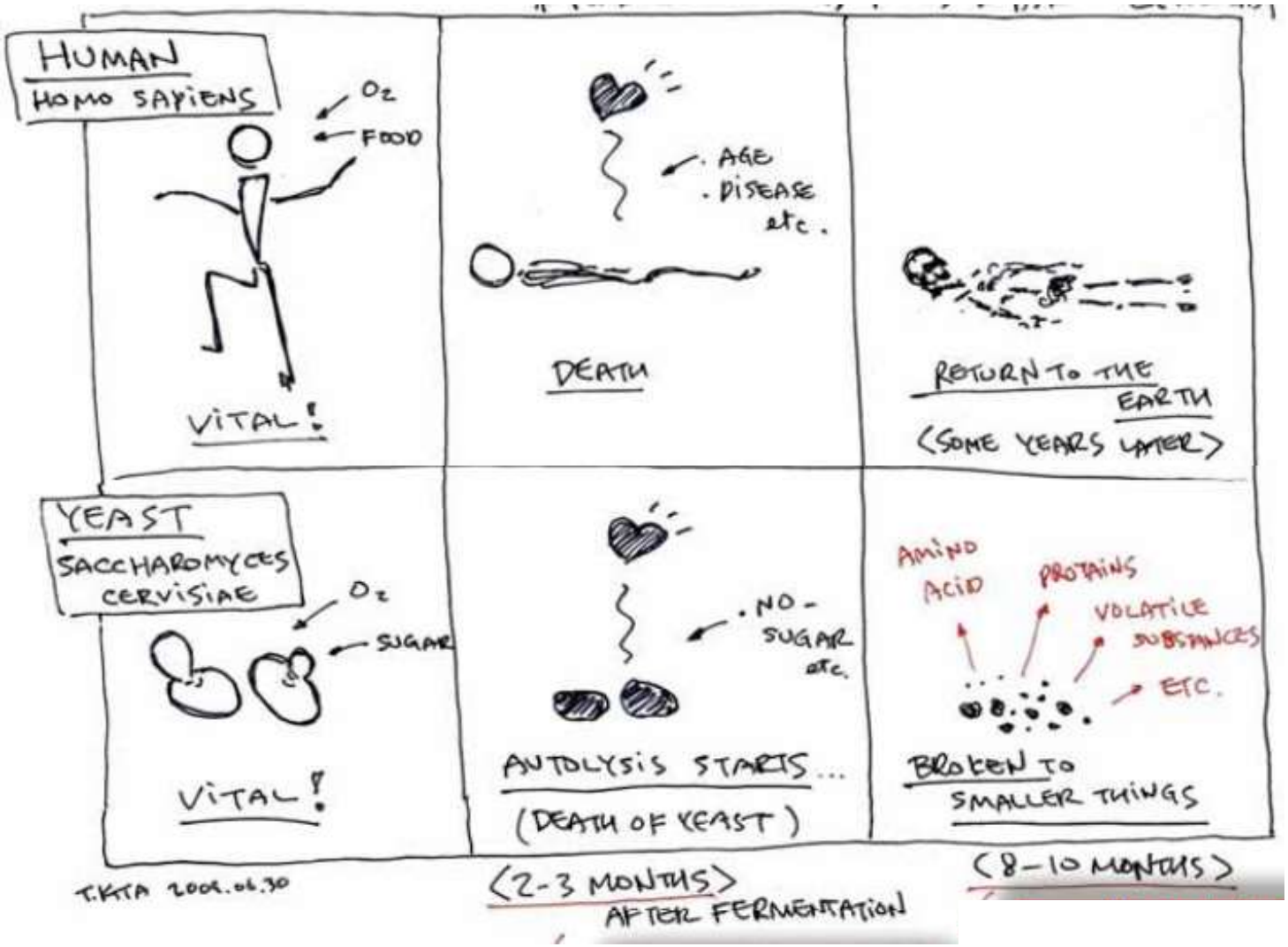
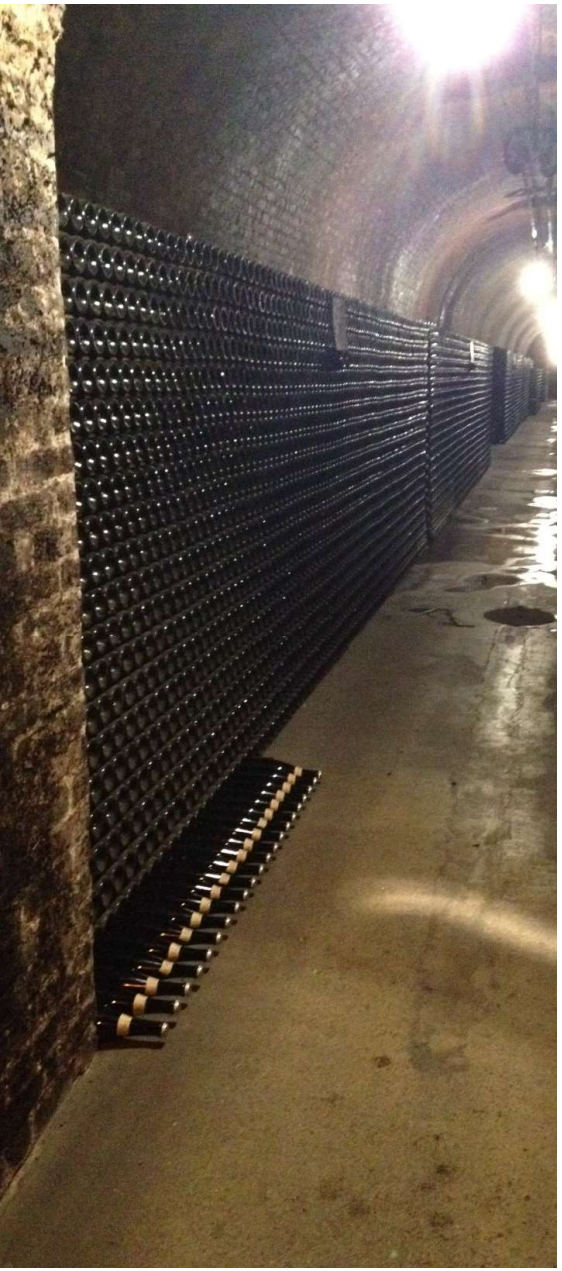


Image modified from: http://www.kitasangyo.com/e-Academy/wine/bottle_fermented_sparkling_wine_ed5_digest_e.pdf



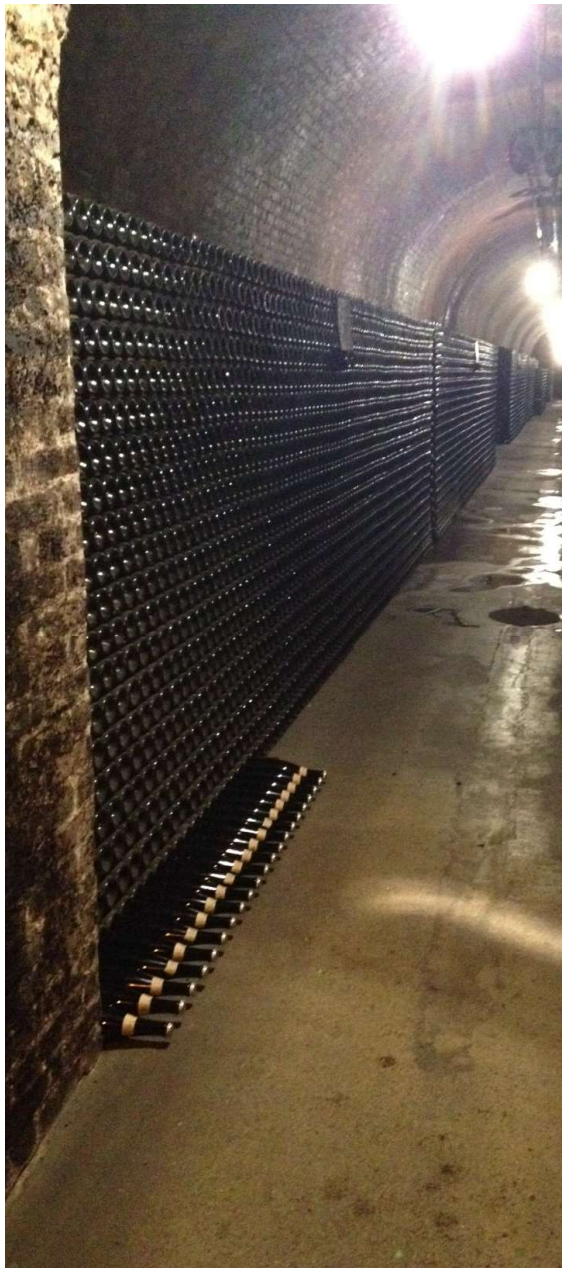
Lees aging in wine - autolysis

- At the end of fermentation (30-40 days) the yeast starts to slowly release several compounds (mainly amino acids) that were accumulated as a reserve during the fermentation.
- These compounds originate both from yeasts and wine, during fermentation, in starvation conditions, yeasts accumulate them as a reserve and once the fermentation has finished, yeasts release these compounds into the wine, modifying its characteristics.
- This is still not autolysis, but simply a free exchange back to the wine (Zoecklein, 2002).

Real autolysis

Real autolysis:

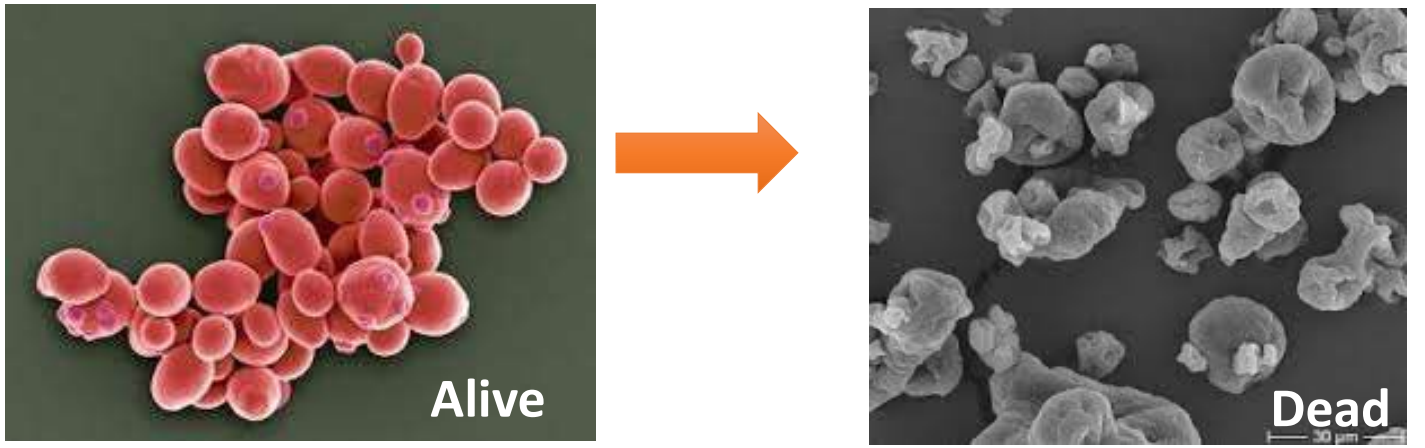
- does not begin until 2–4 months after the completion of secondary fermentation.
- is considered a irreversible lytic event that takes months to occur naturally.
- is mostly attributable to degradation of the yeast cell wall by glucanase activity
- In sparkling wines, proteolytic activity decreases during active bottle fermentation and in the following months, but after 9 months of fermentation and aging, it gradually increases.
- For sparkling ageing in bottles can be 9 months to 10+ years



Yeast autolysis =

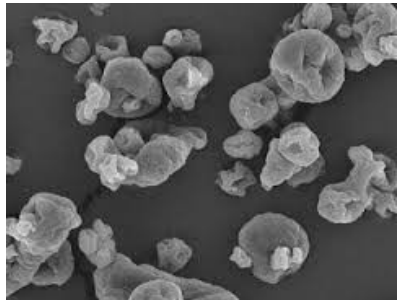
Enzymatic self-degradation of cells constituents mediated by glucanases causing the release of many parietal and cytoplasmic compounds with proved foaming and sensory properties

- As a result: amino acids, mannoproteins and polysaccharides are released, which could positively effect foaming and characterise the flavour and aroma of the finished product.
- Lees ageing in sparkling causes increase in mannoproteins and polysaccahrides with high concentrations of arabinose and galactose (PrAGs) after 6 months, which could positively effect foaming.



(Alexandre and Guilloux-Benatier, 2006; Nunez et al., 2005; Moreno-Arribas et al., 2000).

Autolysis causes slow release in wine of:



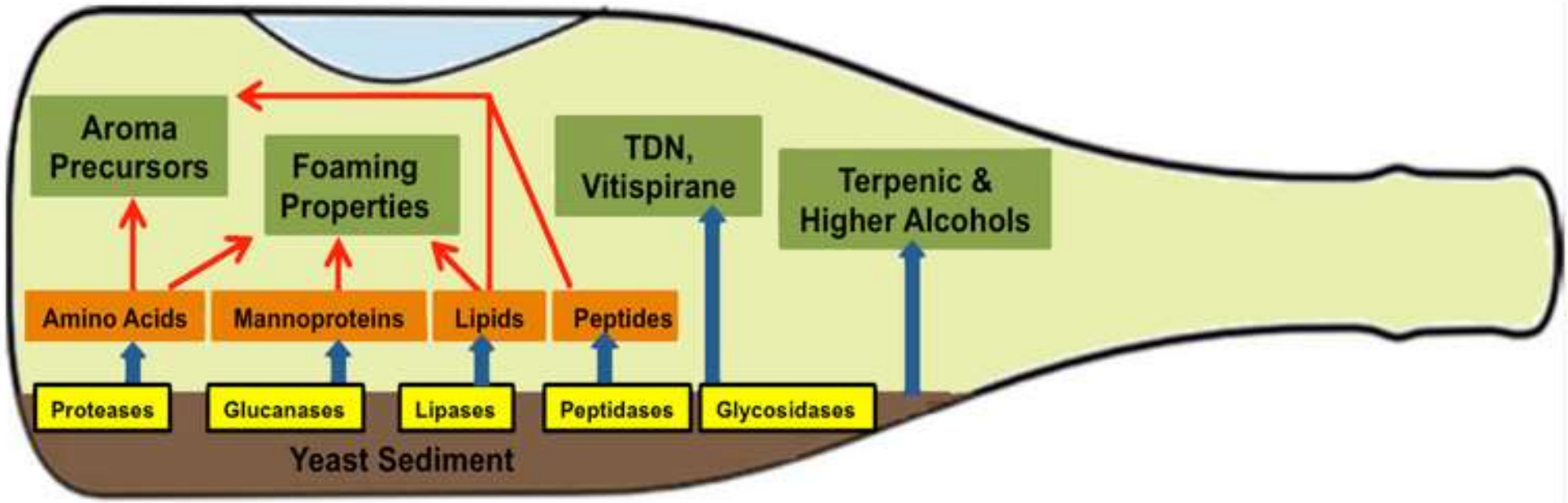


Image modified from: http://pubs.acs.org/doi/abs/10.1021/jf504268u Kemp et al 2015.

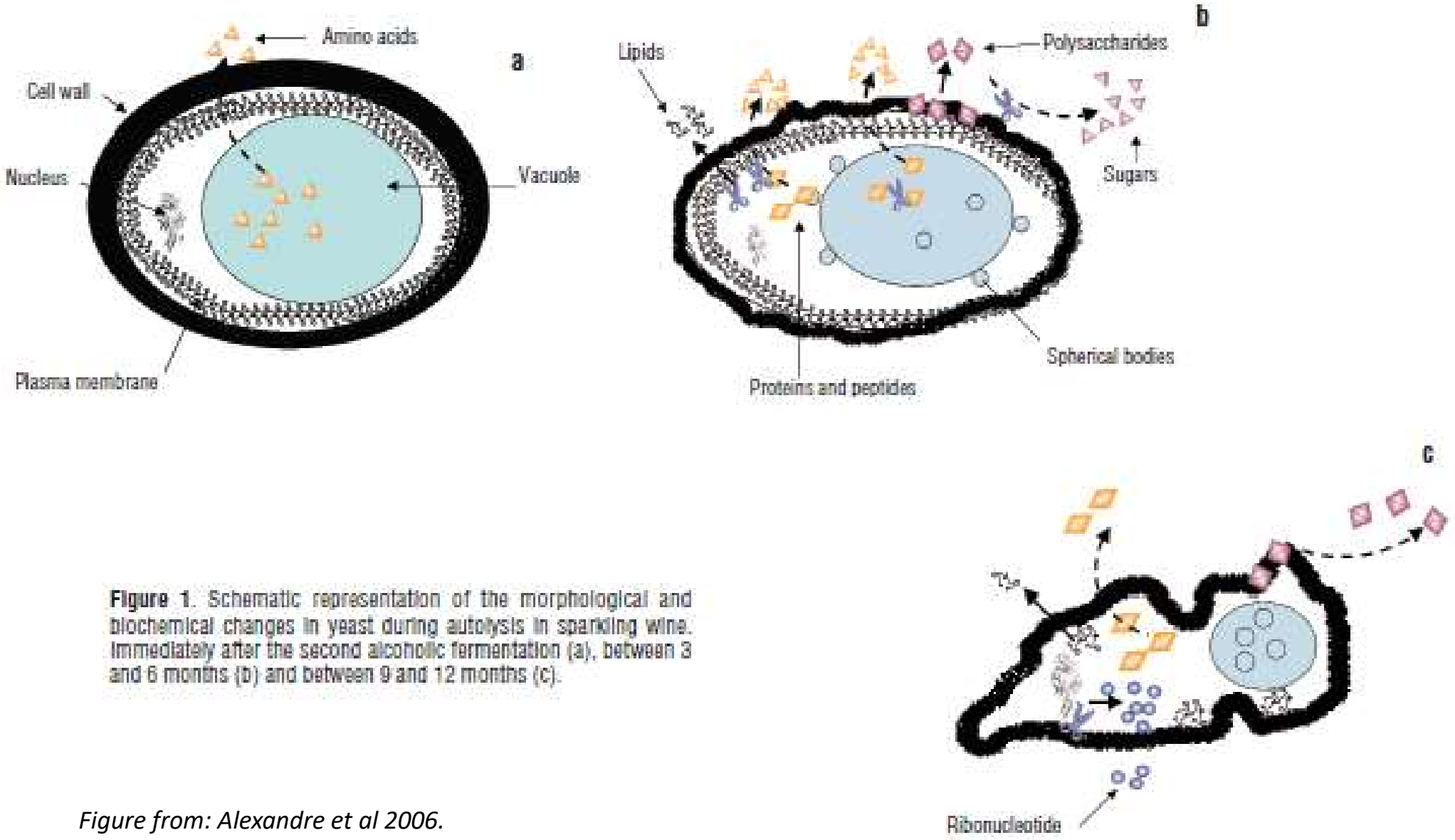
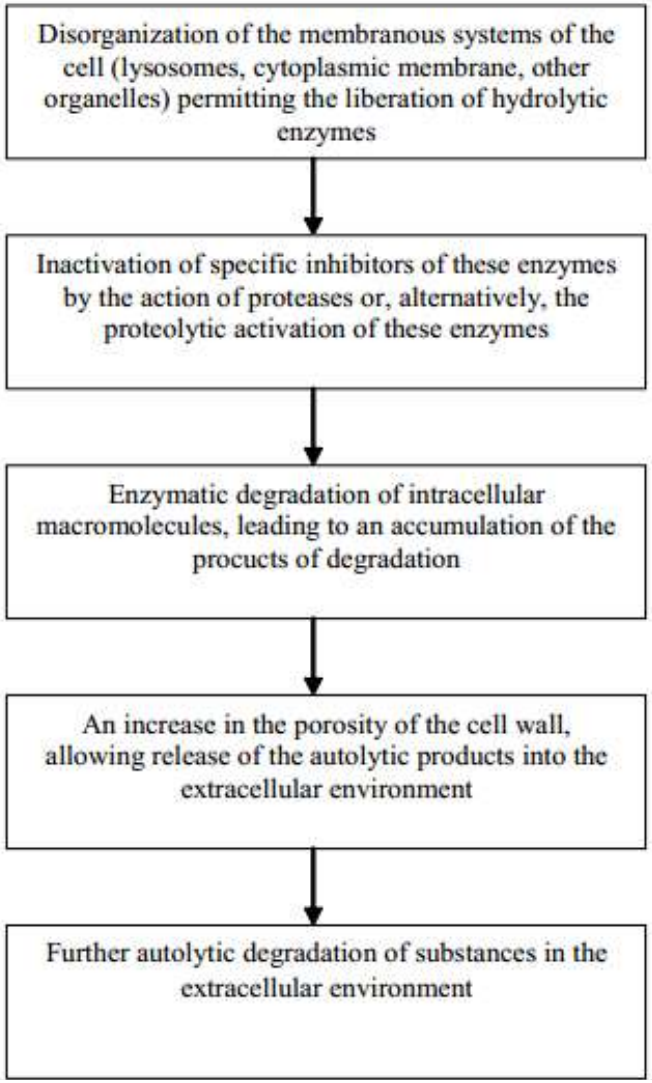


Figure 1. Schematic representation of the morphological and biochemical changes in yeast during autolysis in sparkling wine. Immediately after the second alcoholic fermentation (a), between 3 and 6 months (b) and between 9 and 12 months (c).

Figure from: Alexandre et al 2006.

Stages of the autolysis process (Charpentier and Feuillat, 1993)



Autolysis is affected by:

- % alcohol: acts as plasmolysing agent
- pH: higher pH favours quicker autolysis
- Temperature, higher temps cause increased speed, but interfere with natural ageing, so opt. 10 - 15°C
- Time. Very little autolysis for first few months after AF, then most significant increase in next six months.

Effects of autolysis on nitrogen compounds

- Nitrogen release is thought to reflect the autolytic activity of the yeast proteolytic activity in particular.
- At end of fermentation, peptides are released slowly back to the wine (between 6-12 months of autolysis) and are then degraded to amino acids
- The amount of peptides released by yeast autolysis during sparkling wine aging is variable and depends on grape variety and aging time (Moreno-Arribas et al 1998)
- With long ageing amino acid content decreases as they are used for the formation of higher alcohols, lactones as sotolon (celery, nutty flavour) which content increases (threonine precursors of sotolon formation) (Pham et al 1995)
- Foam effect: hydrophobicity of peptides might account for the foaming properties of sparkling wine. A few years later it was found that foam characteristics were positively correlated with the concentrations of most free amino acids and proteins

See Kemp et al JAFC 2015 for more details

Effects of autolysis on polysaccharides

- Polysaccharides deriving particularly from glucans degradation
- Mostly constituted by mannose and glucose
- Increase their content during ageing
- Important for foam stability of wines (Moreno-Arribas et al 2000), particularly neutral polysaccharides

See Kemp et al JAFC 2015 for more details (available on PoL)

Effects of autolysis on lipids

- Lipids are important constituents of sparkling wine as they contribute to:
  - flavour compounds development
  - affect foam stability (controversial effect, Maujean, et al., 1990, Pueyo, et al., 1995; Gallart, et al., 2002)
- Lipids concentration increases during pris de mousse (Troton, et al., 1989)

See Kemp et al JAFC 2015 for more details (available on PoL)

Effects of autolysis on volatiles

- Tertiary aromas develop during aging on lees
  - Terpenic alcohols and higher alcohols are also released during autolysis
  - cis & trans farnesol (sunflower)
  - Nerolidol (found in Champagne)
  - Several aldehydes found in sparkling, major is Methyl-3-Buthanal with 40% of the total) (nutty, toasty)
  - Acetates in Cava decrease during aging
  - Diethyl succinate, vitispirane, and 1,1,6-trimethyl-1,2-dihydronaphthalene (TDN) levels increased over time
  - Esters concentration decreases over time
  - Amino acids, proteins and lipids that act as surfactants.

See Kemp et al JAFC 2015 for more details

Table 1 *Yeast autolysis compounds affecting sparkling wines quality*

Autolysis compounds	Origin	Main characteristics affected by autolysis compounds	Average amount (mg l^{-1})
Nitrogen compounds: Proteins, Peptides, Amino acids	Yeast cell content	Organoleptic characteristics, Foam quality (Martínez-Rodriguez et al.,2003)	Proteins: 5-10 (Liger-Belair, 2005) Peptides (Ile–Arg, Arg–Ile, Ile–Val, Tyr–Lys) : < 10 (De Person et al., 2004) Amino acids: 0,8-2 (Liger-Belair, 2005)
Polysaccharides: Mannoproteins	Yeast cell wall, grapes	Mouthfeel, Yeast flocculation, Foam quality, Wine stability (Alexandre,and Guilloux-Benatier, 2006, Caridi, 2006)	≈ 200 (Liger-Belair, 2005)
Lipids and their derivatives: Fatty acids, Esters, Ketones, aldehydes	Yeast cell content	Foam quality, Flavour (Alexandre and Guilloux-Benatier, 2006)	≈ 10 (Liger-Belair, 2005)
Nucleic acids: 5'-UMP 5'-AMP 5'-GMP	Yeast cell content	Mouthfeel, Flavour (Charpentier et al., 2005)	5'-UMP ≈ 1.5 5'-AMP ≈ 0,2 5'-GMP ≈ 0,06 (Charpentier et al., 2005)
Volatile compounds: Esters, Terpenic alcohols, Higher alcohols, Aldehydes	Yeast Cell	Aromatic quality	Volatile organic compounds (VOC) ≈ 700 (Liger-Belair, 2005)

TABLE 1: Autolysates originating from within the yeast cell (Alexandre and Benatier, 2006)

Compound	Contribution to wine
Lipids	Foam quality
proteins	Foam quality and flavour
peptides	Aroma, flavour and foam quality
Amino acids	Aroma, flavour and foam quality
Nucleotides	Flavour
Nucleosides	Flavour

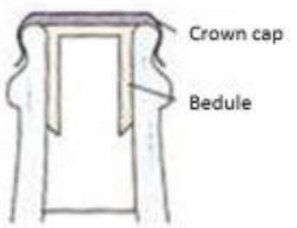
TABLE 2: Autolysates originating from the yeast cell wall (Alexandre and Benatier, 2006)

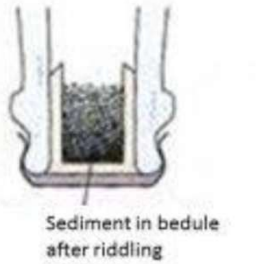
Compound	Contribution to wine
glucans	Foam quality
mannoproteins	Mouthfeel

What can be done to favour autolysis?

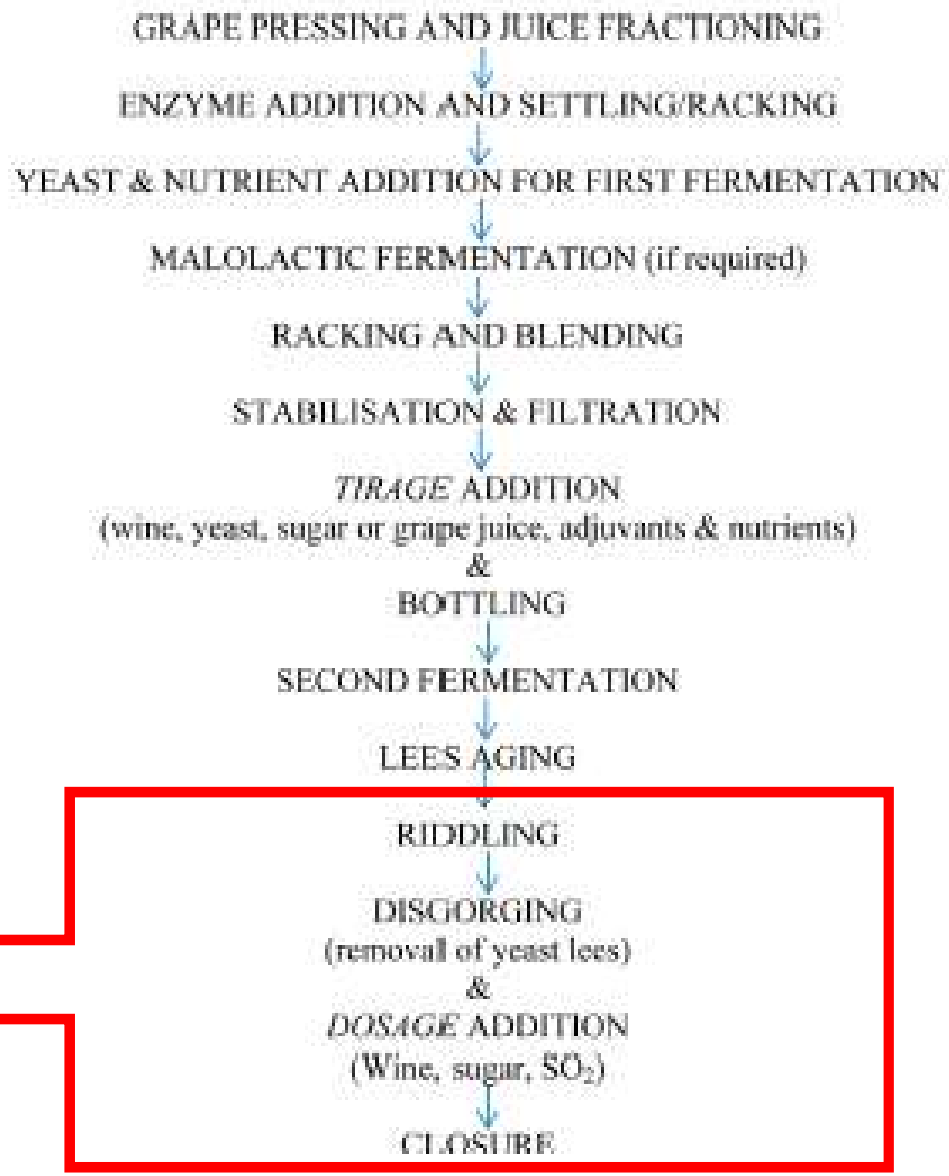
- Time on lees: perceived autolytic character is small in short ageing (9-15 months) and great in long ageing (3-5 years)
- Temperature: autolysis is an enzymatic process so low ageing temperatures are not encouraging a fast autolysis
- Addition of enzymes as β-glucanases to promote release of yeast cell wall material as mannoproteins
- Yeast strain: different strains have different behaviour during ageing
- Yeast biomass: quantity and size of yeast
- UV mutagenesis on Yeast cells to increase the quantity of polysaccharides and nitrogenous compounds released in wine during autolysis *(Gonzalez et al Int J of Food Microb 2003)*
- Addition of dead yeast cells at tirage to have autolysis at the end of 2nd ferment
- Use of killer strains of yeast alongside sensitive strains so one strain dies and starts autolysis while killer yeast completes fermentation *(Todd et al AJEV 2000)*

3. Riddling and Disgorging





Finishing


GRAPE PRESSING AND JUICE FRACTIONING
ENZYME ADDITION AND SETTLING/RACKING
YEAST & NUTRIENT ADDITION FOR FIRST FERMENTATION
MALOLACTIC FERMENTATION (if required)
RACKING AND BLENDING
STABILISATION & FILTRATION
TIRAGE ADDITION
(wine, yeast, sugar or grape juice, adjuvants & nutrients)
&
BOTTLING
SECOND FERMENTATION
LEES AGING
RIDDLING
DISGORGING
(removall of yeast lees)
&
DOSAGE ADDITION
(Wine, sugar, SO2)
CLOSURE

Riddling (rémuage)

- After sufficient ageing time on lees, riddling (rémuage) is carried out.
- Aim: to convey yeasts sediment into the bidule, facilitating lees removal during the subsequent disgorging process.

Traditional Method:

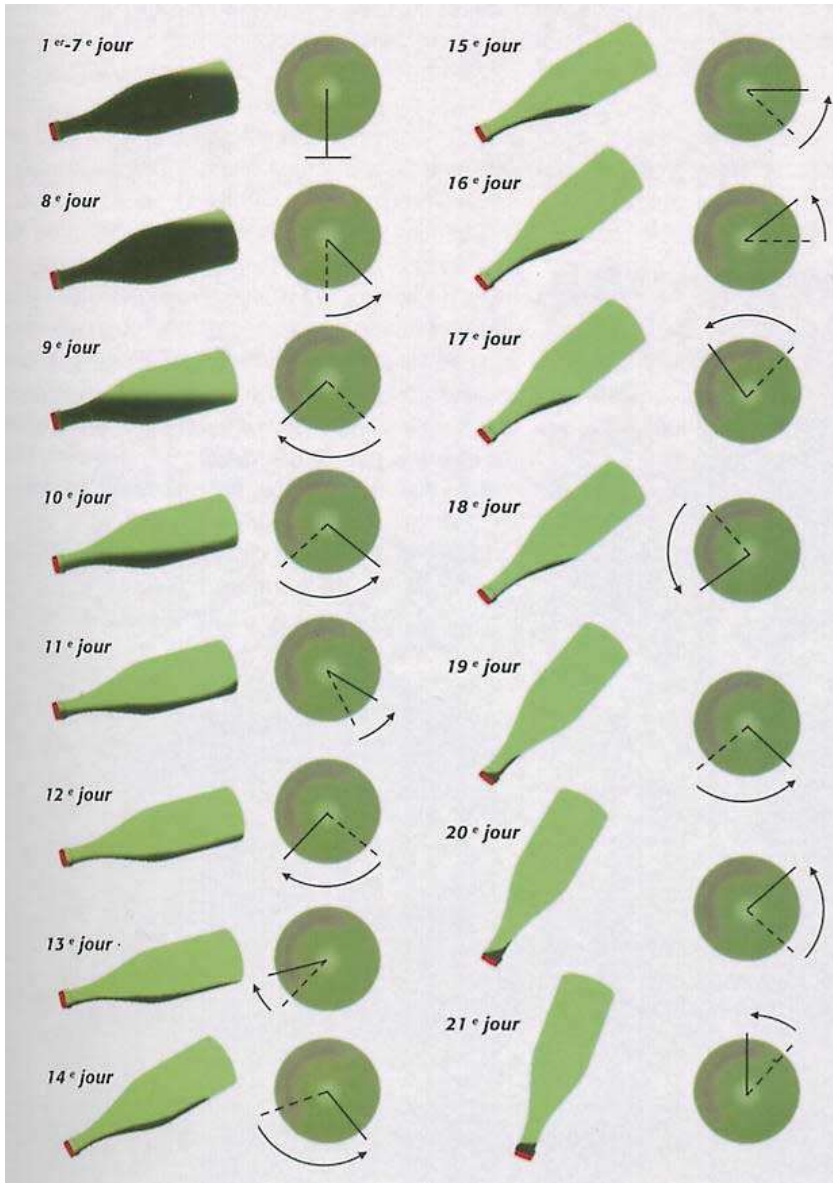
- By gravity slowly conveys the sediment to the neck of the bottle.
- Carried out with the bottles on pupitres, by shaking bottles before loading, and manually turning them 1/8 of a turn for about 4-8 weeks days and gradually increasing inclination until they were almost perpendicular to the floor.
- Twist, lift, slight shake, rattle & knock until yeast goes down into neck. Experienced riddlers can do 30 – 40,000 bottles a day.
- 1 month 'sur pointes' to allow plug to compact.
- Labour intensive, skilled and expensive.

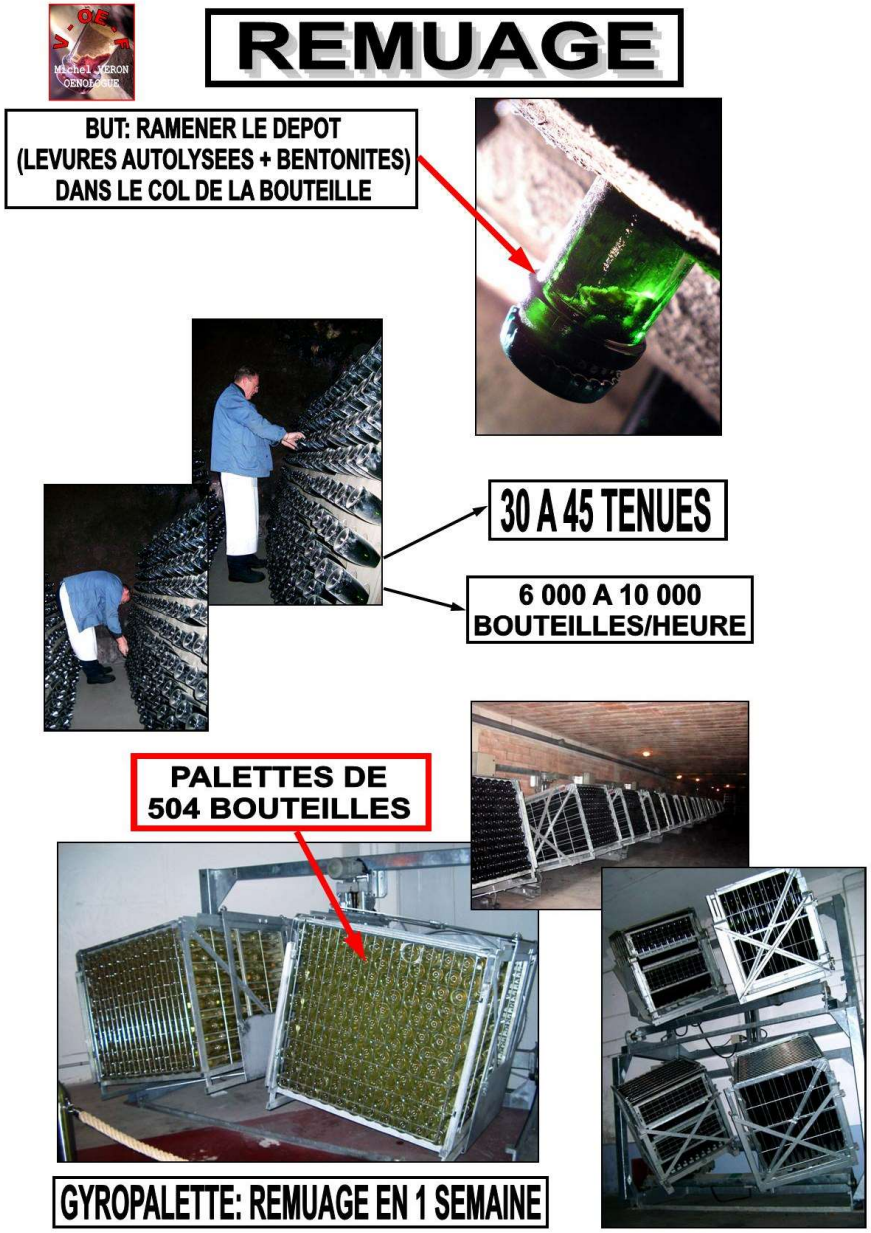
Remuage with Pupitre

Issues:

- Storage space occupied (bottles in pupitre occupy 30-40 times more space than stacked)
- Cost of labor
- Lapse time for bottles available for bottling

Remuage Stages





Gyropallete – Auto Remuage

https://www.youtube.com/watch?v=ZHQFKmFzDHs

- Now this method has been replaced by automated systems that can move all the bottles simultaneously.
- Mechanical gyro-palettes
- Bottles loaded into large cages (350 - 4000 bottles) & on to programmed machine.
- Much quicker, economical & space saving.

Dégorgement (disgorging)

- Removal of the lees from the bottle
- When the sediment has been completely conveyed into the bidule, bottles are disgorged (manually or automatically)
- This procedure is performed by inserting the neck of the bottle in a solution which freezes the sediment trapped in the bidule.
- The bidule helps to ensure that the yeast plug will be ejected uniformly and that no yeast residue will be left.
- Bottles are then placed neck-up, uncorked and the pressure within the bottle ejects both bidule and ice plug.
- Dosage is added to adjust sugar level and fill the bottle

Health and safety

When handling sparkling wine (at any point in the chain) it is always advisable to wear PPE:

- Safety Goggles – bottles can (and do!) explode and shatter, particularly during loading riddling cages and disgorging.
- Gloves – there is often broken glass in the stillage where the wine has been stored, and in the event a bottle breaks whilst being held gloves would be sensible. However, it is not usually possible to manually disgorge wearing gloves.
- It is also a good idea to stay out of the cellar in the 6 weeks after tirage bottling, and if you must enter, wear goggles and don't make load noises. Avoid taking tour groups through your cellar at this time as bottles may explode and shower them with glass.

Manual Disgorging (a la volée)

- Disgorging was traditionally done ‘a la volée’ but now almost always by neck freezing.
- Either in solution of brine, glycol or calcium chloride at -20°C for 8 - 10 min. Necks must be washed before disgorging

https://www.youtube.com/watch?v=GGHqMDZIlcs

DEGORGEMENT A LA GLACE

BAC A GLACE DE 180 BOUTEILLES

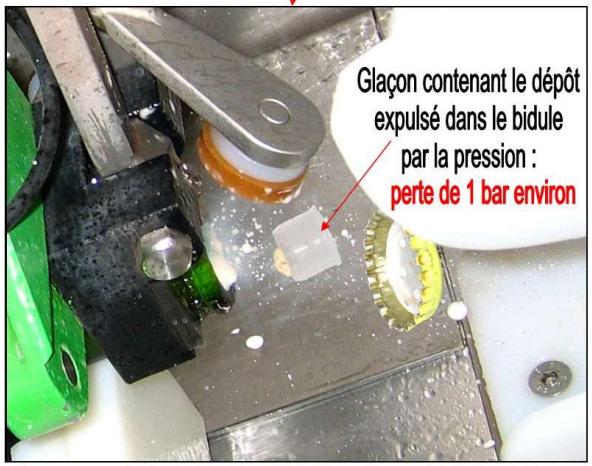
270 litres de monopropylene glycol à -24°C

Formation du glaçon en 10 minutes

Dépôt de levure emprisonné dans le glaçon

VERIFICATION DU GLACON

SORTIE DU RINCE-COLS



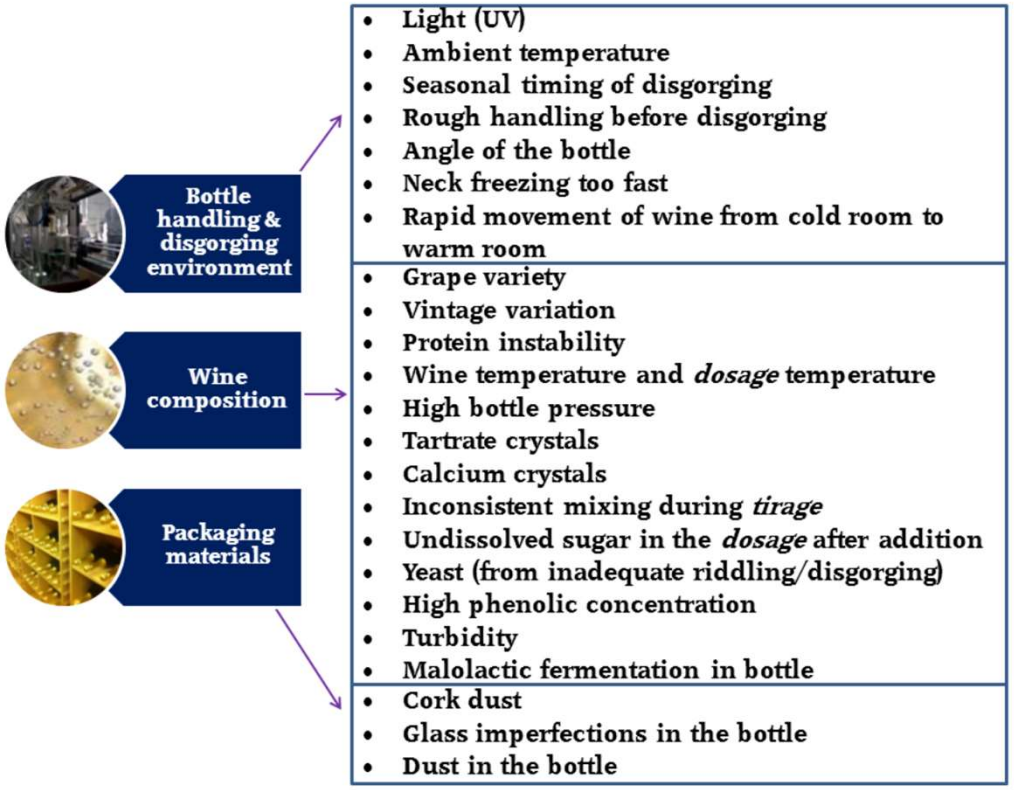
Neck Freezer

‘Automatic’ Disgorging line

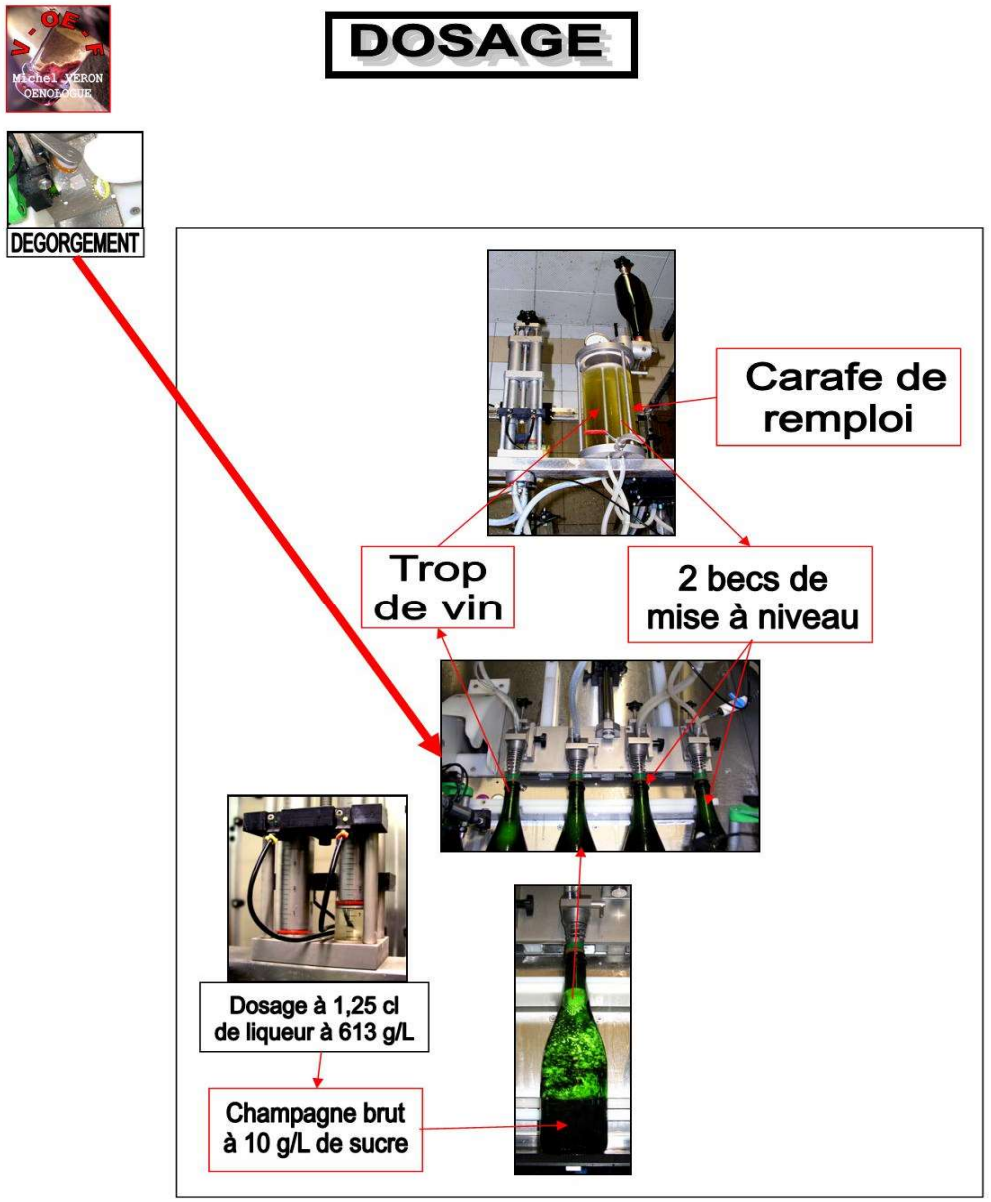
INDICATION OF THE SUGAR CONTENT

Terms	Conditions of use
PART A — **List of terms to be used for sparkling wine, aerated sparkling wine, quality sparkling wine or quality aromatic sparkling wine**	
brut nature, naturherb, bruto natural, pas dosé, dosage zéro, natūralusis briutas, īsts bruts, přírodně tvrdé, popolnoma suho, dosaggio zero, брют натюр, brut natur	If its sugar content is less than 3 grams per litre; these terms may be used only for products to which no sugar has been added after the secondary fermentation.
extra brut, extra herb, ekstra briutas, ekstra brut, ekstra bruts, zvláště tvrdé, extra bruto, izredno suho, ekstra wytrawne, екстра брют	If its sugar content is between 0 and 6 grams per litre.
brut, herb, briutas, bruts, tvrdé, bruto, zelo suho, bardzo wytrawne, брют	If its sugar content is less than 12 grams per litre.
extra dry, extra trocken, extra seco, labai sausas, ekstra kuiv, ekstra sausais, különlegesen száraz, wytrawne, suho, zvláště suché, extra suché, екстра сухо, extra sec, ekstra tør	If its sugar content is between 12 and 17 grams per litre.
sec, trocken, secco, asciutto, dry, tør, ξηρός, seco, torr, kuiva, sausas, kuiv, sausais, száraz, półwytrawne, polsuho, suché, сухо	If its sugar content is between 17 and 32 grams per litre.
demi-sec, halbtrocken, abboccato, medium dry, halvtør, ημίξηρος, semi seco, meio seco, halvtorr, puolikuiva, pusiau sausas, poolkuiv, pussausais, félszáraz, półsłodkie, polsladko, polosuché, polosladké, полусухо	If its sugar content is between 32 and 50 grams per litre.
doux, mild, dolce, sweet, sød, γλυκός, dulce, doce, söt, makea, saldus, magus, édes, helu, słodkie, sladko, sladké, сладко, dulce, saldais	If its sugar content is greater than 50 grams per litre.

Issues at disgorging



Dosage


DOSAGE
Michel VERON
OENOLOGUE
DEGORGEMENT
Carafe de remploi
Trop de vin
2 becs de mise à niveau
Dosage à 1,25 cl de liqueur à 613 g/L
Champagne brut à 10 g/L de sucre

What does dosage bring to the wine?

- Tops up headspace in the bottle after disgorging!!!
- Sugar/sweetness
- Acidity
- Alters flavour depending on wine style & % sugar used

- BALANCE
- Your definition of balance (non-wine terms) in English sparkling wine

What can be included in *dosage*?

- Wine
- (later press fractions, same wine as in bottle, still wines, oldest sparkling in winery, different sparkling wine, oaked wine, aged *dosage*…)
- Sugar
- Sulfur dioxide (SO2)
- Brandy
- Copper sulfate
- CMC / Metatartaric acid

Residual sugar (RS) Levels

- **Brut nature**, **zero-*dosage***, no added sugar: no more than 3 g/L RS
- **Extra brut**: 0-6 g/L RS
- **Brut**: 0-12 g/L RS
- **Extra dry**: between 12 and 17 g/L RS
- **Sec**: between 17 and 32 g/L RS
- **Demi sec**: between 32 and 50 g/L RS
- **Doux>** 50g/L RS

Choice of dosage liqueur

LIQUEUR made with WINE

- **Choice of wine + sugar important**

- ***Young and neutral wine*: neutral liqueur**
- ***Young and aromatic*: aromatic touch brought by liqueur**
- ***Aged wine*: will bring roundness and evolution**
- ***Barrel aged wine*: will bring a touch of wood**

LIQUEUR based on RECTIFIED GRAPE CONCENTRATE: *Different advantages:* Neutral and sterile, no need for filtration, consistency, adapts well to all styles of cuvees

Types of sugar

- **Corn syrup**
- **Beet sugar**
- **Pure sugar: Cane sugar/Sucrose (glucose & fructose)**
- **Glucose**
- **Fructose**
- **Dextrose**
- **Rectified concentrated grape must (RCGM)**
- **Clarified & filtered own grape juice**

Sugar influence on sparkling wine

- Corn syrup adds candied fruit character
- Beet sugar may impact palate especially during aging
- Sugar addition decelerates aging?
- Wines with glucose *dosage* had “green flavours” compared to sucrose added wines. *(McMahon, et al., 2017)*
- Sucrose & fructose wines rated higher than those with glucose added. *(McMahon, et al., 2017)*

Impact of CO_2 on aroma and flavour

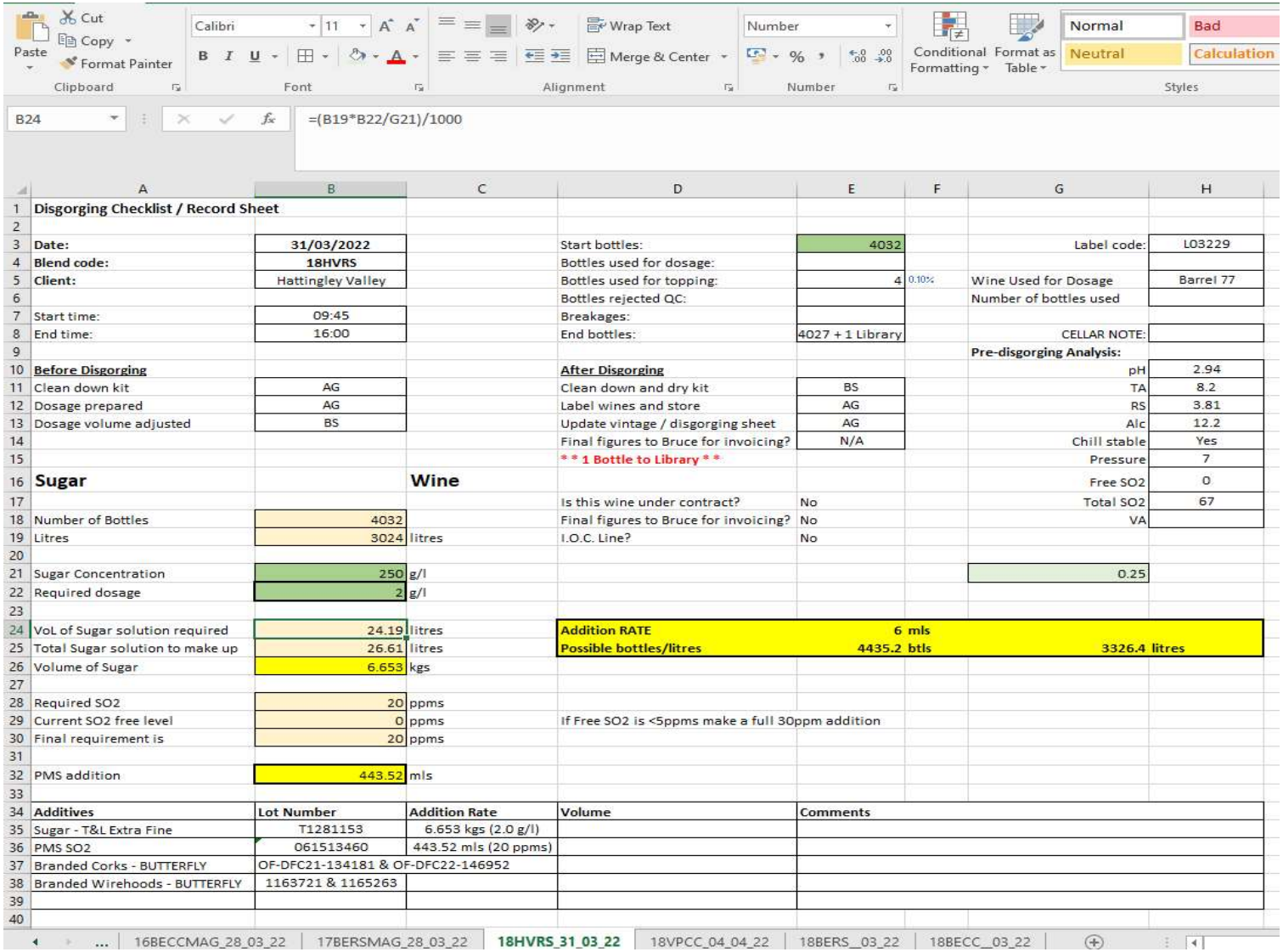
- CO_2 effect on sugar perception
- Sugar increases our perception of “fruitiness” in wines
- CO_2 overpressure mainly affects concentration of ethyl esters of organic acids. *(Martínez-Garcíaet al. 2017)*
- CO_2 increase sourness perception
- CO_2 reduces the perception of sweetness

Dosage calculations

- **Millilitres of *dosage* required = …mL**

$$\frac{\text{(Bottle volume mL) (Desired sugar level g/L)}}{\text{(Sugar concentration of stock solution)}}$$

Disgorging Calculations



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B24 =(B19*B22/G21)/1000

	A	B	C	D	E	F	G	H
1	**Disgorging Checklist / Record Sheet**							
2								
3	**Date:**	**31/03/2022**		Start bottles:	4032		Label code:	L03229
4	**Blend code:**	**18HVRS**		Bottles used for dosage:				
5	**Client:**	Hattingley Valley		Bottles used for topping:	4	0.10%	Wine Used for Dosage	Barrel 77
6				Bottles rejected QC:			Number of bottles used	
7	Start time:	09:45		Breakages:				
8	End time:	16:00		End bottles:	4027 + 1 Library		CELLAR NOTE:	
9							**Pre-disgorging Analysis:**	
10	**Before Disgorging**			**After Disgorging**			pH	2.94
11	Clean down kit	AG		Clean down and dry kit	BS		TA	8.2
12	Dosage prepared	AG		Label wines and store	AG		RS	3.81
13	Dosage volume adjusted	BS		Update vintage / disgorging sheet	AG		Alc	12.2
14				Final figures to Bruce for invoicing?	N/A		Chill stable	Yes
15				* * 1 Bottle to Library * *			Pressure	7
16	**Sugar**		**Wine**				Free SO2	0
17				Is this wine under contract?	No		Total SO2	67
18	Number of Bottles	4032		Final figures to Bruce for invoicing?	No		VA	
19	Litres	3024	litres	I.O.C. Line?	No			
20								
21	Sugar Concentration	250	g/l				0.25	
22	Required dosage	2	g/l					
23								
24	VoL of Sugar solution required	24.19	litres	**Addition RATE**	**6 mls**			
25	Total Sugar solution to make up	26.61	litres	**Possible bottles/litres**	**4435.2 btls**		**3326.4 litres**	
26	Volume of Sugar	6.653	kgs					
27								
28	Required SO2	20	ppms					
29	Current SO2 free level	0	ppms	If Free SO2 is <5ppms make a full 30ppm addition				
30	Final requirement is	20	ppms					
31								
32	PMS addition	443.52	mls					
33								
34	**Additives**	**Lot Number**	**Addition Rate**	**Volume**	**Comments**			
35	Sugar - T&L Extra Fine	T1281153	6.653 kgs (2.0 g/l)					
36	PMS SO2	061513460	443.52 mls (20 ppms)					
37	Branded Corks - BUTTERFLY	OF-DFC21-134181 & OF-DFC22-146952						
38	Branded Wirehoods - BUTTERFLY	1163721 & 1165263						
39								
40								

... | 16BECCMAG_28_03_22 | 17BERSMAG_28_03_22 | **18HVRS_31_03_22** | 18VPCC_04_04_22 | 18BERS__03_22 | 18BECC__03_22

Bottling handling and disgorging environment	Ensure neck freezing, lees removal and dosage addition is not under UV lighting. Cover all windows and close doors to remove natural sunlight from entering the room.
	A warm room of 15° C with cold wine of 10° – 12° C will result in gushing. Aim for an ambient temperature and wine temperature of 12° C.
	Avoid disgorging in winter due to extremely low temperatures or in the middle of summer if the wine has to be moved from a different building or the disgorging area does not have temperature control. Allow time for the wine temperature to adjust between rooms with different temperatures.
	Careful handling of each bottle prior to disgorging out of UV lighting and with as little movement as possible.
	Ensure each bottle is at an angle when being disgorged and dosage is added. Most machines now have this built in to prevent dosage entering straight down into the bottle and to allow it to slide down the side of the bottle.
	As part of the quality-control program, check that the sediment plug in the neck of the bottle is firm prior to opening.
Wine composition	Vintage variation and grape variety will impact gushing potential, but reducing its frequency can be achieved using techniques below.
	Ensure wine temperature, dosage temperature and ambient temperature are 12° C where possible (or at least the same temperature).
	Ensure bottle pressure is 6 atm or below. Check accuracy of sugar levels in relation to the desired pressure prior to *tirage* addition at bottling.
	While there are other options for stabilization if cold stabilizing is chosen, seed the wine with a crystalline tartrate (potassium or calcium or combination) at -4° C.
	Ensure sugar has completely dissolved in the base wine and the *liqueur de tirage* before bottling it by constant tank stirring during bottling.
	Ensure sugar is completely dissolved in the dosage or use sterile filtered grape juice or liquid sugar if available at the correct sugar concentration prior to neck freezing and lees removal.
	Ensure yeast for second fermentation has good flocculating ability. Consider using an adjuvant and check that the riddling program has moved all sediment to the cap.
	Ensure adequate time is allowed for each bottle in the neck freezer for yeast lees to freeze. Check that the lees plug is firm.
	Reduce phenolic compounds from juice prior to first fermentation for white sparkling wine. Ensure that wine with high phenolic content (rosé and red wines) is riddled, neck frozen and lees removed at low temperatures under low light where possible.
	If MLF has not been conducted or is not required then consider sterile filtration of the base wine before bottling, ensure that the storage temperature for second fermentation is low.
Packaging materials	Bottle quality control: bottle design, shrink-wrapped, sterility and glass color.
	Cork quality control: Quality cork, dust-free corks and consider cork options.

Table 4. Remedial checklist for sparkling winemakers

Kemp et al. (2015).

Corking

- Corks are composites with 2 or 3 pieces of natural cork. However Mytik is becoming more commonly used
- Can be coated with silicon or paraffin wax.
- Wire muzzles (muselet) should be used.
- Bottles are well mixed
- Wires generally need 1 month ‘pour le marriage’ to allow flavours to develop and liquer to integrate. 3 months is optimum.

- https://www.youtube.com/watch?v=AEJG45N-quU
- http://plumptonwinery.tumblr.com/post/149644597428/technical-elements-in-sparkling-wine-stopper
- https://www.youtube.com/watch?v=Fy3QBPU1g6g&feature=em-upload_owner&noredirect=1

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