

The Influence of Different Dry Hopping Methods on the Flavour Stability of Dry Hopped Beers

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Trial Number	1-s	2-s-y	3-d	4-d-y	5-s-p	6-s-y-p
Dry Hopped	static	Static	dynamic	dynamic	static	static
Yeast	no	yes	no	yes	no	yes
Pasteurized	no	no	no	no	yes	yes
Trial Number	7-d-p	8-d-y-p	9	10-p	11-y	12-y-p
Dry Hopped	dynamic	dynamic	no	no	no	no
Yeast	no	yes	no	no	yes	yes
Pasteurized	yes	yes	no	yes	no	yes

- Base beer: Bitburger Pils (11.7°P, 5.0 ABV, 36 IBU, no distinct hop aroma)
- Yeast was removed by a centrifuge
- Dynamic dry hopping was completed after 8 hour circulation
- Static dry hopping – 1 week contact time
- No further filtration
- Hop variety used Hallertau Mittelfrueh, at 250 g/hl

Analytical Values of the Beers

Trial Number		1-s	2-s-y	3-d	4-d-y	5-s-p	6-s-y-p
Apparent attenuation	%	80,7	80,8	80,6	80,6	80,6	80,9
Alcohol (vol.)	%	5,01	5,01	5,01	5,01	5,00	5,01
Original Gravity	%	11,72	11,70	11,73	11,74	11,70	11,70
pH		4,52	4,46	4,52	4,51	4,52	4,47
Bitterness Units	EBC	41	39	42	42	43	38
Foam (Nibem)	s	311	280	283	262	276	303
Polyphenols	mg/L	231	213	228	228	230	218
Anthocyanogens	mg/L	124	121	118	121	117	120

- Increased BU values between 2-7
- Foam was lower in dry hopped beers
- Increased polyphenol and anthocyanogen content in dry hopped beers

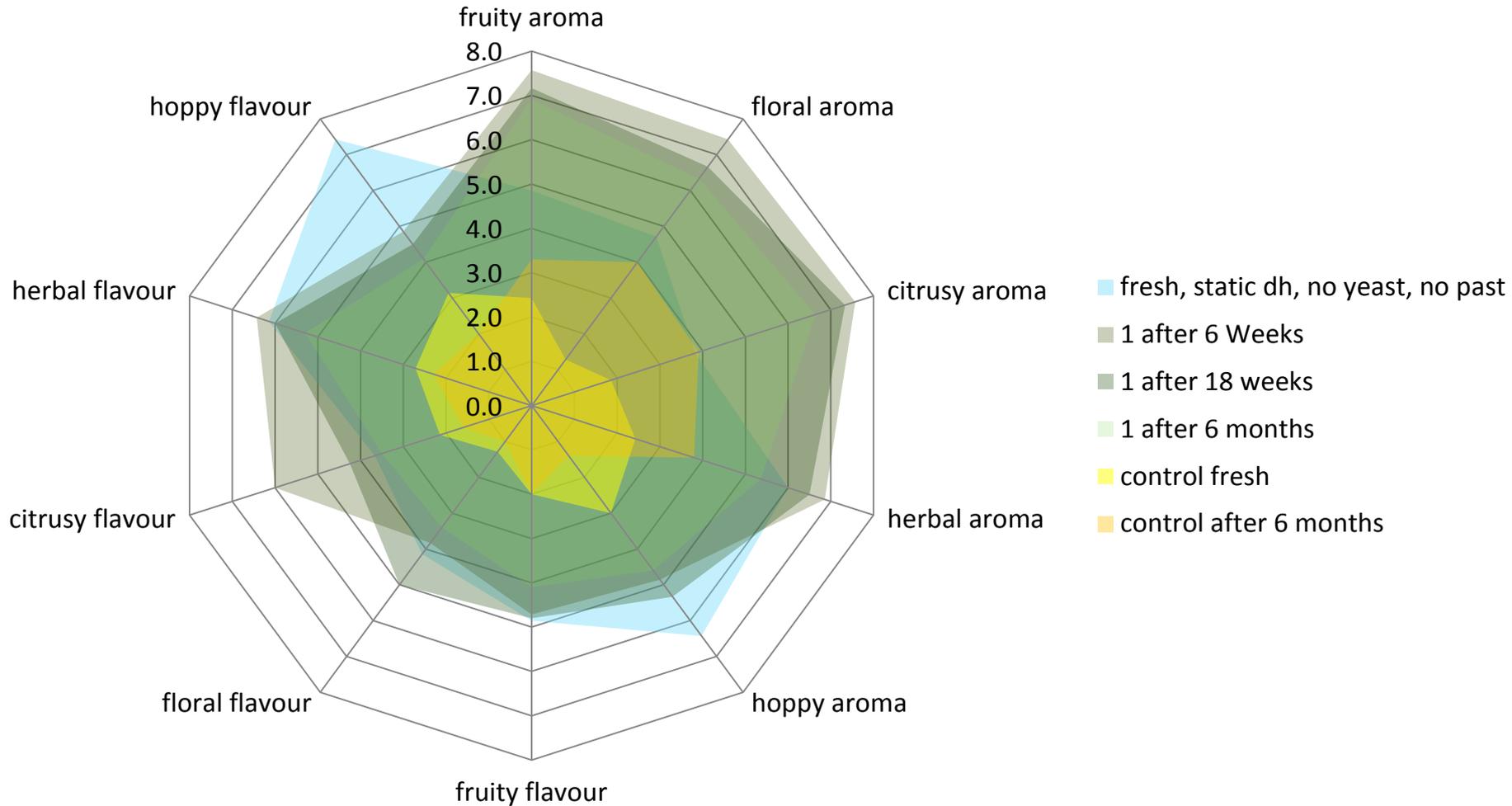
Analytical Values of the Beers

Trial Number		7-d-p	8-d-y-p	9	10-p	11-y	12-y-p
Apparent attenuation	%	80,6	80,6	81,1	81,1	81,1	81,0
Alcohol (vol.)	%	5,01	5,01	5,03	5,03	5,03	5,01
Original Gravity	%	11,74	11,72	11,69	11,68	11,68	11,66
pH		4,52	4,52	4,46	4,47	4,46	4,46
Bitterness Units	EBC	42	42	36	36	36	36
Foam (Nibem)	s	257	242	317	316	317	317
Polyphenols	mg/L	231	220	197	199	199	199
Anthocyanogens	mg/l	116	116	98	101	101	107

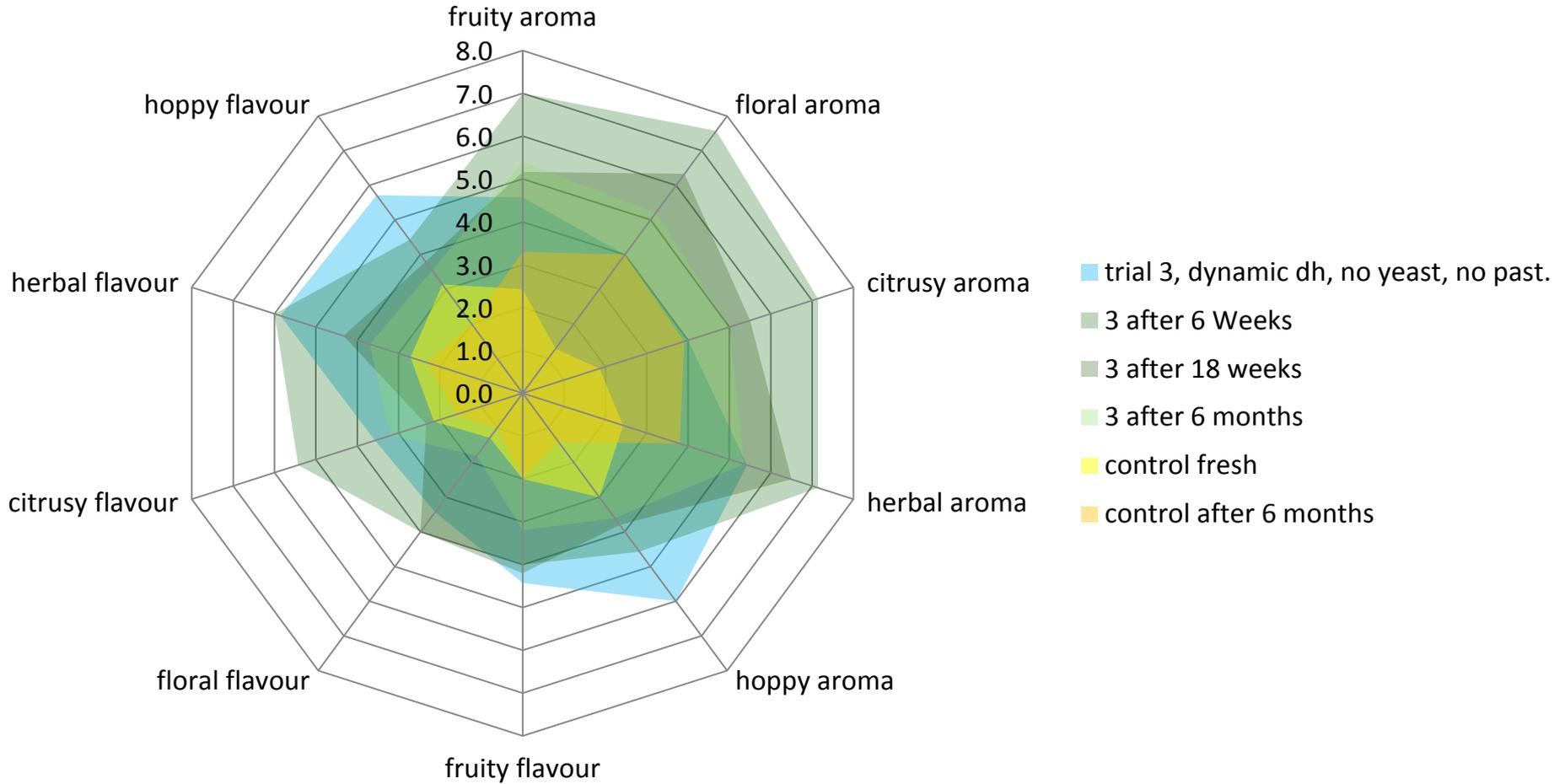
Static vs. Dynamic

(no yeast, no past.)

Static vs. Dynamic – No Yeast or Past.

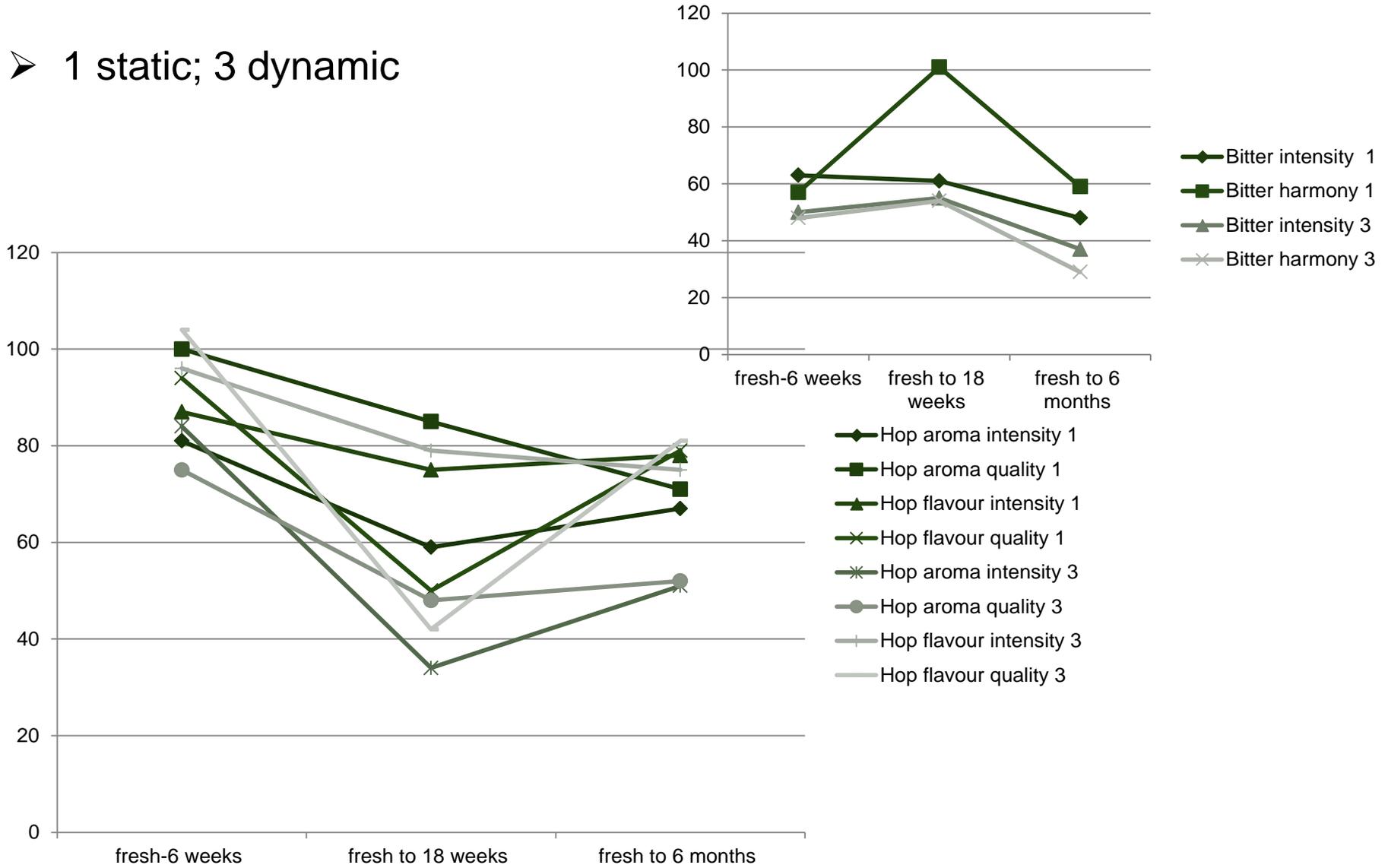


Static vs. Dynamic – No Yeast or Past.

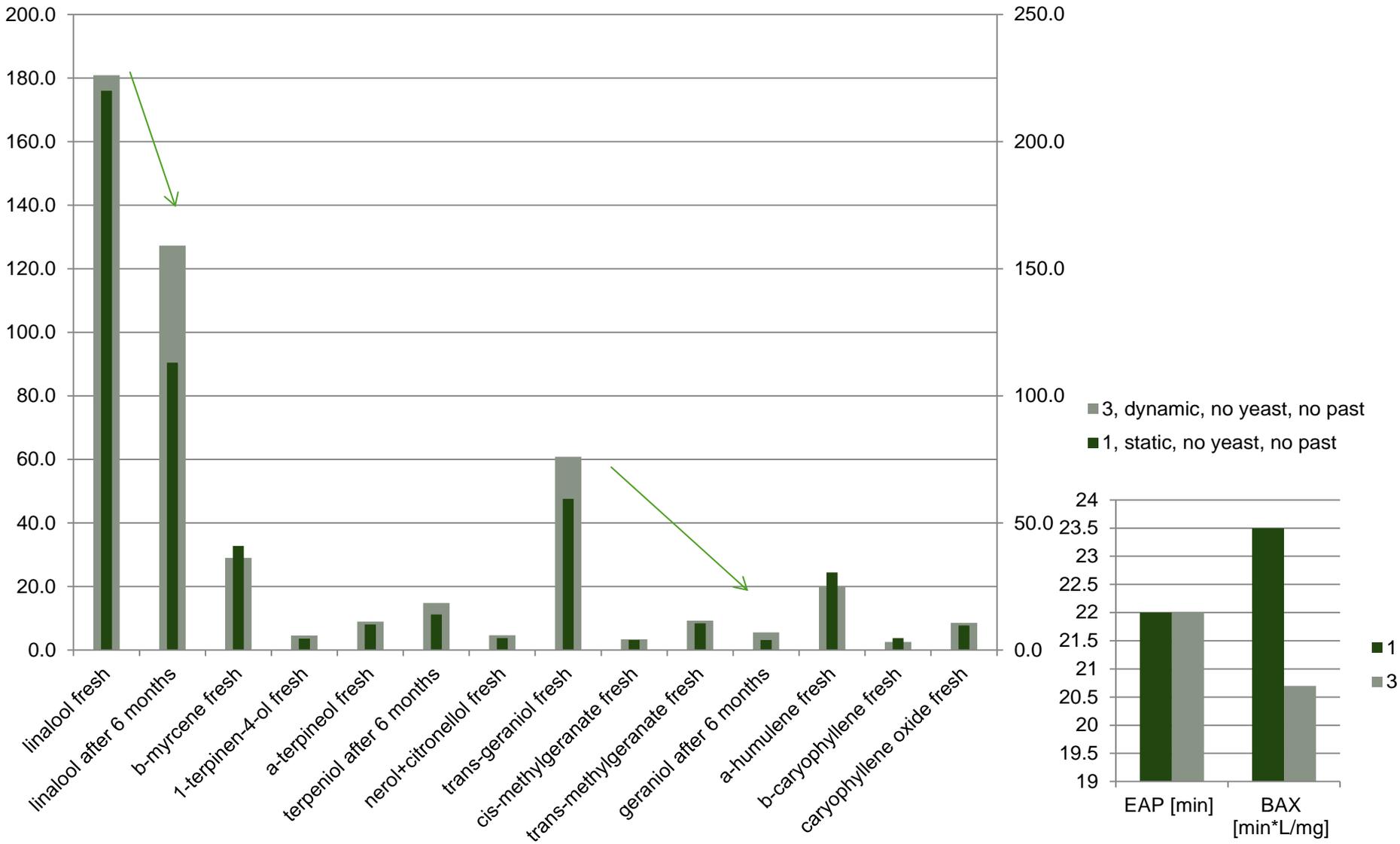


Loss of aroma, flavour and bitterness

➤ 1 static; 3 dynamic

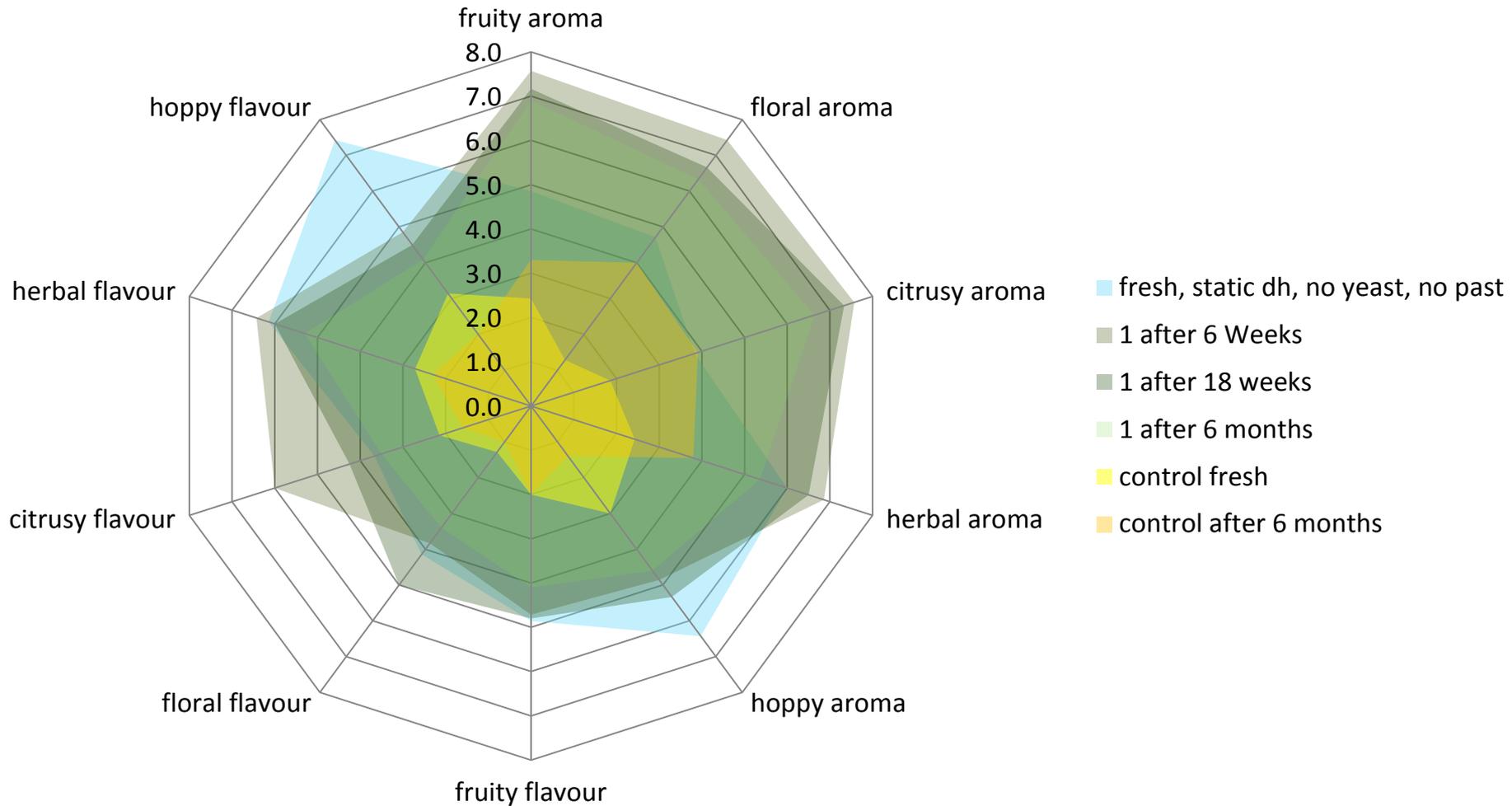


Hop oil components and stability..

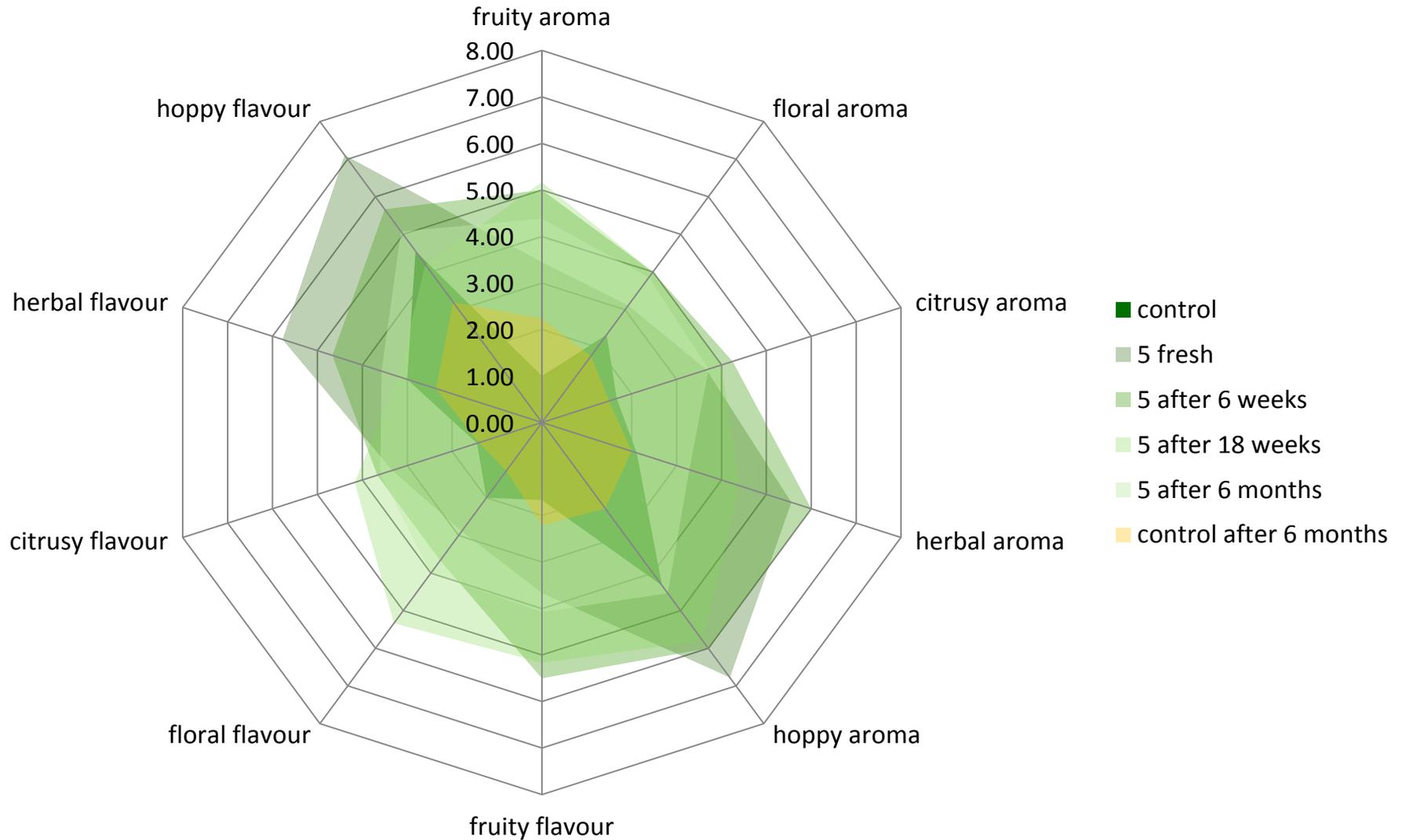


Past vs. no past (static, no yeast.)

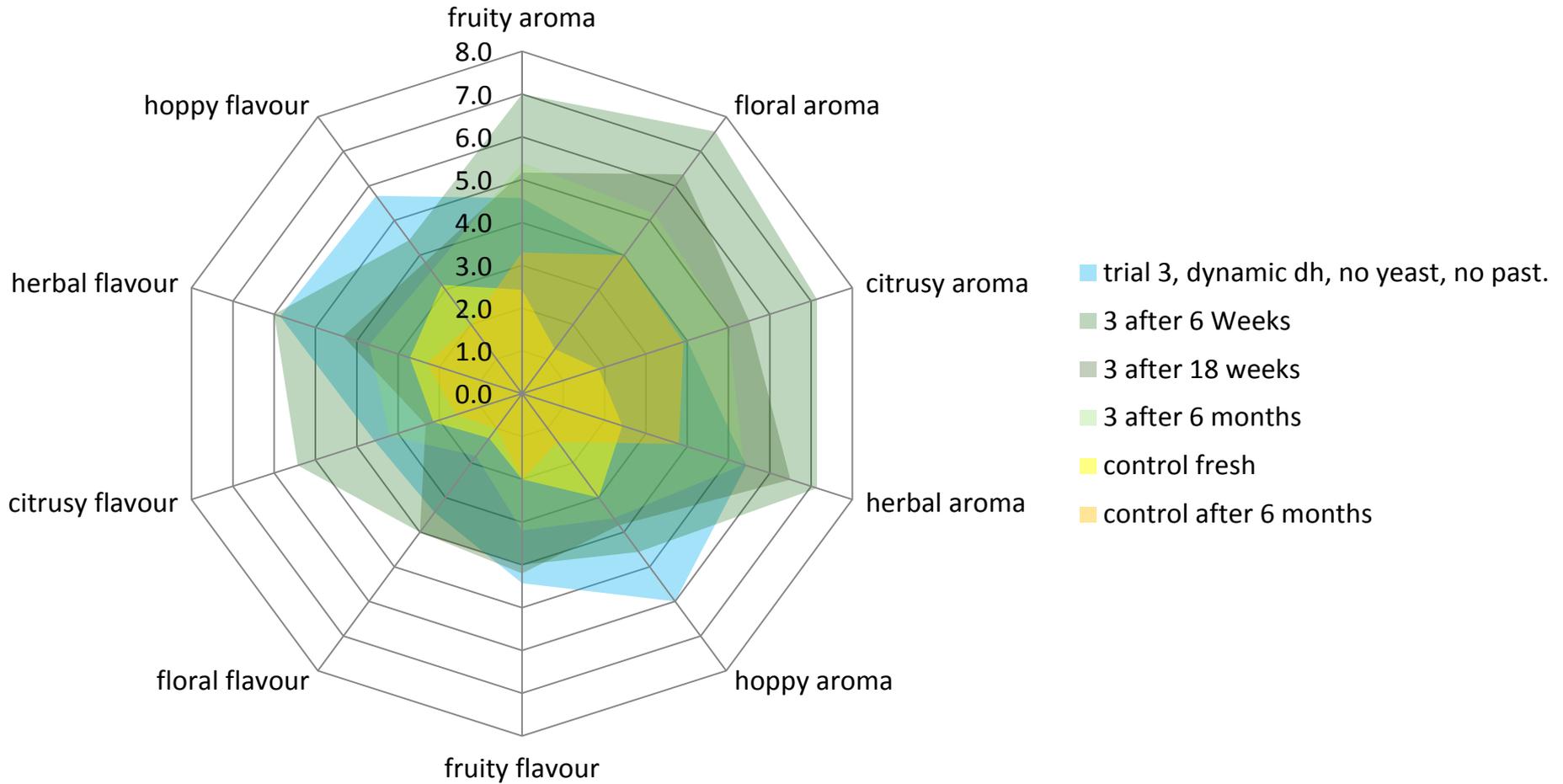
No pasteurization, static, no yeast,



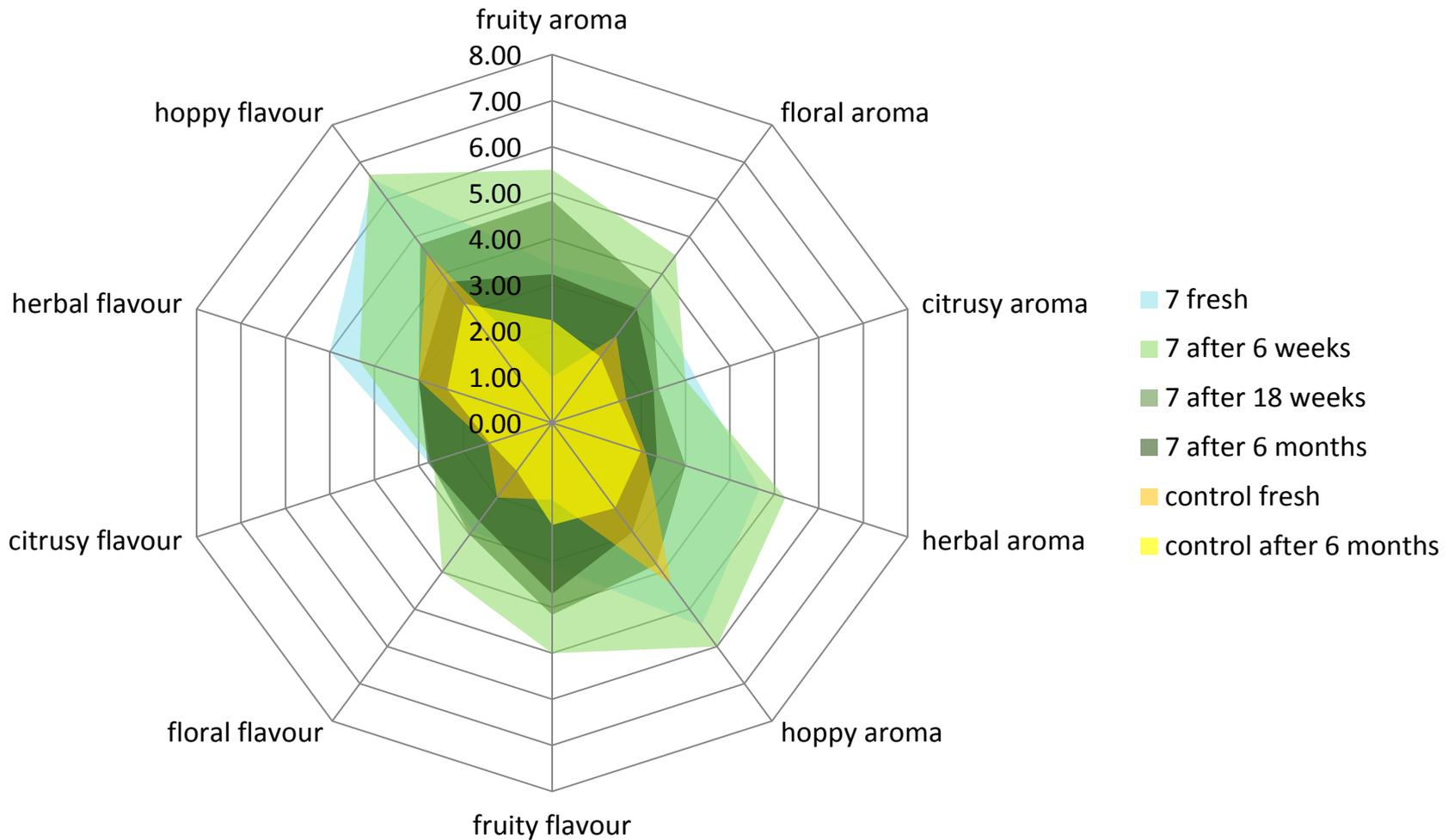
Pasteurized, static, no yeast



No pasteurization, dynamic, no yeast

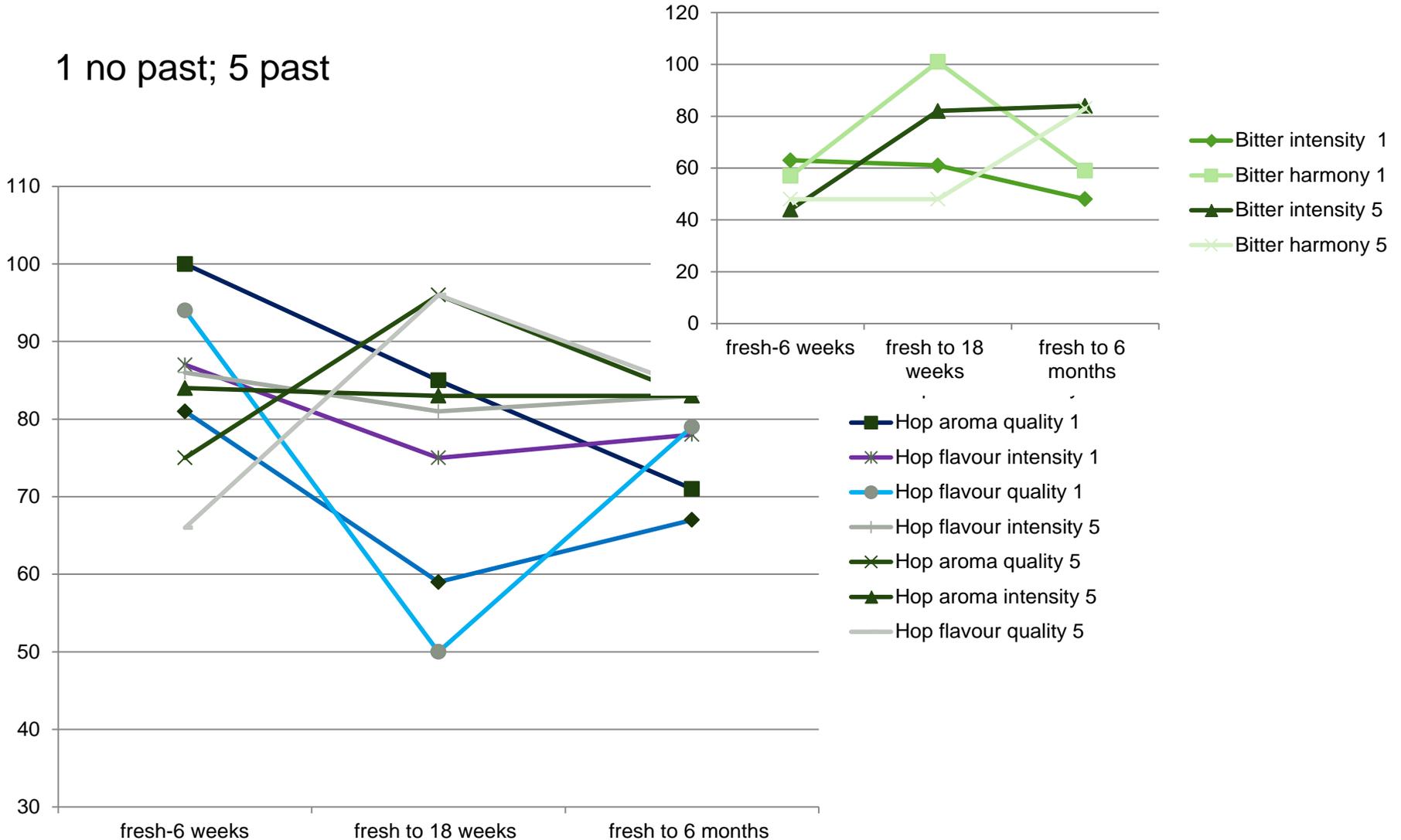


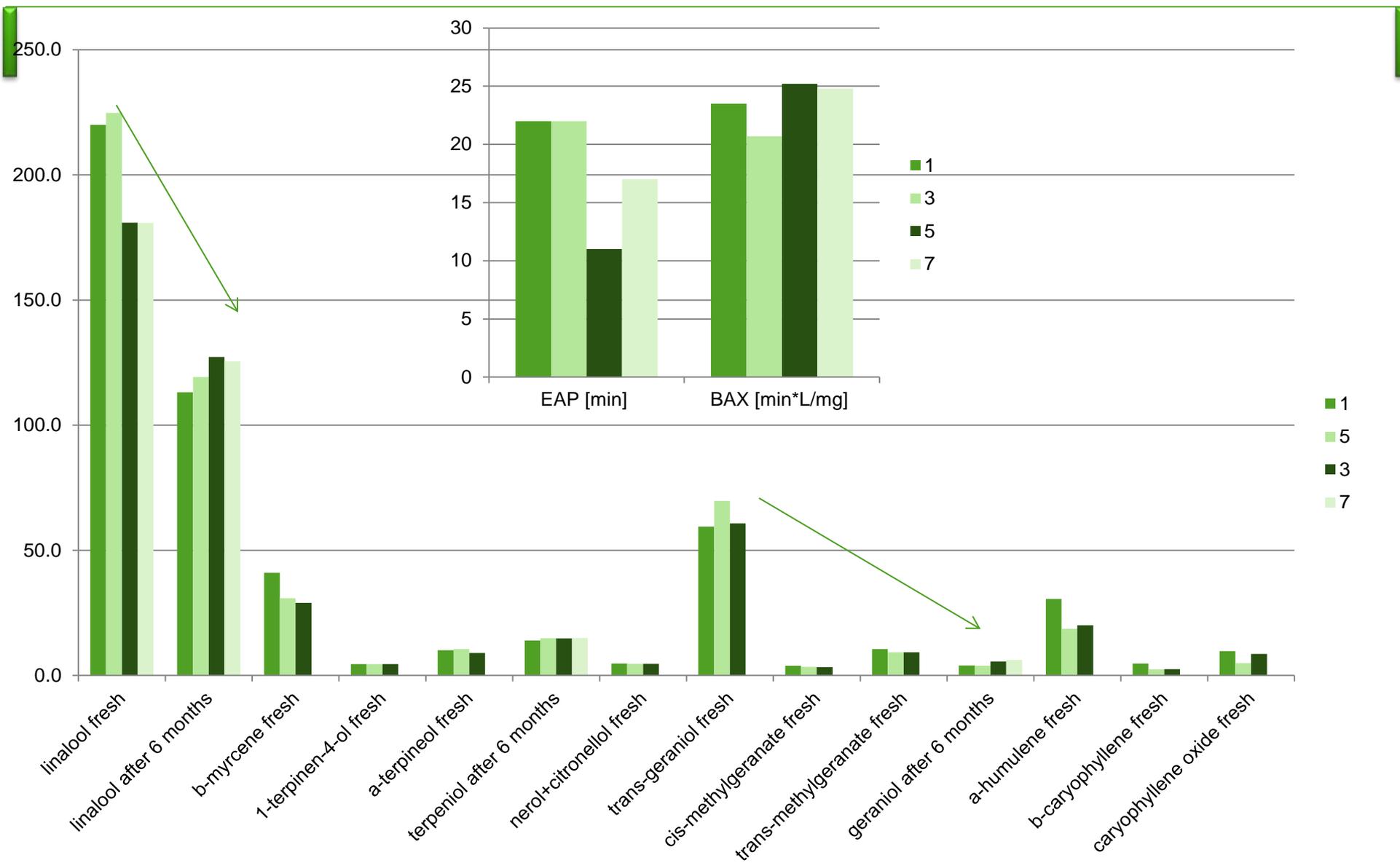
Pasteurized, dynamic, no yeast



Loss of aroma, flavour and bitterness – No past vs. past – static dry hopping

1 no past; 5 past

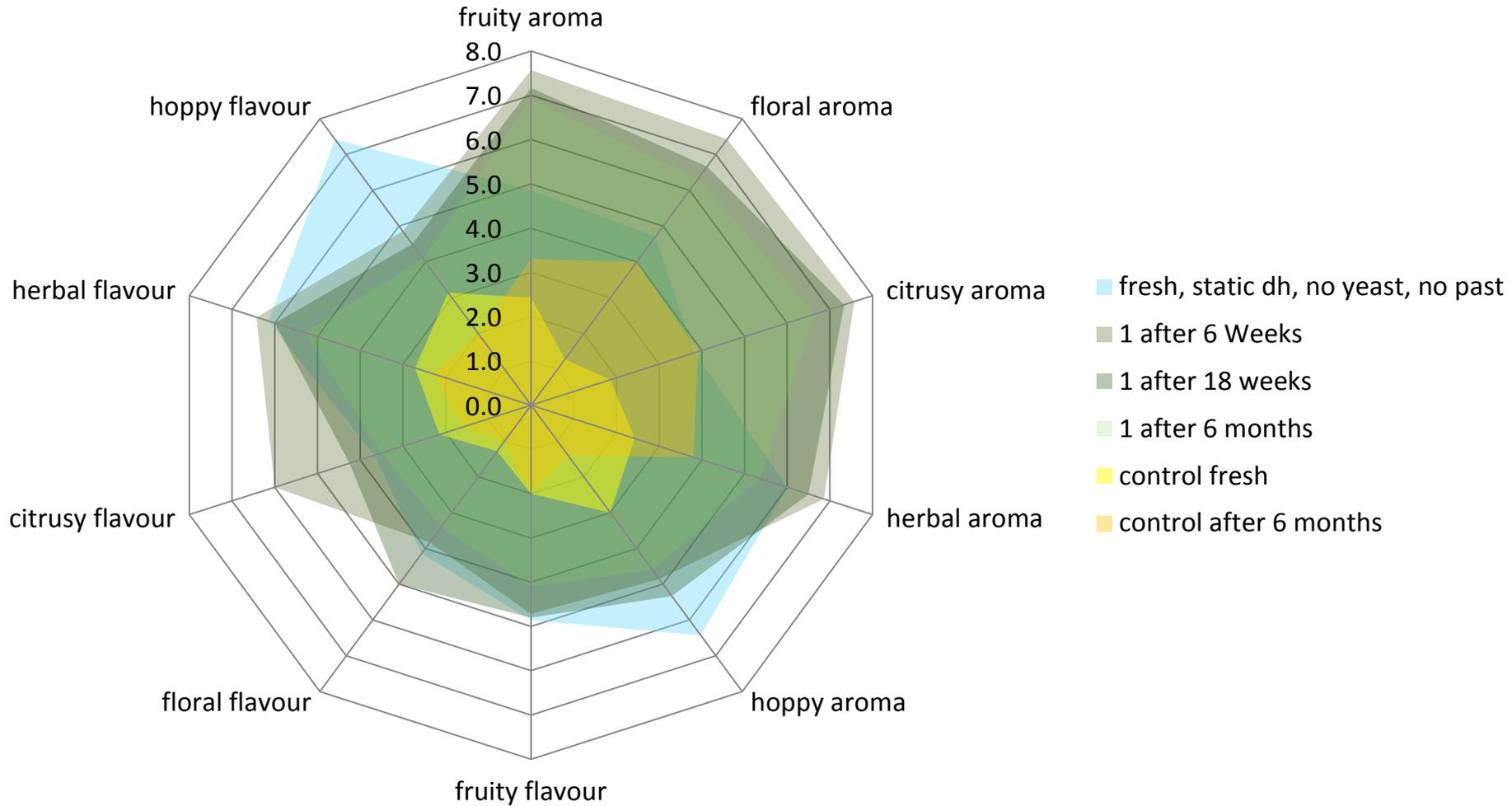


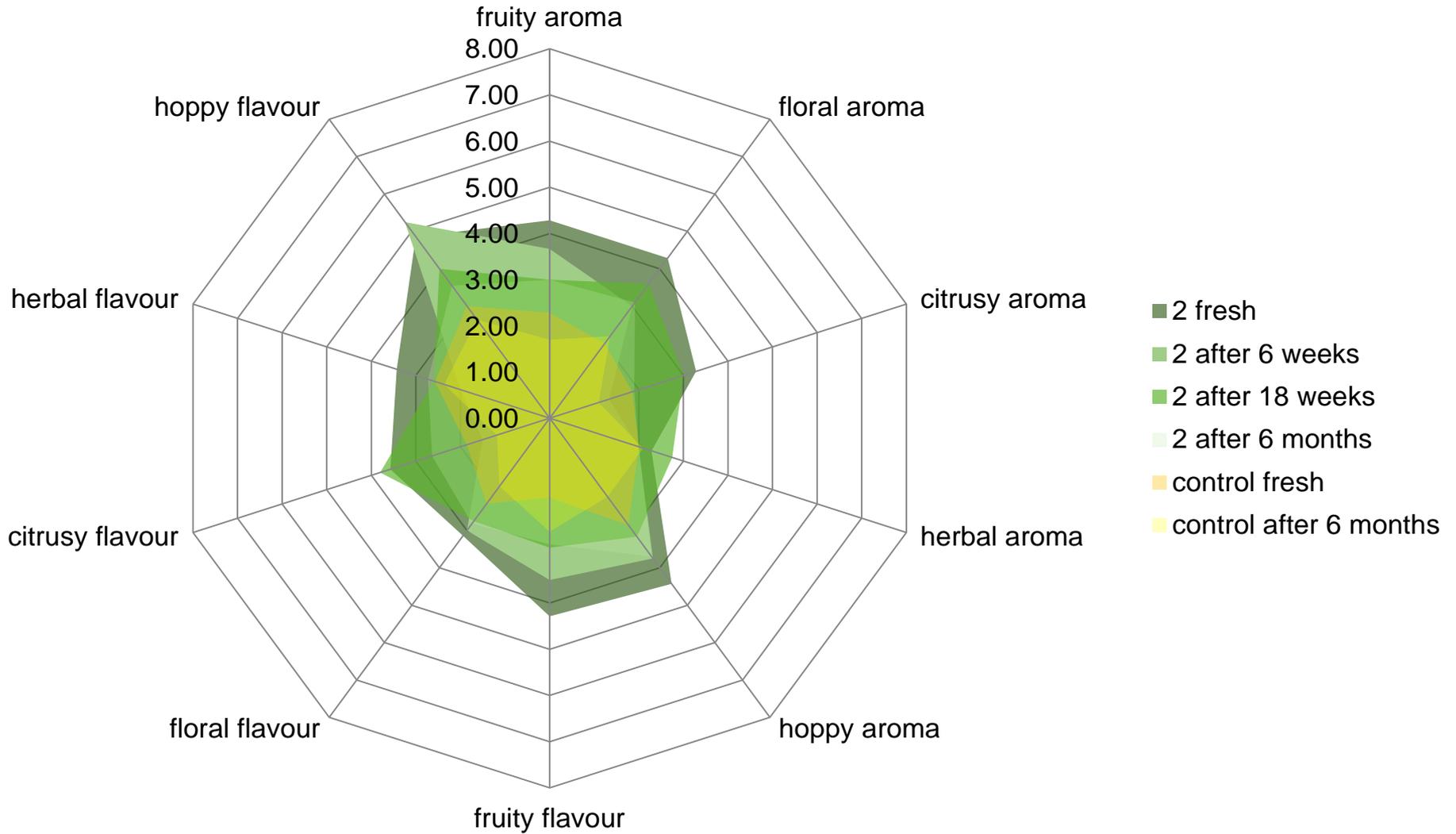


With yeast vs. no yeast

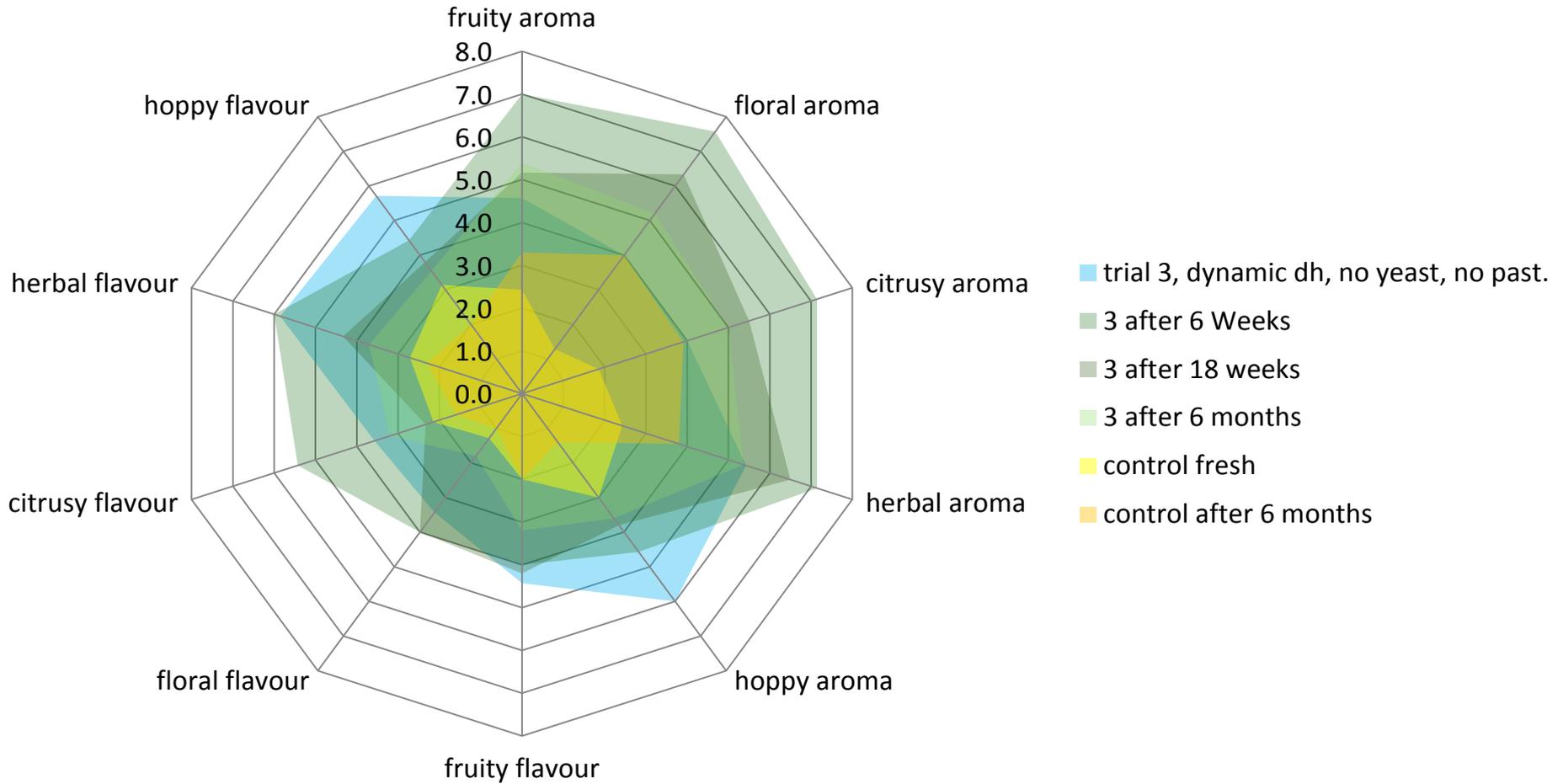
(static, no past.)

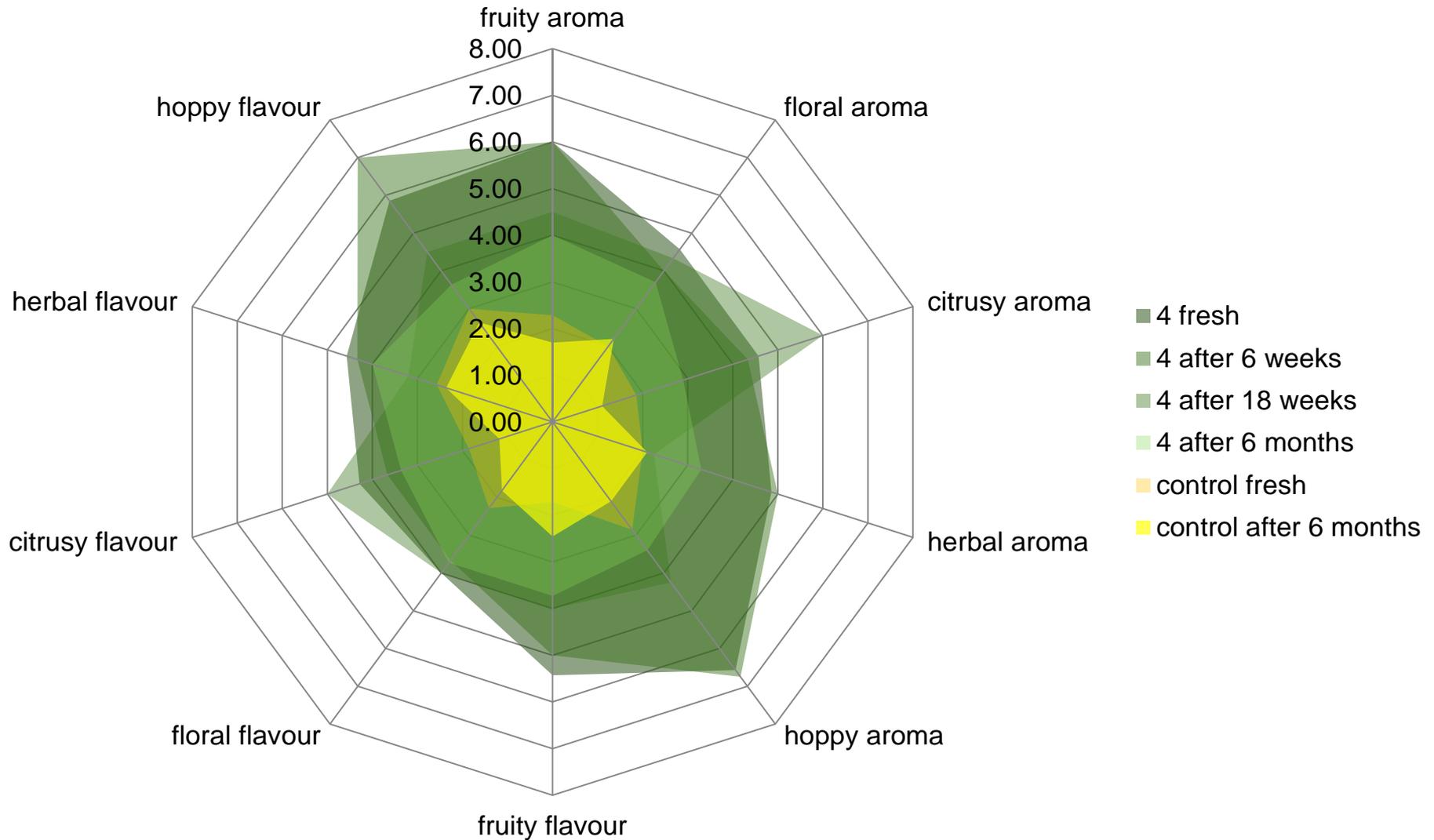
No yeast, static, no past





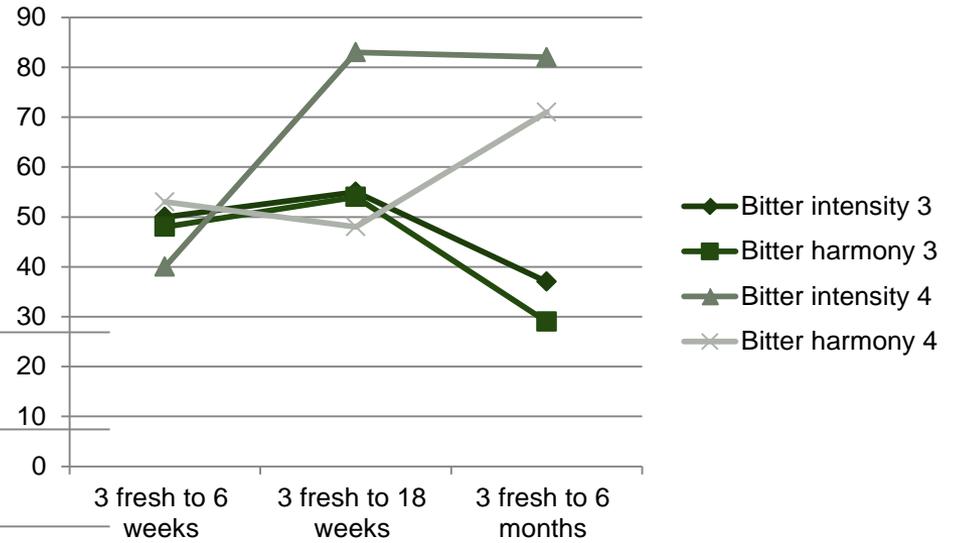
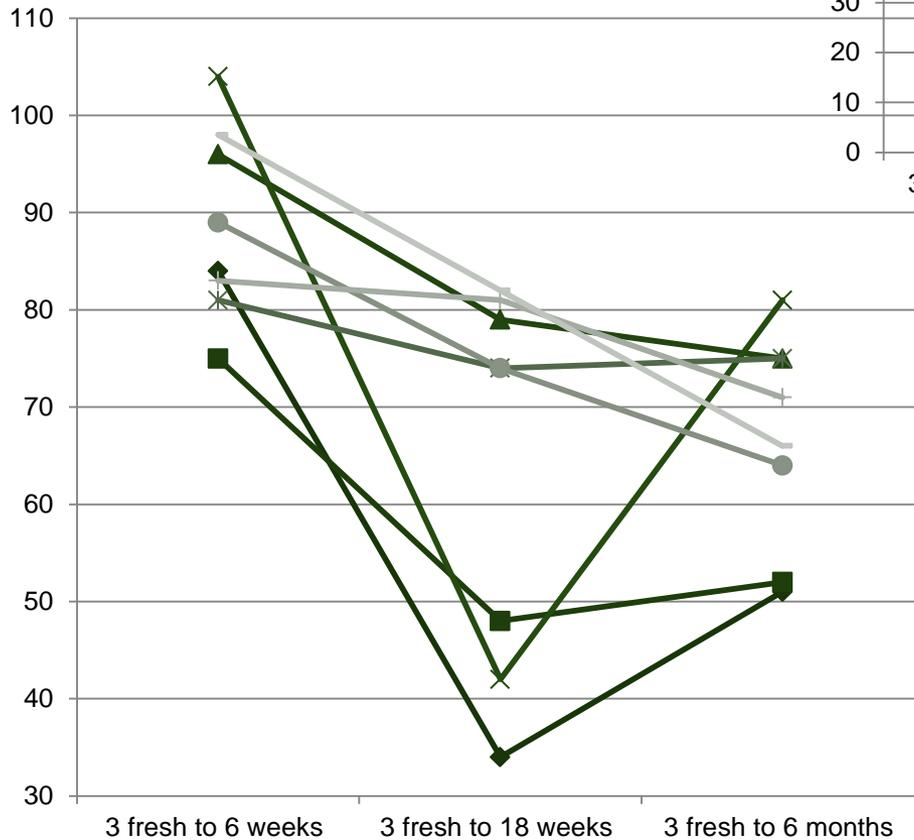
No yeast, dynamic, no past



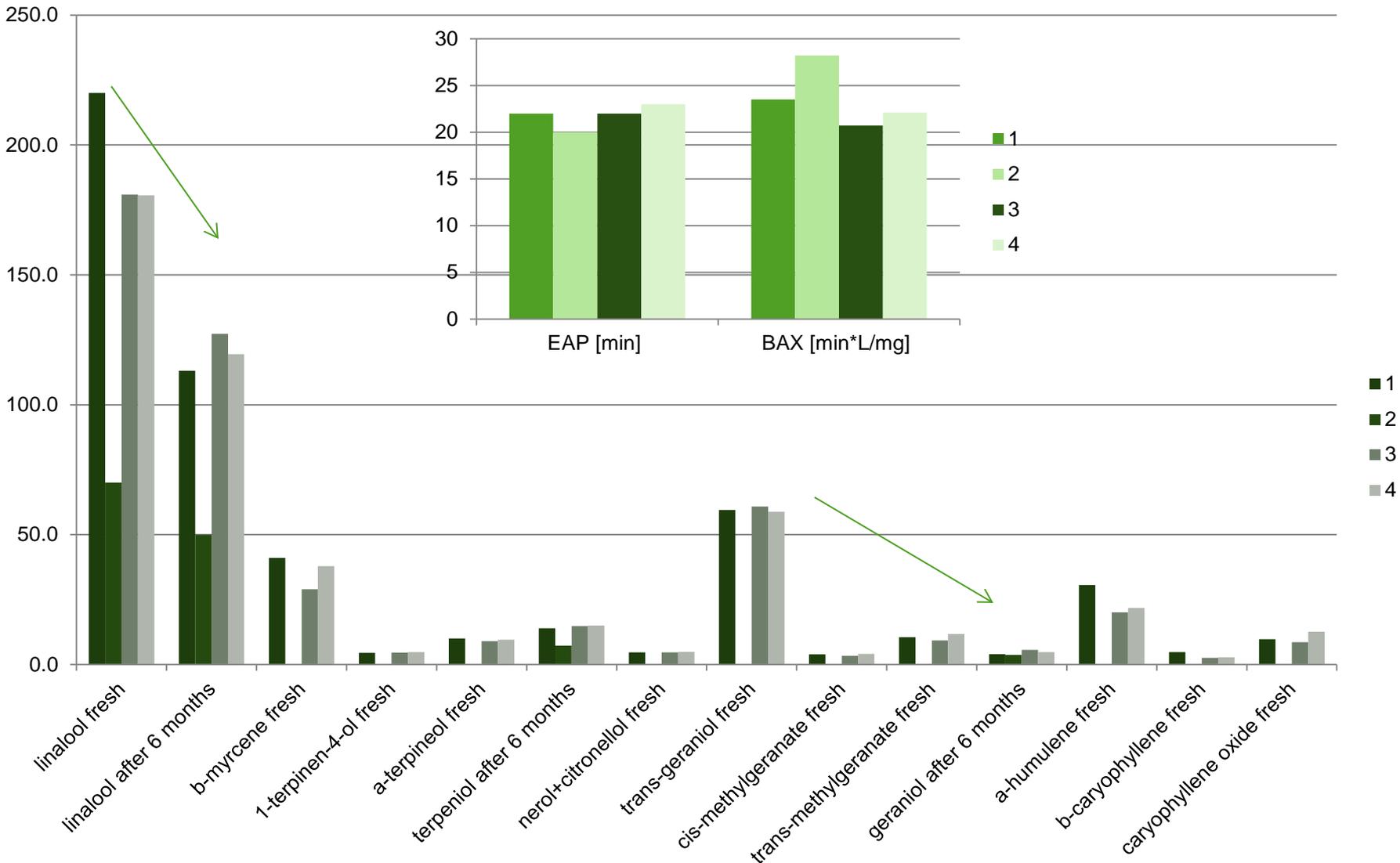


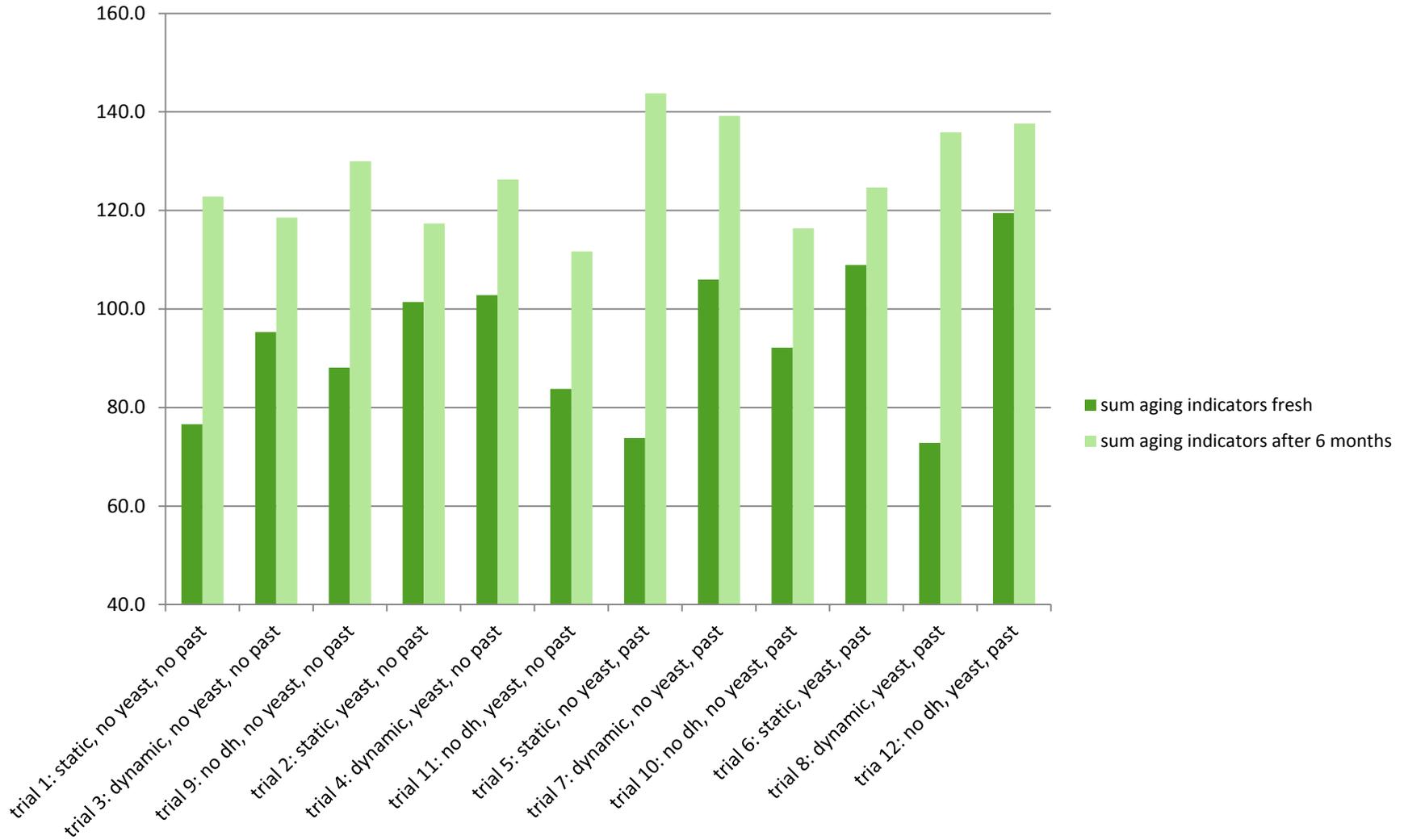
Loss of aroma, flavour and bitterness – No yeast vs. With yeast – static dry hopping

3 no yeast; 4 with yeast



- ◆ Bitter intensity 3
- Bitter harmony 3
- ▲ Bitter intensity 4
- × Bitter harmony 4
- ◆ Hop aroma intensity 3
- Hop aroma quality 3
- ▲ Hop flavour intensity 3
- × Hop flavour quality 3
- * Hop aroma intensity 4
- Hop aroma quality 4
- + Hop flavour intensity 4
- Hop flavour quality 4





Lower values with dry hopping
Lower values in no past. beers after 6 months

Static vs. Dynamic mode of dry hopping

- dynamic dry hopping positively correlates with medium size polyphenols (procyanidines, polydatine, polyphenolglycosides)
- A negative correlation for dynamic dry hopping was shown for foam values, decanoic acid (indicates yeast quality) and low molecular carbonic acids
- No clear conclusion for flavour/aroma

No pasteurization vs. pasteurization

- Pasteurization correlates with (increase) HMF
- A negative correlation for anthocyanogenes, trans-2-nonenal and ITT values
- Unpasteurized beers showed a stronger decrease in hop aroma; flavour and bitterness (intensity and quality) throughout the whole 6 months
- A stronger decrease of hop aroma and flavour intensity and quality was visible within the first 3 months of storage for the unpasteurized beers
- Pasteurized beers proved to be relatively stable in hop aroma and flavour intensity and quality throughout the whole 6 months, despite of lower EAP
- Pasteurization decreased the aroma and flavour intensities of floral, citrus and fruity characters (more aroma than flavour)

No yeast vs. yeast

- The beers without yeast showed bigger differences compared to the controls in regard to flavour and aroma quality and bitterness harmony
- The BAX values of the beers with yeast are lower
- A negative correlation was shown for the amount of tannins
- With yeast the bitter intensity and harmony was more stable during storage
- A stronger decrease of hop aroma and flavour intensity and quality was visible within the first 3 months of storage
- The presence of yeast decreased the aroma and flavour intensities of floral, citrus and fruity characters (more aroma than flavour)

- A higher amount of sesquiterpenoids correlates with higher intensities of hoppy/spicy flavour and aroma.
- The forecast of flavour stability with the means of EAP and BAX values does not correlate with the actual sensory findings

Thank you for your attention!
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www.HopsAcademy.com
www.BarthHaasGroup.com