



Formulation Design of Tomato Juice

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Objective of FunTomP: Tomato Juice



Juices & Sauces

- To produce functional tomato juice with the obtained olive powder, sugar beet leaf protein (rubisco) or alternative protein sources (e.g. pea protein) and preserving the developed juice with novel and eco-friendly processing technologies (e.g. UV-C, ultrasound) that will impact the nutrients minimally.

Ingredients to functionalize tomato Juice



Juices & Sauces

- Tomato peel powder (TPP)



- Pea protein powder



- Olive powder



To achieve this objective....



Juices & Sauces

- A mixture design was performed
- **Definition:** Mixture design is a response surface methodology in which the combination of two or more ingredients or compounds is tested. The factors are the components of a mixture, and the response varies as the proportions (amount) of the components vary, i.e., the response is affected by the change of the proportions. Mixture design is a powerful tool for determining the proportions of ingredients in a blend and therefore obtaining an optimized formulation (Buruk Sahin et al, 2016).

Experimental Design Type



Juices & Sauces

Build Information

File Version	23.0.0.0			
Study Type	Mixture		Subtype	Randomized
Design Type	D-optimal	Coordinate Exchange	Runs	20
Design Model	Quadratic		Blocks	4
Build Time (ms)	51.00			

A D-optimal design was used to find the optimum formulation

D-optimal mixture design is an experimental design that enables food formula optimization with smaller number of runs and thus needs low cost of experimentation/analysis (Surya et al., 2021)

Mixture Components



Juices & Sauces

	Component	Name	Units	Type	Minimum	Maximum
	A	TPP	%	Mixture	1	5
	B	PP	%	Mixture	1	5
	C	OP	%	Mixture	1	5
	D	J/P	%	Mixture	84	94.8
				Total =		99.00

A-tomato peel powder (TPP)

B-pea protein (PP)

C-olive powder (OP)

D-**J/P** (J stands for juice and represents the liquid extract obtained from tomato pulp after centrifugation and P stands for tomato pulp)

Lower and Upper limits (%) of ingredients used were defined

Total ingredient percentage was 99% because the remaining 1% is the **salt** quantity to be added

Final Design

	Std	Block	Run	Build Type	Space Type	Component 1 A:TPP %	Component 2 B:PP %	Component 3 C:OP %	Component 4 D:J/P %
	5	Block 1	1	Replicate	Vertex	5	1	1	92
	2	Block 1	2	Model	Edge	3.08639	1	5	89.9136
	1	Block 1	3	Lack of Fit	Plane	5	3.7115	3.68012	86.6084
	6	Block 1	4	Model	Edge	1	2.63611	1	94.3639
	4	Block 1	5	Model	Vertex	5	1	1	92
	11	Block 2	6	Model	Edge	2.2	1	1	94.8
	9	Block 2	7	Model	Edge	1	3.20508	5	89.7949
	8	Block 2	8	Model	Edge	1	5	3.46051	89.5395
	7	Block 2	9	Model	Vertex	5	5	1	88
	12	Block 2	10	Model	Vertex	5	5	5	84
	10	Block 3	11	Center	Center	3	3	3	90
	3	Block 3	12	Center	Center	3	3	3	90
	15	Block 3	13	Model	Vertex	1	1	5	92
	13	Block 3	14	Center	Center	3	3	3	90
	14	Block 3	15	Model	Vertex	1	5	1	92
	19	Block 4	16	Lack of Fit	Edge	5	2.98698	1	90.013
	17	Block 4	17	Model	Vertex	5	1	5	88
	18	Block 4	18	Replicate	Vertex	5	1	5	88
	20	Block 4	19	Model	Edge	1	1	2.63521	94.3648
	16	Block 4	20	Model	Edge	2.51272	5	5	86.4873

- The design consisted of 20 formulations (runs) that were partitioned into four blocks of five runs

Study Scheduling

Block	Preparation	Tasting Session
1	23rd October 2023	24th October 2023
2	25th October 2023	26th October 2023
3	30th October 2023	31st October de 2023
4	1st November 2023	2nd November 2023

- The study was conducted for two weeks.

Tomato pulp Production + cold
break at 66 °C in thermomix



Larger picture of supernatant=juice
(J) and obtained pellet



Centrifugation to separate juice (J) at
4500 RPM for 5 minutes



Supernatant=juice (J)



Juice (70%) +
pulp



PP



TPP



High-pressure
homogenization:
max. 70 bars



Olive powder
(OP)



Salt (1%)



Samples with
varying ingredient
proportions



Pasteurization (95 °C
for 5 minutes)

Block	Run	Build Type	Space Type	TPP %	PP %	OP %	J/P %	Juice (J) %	Pulp (P) %
Block 1		1 Replicate	Vertex	5	1	1	92	70	22
Block 1		2 Model	Edge	3.08639	1	5	89.9136	70	19.9136
Block 1		3 Lack of Fit	Plane	5	3.7115	3.68012	86.6084	70	16.6084
Block 1		4 Model	Edge	1	2.63611	1	94.3639	70	24.3639
Block 1		5 Model	Vertex	5	1	1	92	70	22
Block 2		6 Model	Edge	2.2	1	1	94.8	70	24.8
Block 2		7 Center	Center	1	3.20508	5	89.7949	70	19.7949
Block 2		8 Model	Edge	1	5	3.46051	89.5395	70	19.5395
Block 2		9 Model	Edge	5	5	1	88	70	18
Block 2		10 Model	Vertex	5	5	5	84	70	14
Block 3		11 Center	Center	3	3	3	90	70	20
Block 3		12 Model	Vertex	3	3	3	90	70	20
Block 3		13 Center	Center	1	1	5	92	70	22
Block 3		14 Model	Vertex	3	3	3	90	70	20
Block 3		15 Model	Vertex	1	5	1	92	70	22
Block 4		16 Lack of Fit	Edge	5	2.98698	1	90.013	70	20.013
Block 4		17 Model	Vertex	5	1	5	88	70	18
Block 4		18 Replicate	Vertex	5	1	5	88	70	18
Block 4		19 Model	Edge	1	1	2.63521	94.3648	70	24.3648
Block 4		20 Model	Edge	2.51272	5	5	86.4873	70	16.4873

70% juice and the remainder represents the pulp

Tasting

Response	Name
R1	Colour
R2	Brightness
R3	Opacity
R4	Viscosity
R5	Taste
R6	Off-flavour
R7	Sourness
R8	Saltiness
R9	Sweetness
R10	Overall acceptance

Tasting

- 6-points hedonic scale

Code/Ponto	Description/Descrição
1	Dislike extremely / Desgosto extremamente
2	Dislike moderately / Desgosto moderadamente
3	Dislike Slightly / Desgosto ligeiramente
4	Like Slightly / Gosto ligeiramente
5	Like moderately / Gosto moderadamente
6	Like extremely / Gosto extremamente

Tasting

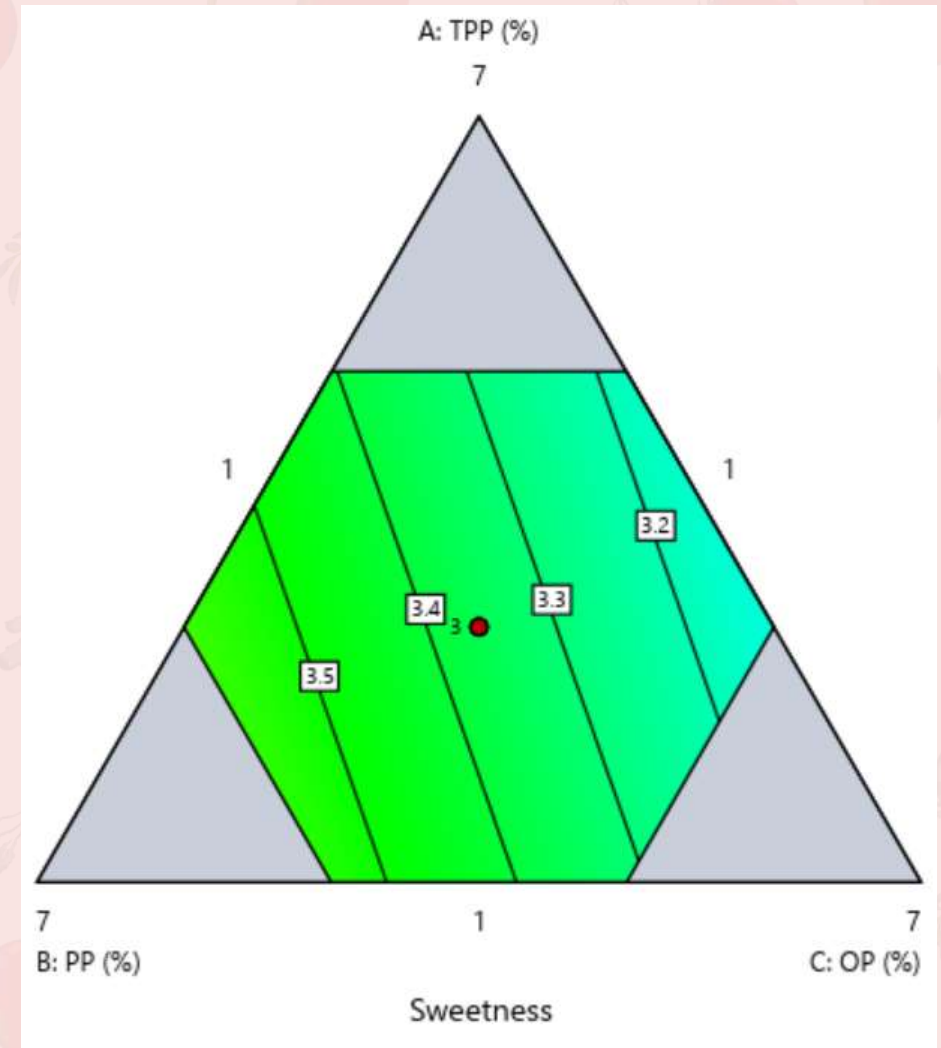
Block	Tasting Session	Number of tasters
1	24th October 2023	17
2	26th October 2023	16
3	31st October de 2023	14
4	2nd November 2023	12



- Untrained panel
- Males & females
- Aged 18 to 66
- Served cold/fresh

Analysis of Responses

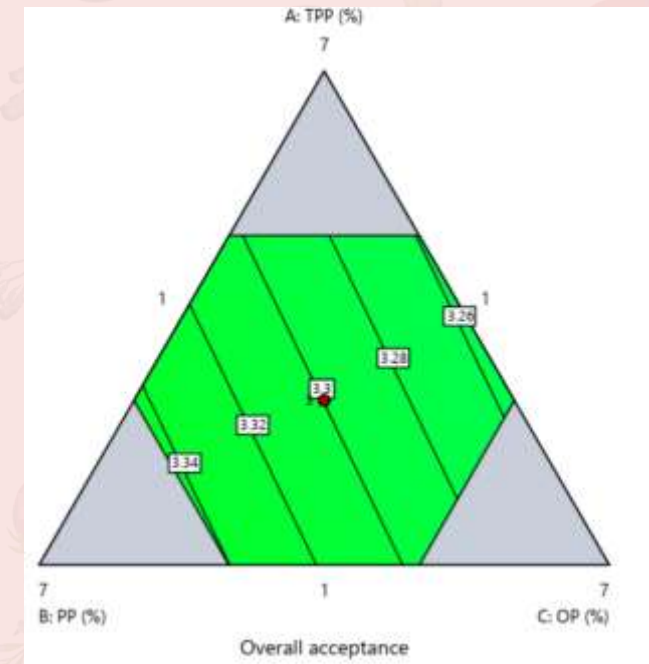
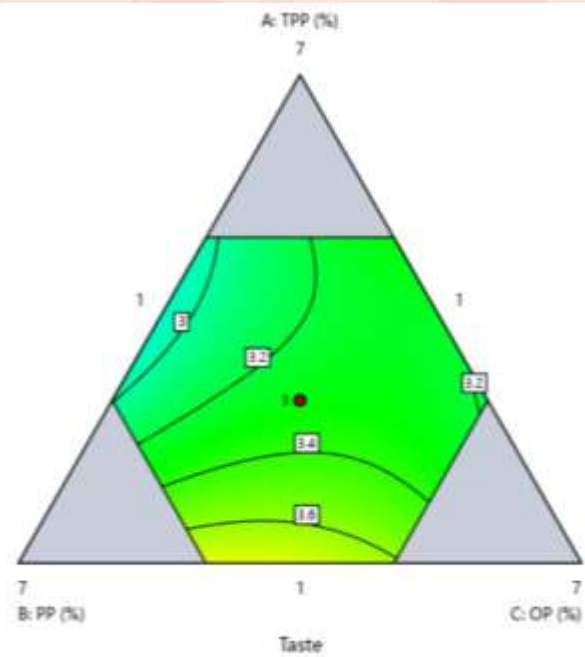
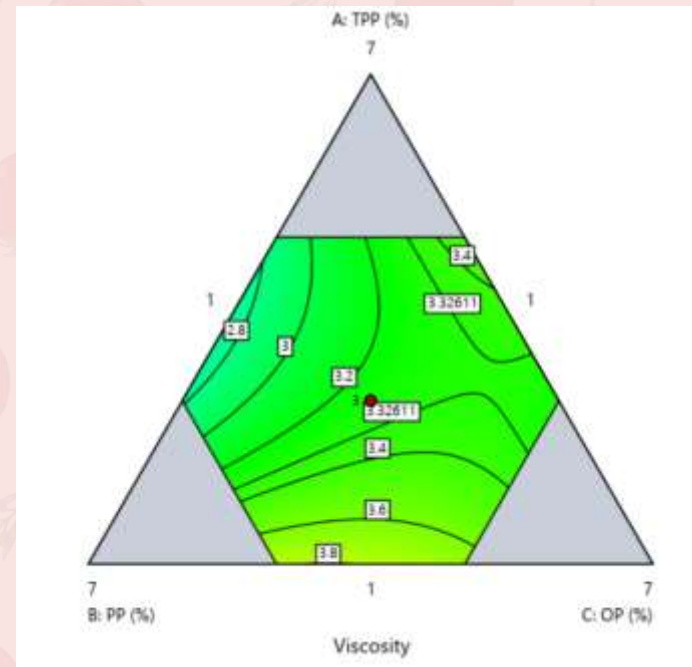
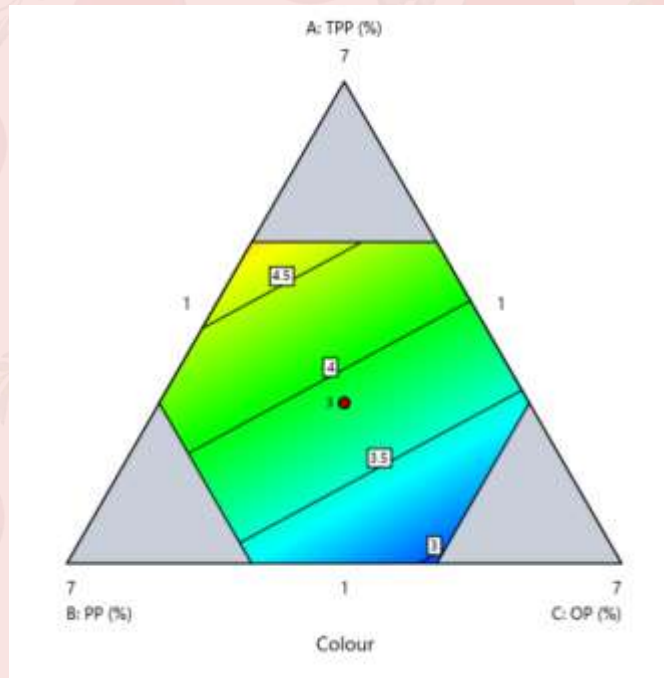
- The data obtained from the sensory evaluation were averaged to obtain a score for each response
- To obtain the best models for each analysed attribute (responses), the mean sensory scores that showed any discrepancy (i.e. outliers) were deleted



Response	Type of Model	Model	Lack of Fit	R ²	R ² adj	R ² pred
color	Linear	F =37.19 Significant	F=4.28 Not significant	0.8956	0.8716	0.7189
brightness	Linear	F=40.60 Significant	F=1.02 Not significant	0.9103	0.8879	0.7745
opacity	Linear	F= 30.87 Significant	F=0.8878 Not significant	0.8853	0.8566	0.7095
viscosity	Reduced Quadratic	F= 56.63 Significant	F=0.7979 Not significant	0.9626	0.9456	0.8866
Taste	Reduced Quadratic	F=20.53 Significant	F=0.2896 Not significant	0.9032	0.8592	0.7642
Off-flavor	Linear	F=12.10 Significant	F=0.4850 Not significant	0.7516	0.6895	0.4255
Sourness	Reduced Quadratic	F=8.80 Significant	F= 0.6270 Not significant	0.7458	0.6610	0.3344
Saltiness	Linear	F=5.90 Significant	F=0.8243 Not significant	0.5959	0.4948	0.0895
Sweetness	Linear	F=31.80 Significant	F=0.4676 Not significant	0.8966	0.8684	0.7497
Overall acceptance	Linear	F=25.86 Significant	F=0.6872 Not significant	0.8660	0.8325	0.6708

- Non-significant lack of fit is good. It implies the model fits

Model graphs of selected responses



Optimization

Constraints

	Name	Goal	Lower Limit	Upper Limit	Lower Weight	Upper Weight	Importance
	A:TPP	is in range	1	5	1	1	3
	B:PP	is in range	1	5	1	1	3
	C:OP	is in range	1	5	1	1	3
	D:J/P	is in range	84	96	1	1	3
	Colour	maximize	4.5	6	10	1	5
	Brightness	maximize	4.5	6	1	1	1
	Opacity	maximize	4	4.78571	1	1	3
	Viscosity	maximize	3.5	4	10	1	5
	Taste	maximize	3.5	6	10	1	5
	Off-flavour	maximize	3.8	6	1	1	3
	Sourness	maximize	3.8	4.3	1	1	4
	Saltiness	maximize	4	6	1	1	3
	Sweetness	maximize	4	6	1	1	3
	Overall acceptance	maximize	4	6	10	1	5

- Upper and lower limits of quality attributes were imposed using the optimum formulation of statease software
- The importance and weight of each response were defined

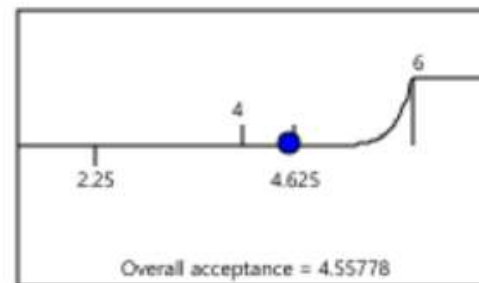
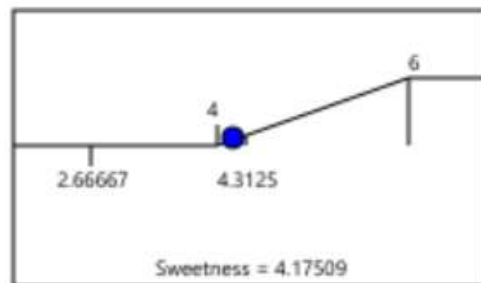
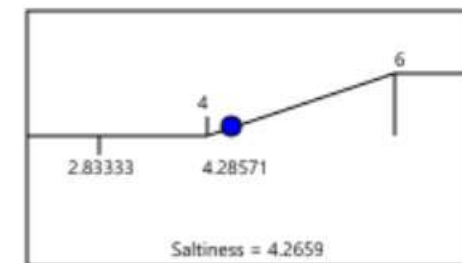
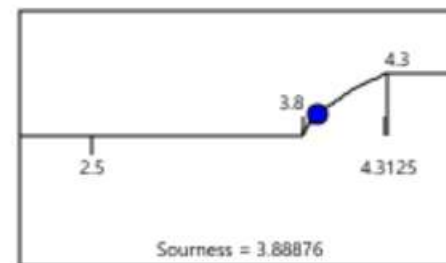
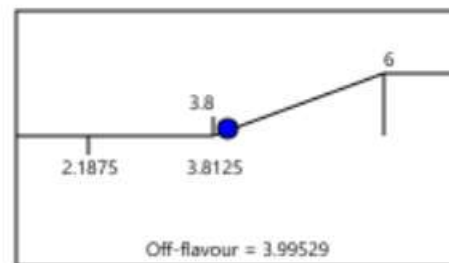
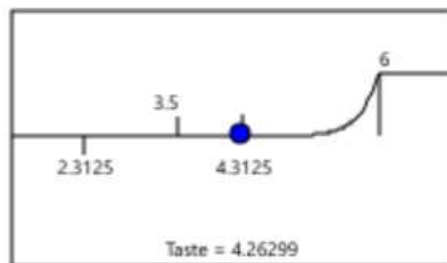
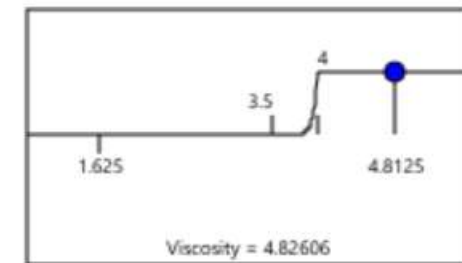
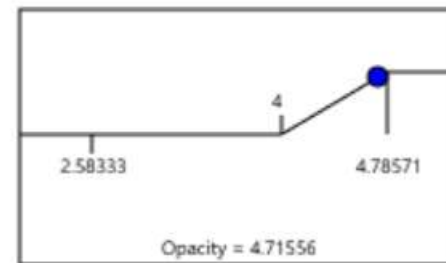
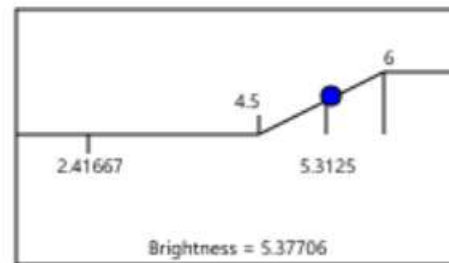
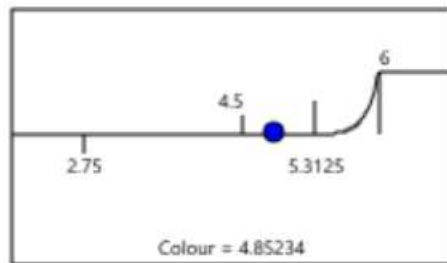
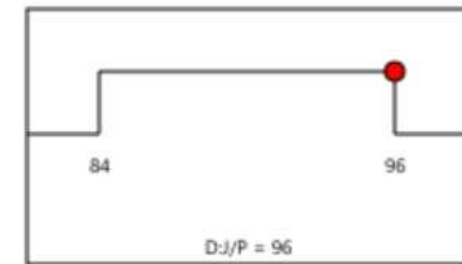
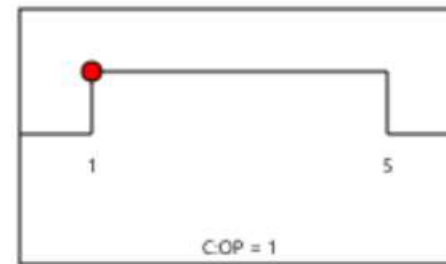
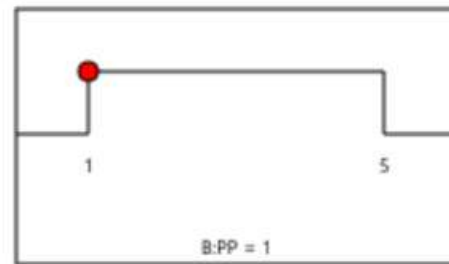
Optimization

- 4 solutions (i.e. formulations) were obtained
- Solution 1 was suggested by the software due to a higher acceptance score

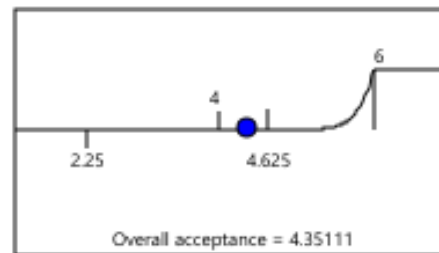
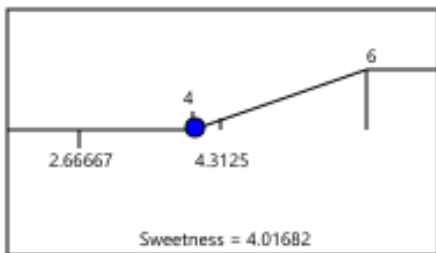
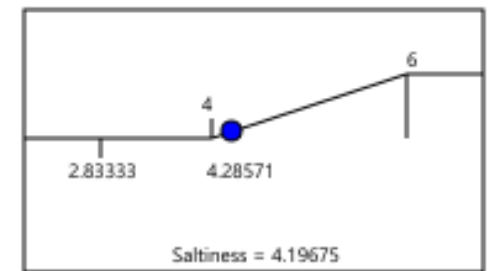
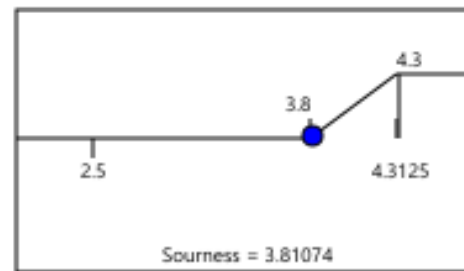
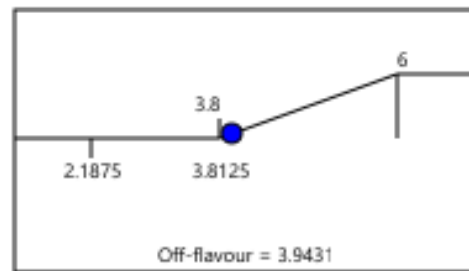
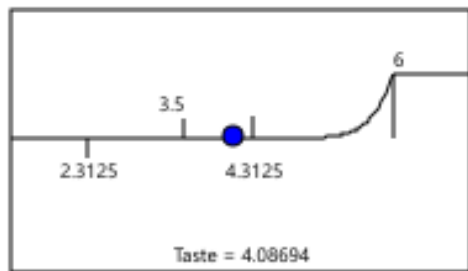
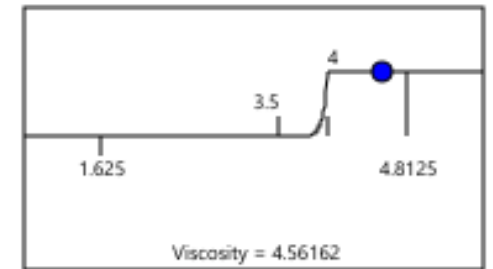
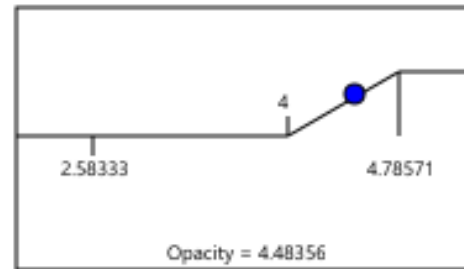
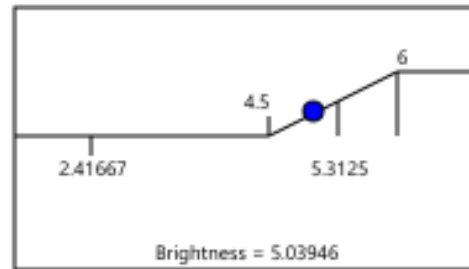
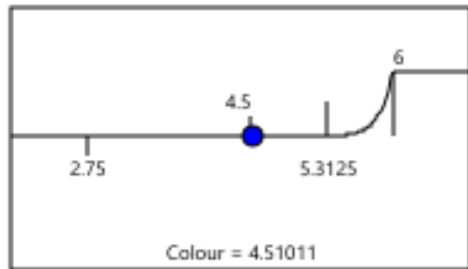
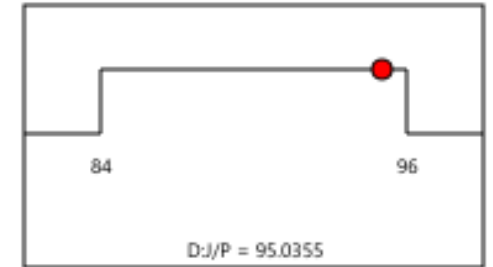
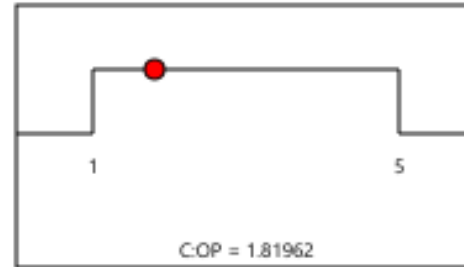
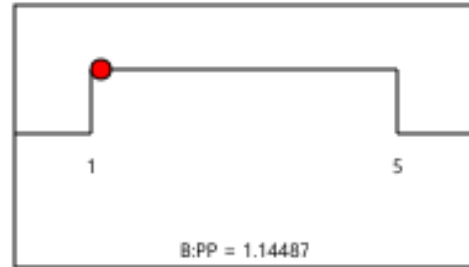
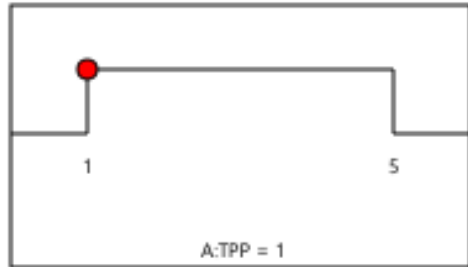
4 Solutions found

	Number	TPP	PP	OP	J/P	Colour	Brightness	Opacity	Viscosity	Taste	Off-flavour	Sourness	Saltiness	Sweetness	Overall acceptance
	1	1.000	1.000	1.000	96.000	4.852	5.377	4.716	4.826	4.263	3.995	3.889	4.266	4.175	4.558
	2	1.000	1.145	1.820	95.036	4.510	5.039	4.484	4.562	4.087	3.943	3.811	4.197	4.017	4.351
	3	1.000	1.549	1.664	94.787	4.500	5.025	4.469	4.526	4.078	3.933	3.822	4.186	4.018	4.306
	4	1.000	2.971	1.000	94.029	4.510	5.018	4.450	4.362	4.008	3.904	3.872	4.159	4.042	4.172

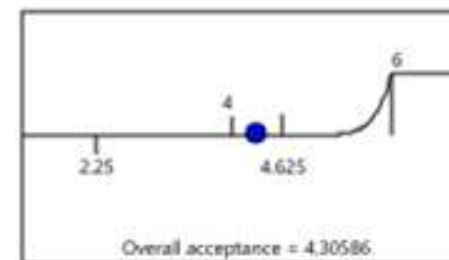
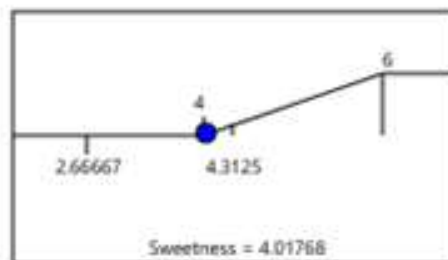
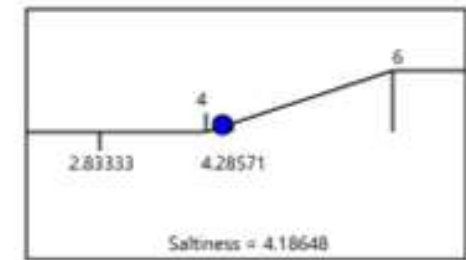
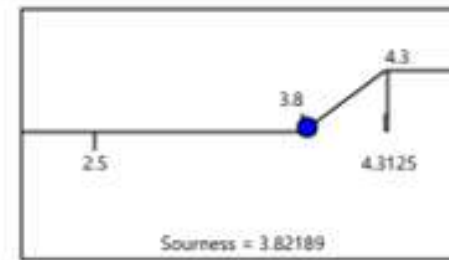
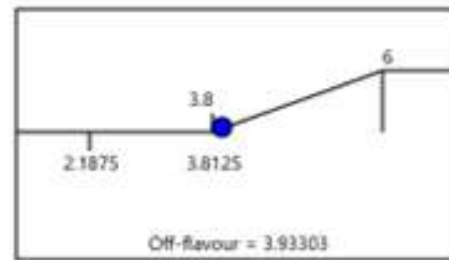
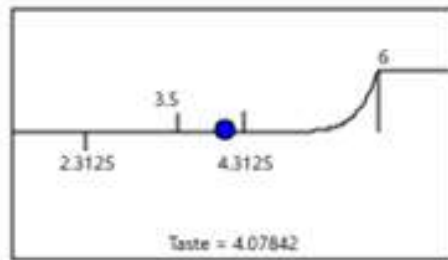
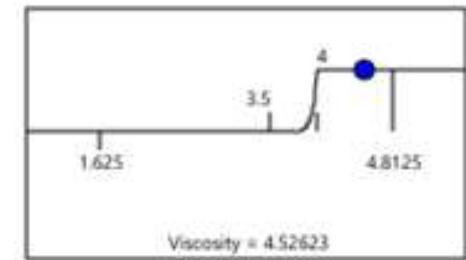
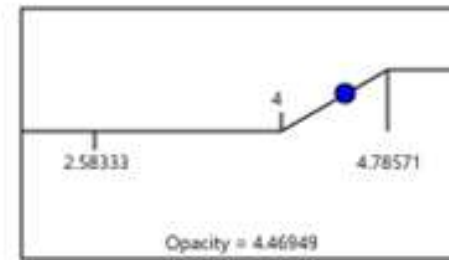
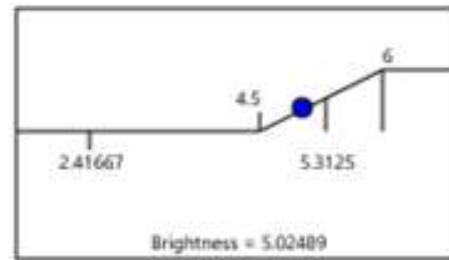
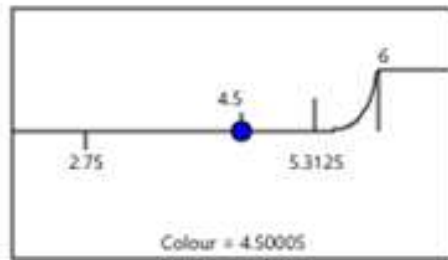
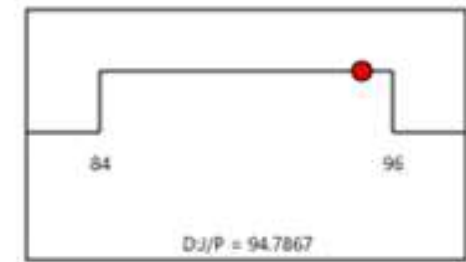
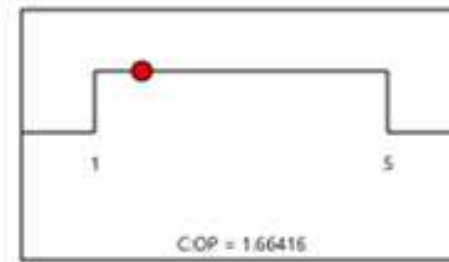
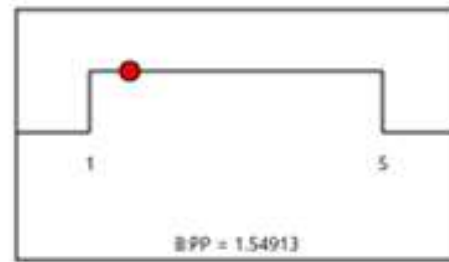
Solution 1: Ramps (Selected)



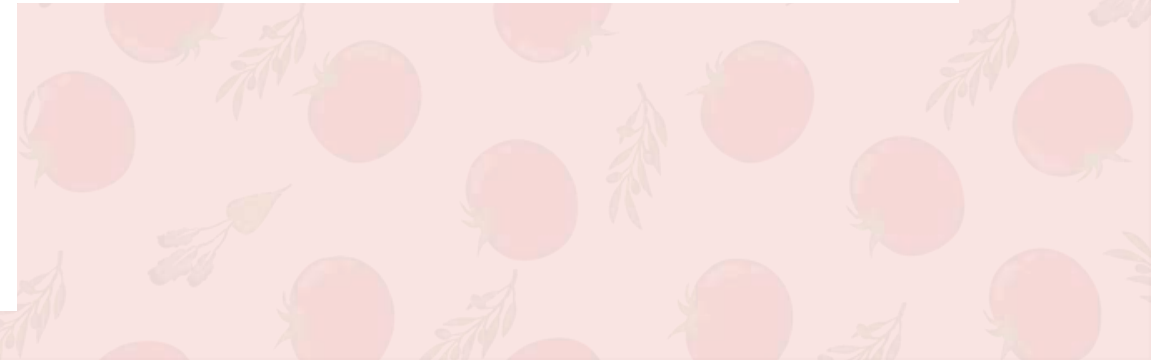
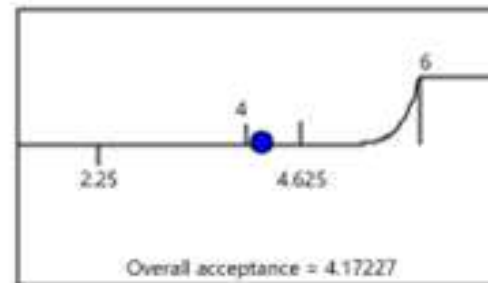
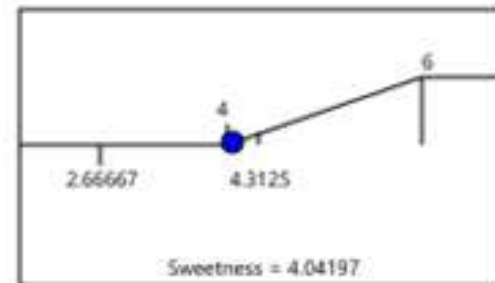
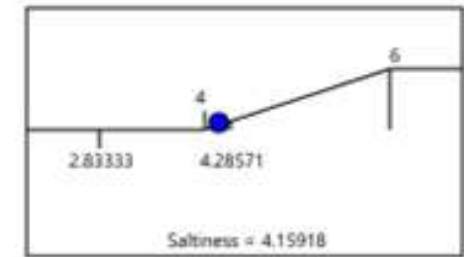
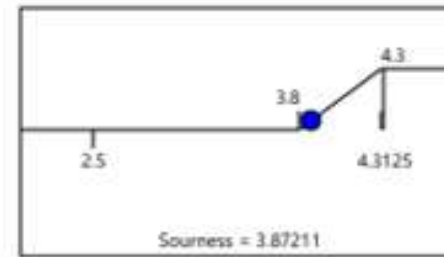
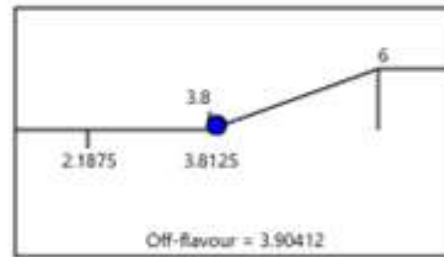
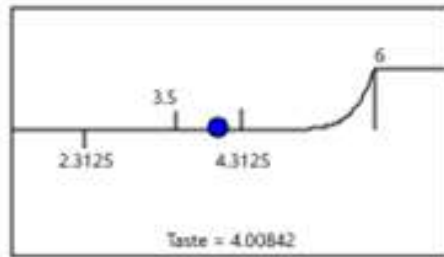
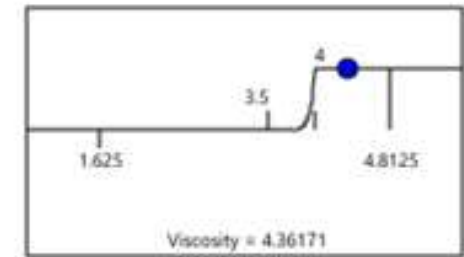
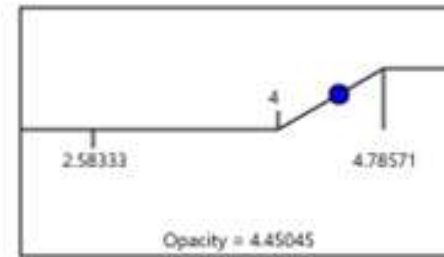
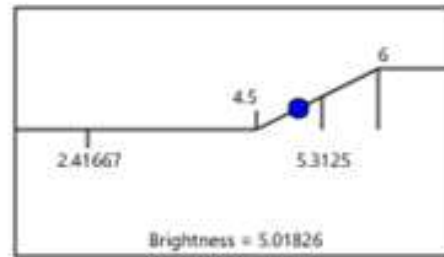
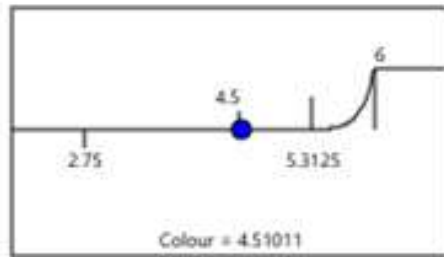
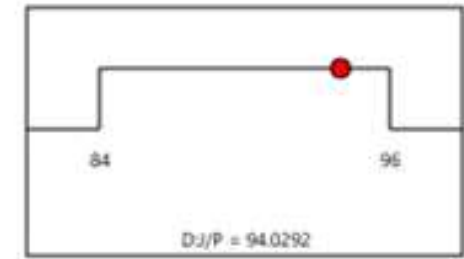
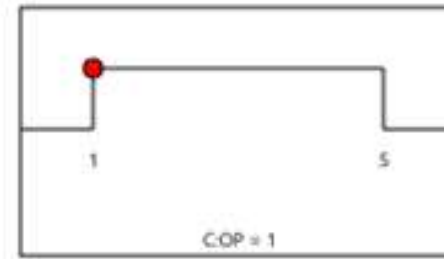
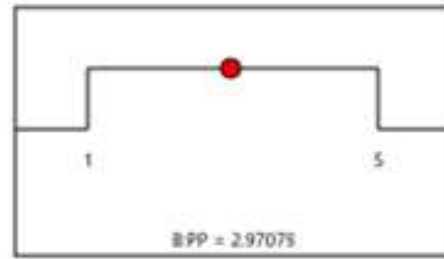
Solution 2: Ramps



Solution 3: Ramps



Solution 4: Ramps



Thank you for your attention



Tomato Bars



Leather



Juices & Sauces



Dry Mixes

Mediterranean Diet



References



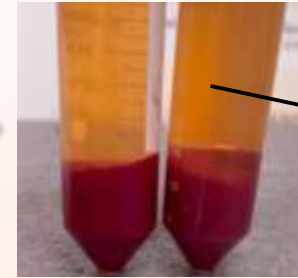
Juices & Sauces

- Surya, R., Romulo, A., & Susilo, E. 2021. Optimization of functional beverage formula made from turmeric, tamarind, and ginger by D-optimal mixture design. *IOP Conference Series: Earth and Environmental Science*, 794(1), 012138. <https://doi.org/10.1088/1755-1315/794/1/012138>
- Buruk Sahin, Y., Aktar Demirtaş, E., Burnak, N. 2016. Mixture design: A review of recent applications in the food industry. *Pamukkale Univ Muh Bilim Derg*, 22(4), 297-304. <http://dx.doi.org/10.5505/pajes.2016.98598>

Tomato pulp Production + cold
break at 66 °C in thermomix



Centrifugation to separate juice (J) at
4500 RPM for 5 minutes



Larger picture of supernatant=juice
(J) and obtained pellet

Supernatant=juice (J)



Juice (70%) +
pulp

PP

TPP

Olive powder
(OP)

Salt (1%)

High-pressure
homogenization

Optimum
formulation

Pasteurization (95 °C
for 5 minutes)