

# PREDICTIVE MODELS OF PH

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#### **ABSTRACT**

Impact of PH levels in our beverages with the manufacturing process

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# Predictive model of PH

#### Overview

In this report we highlight the impact of PH levels in our beverages with the manufacturing process. We use the past manufacturing data to predict the future and stay ahead in our market segment.

PH levels historically vary from 7.88 and 9.36. It has a mean value of 8.55. In order to determine the best results we use the industry standard indicators – Root Mean Square Error (RMSE) and R-Squared values.

### Modelling

We used various modelling techniques and evaluated their performance. We used models like - Generalized Linear model (GLM), Partial Least Squares model (PSL), Ridge model, ENET model, MARS Model, SVM Model, KNN Model, Random Forest, Boosted trees, Cubist and Bagged Trees.

We used historical data and transformed them for a meaningful analysis. The data was then evaluated using all the models mentioned above to evaluate the best performance. We used *Root Mean Square Error (RMSE)* and *R-Squared values* to compare the model performance.

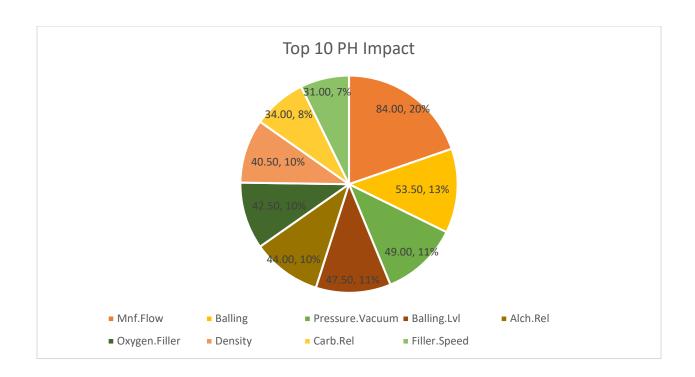
We found that the tree models performed better than the linear and non-linear models. The best model was Cubist. Cubist is a rule-based model that is an extension of Quinlan's M5 model tree. Random Forest model also had very good performance compared to all the other models we tuned and evaluated, so it might be a valid alternative to Cubist if for any reason an alternative is needed. The Cubist R-Squared value is 0.61, meaning that the model explains 61% of variability in the data. RMSE for Cubist is 0.11. The Random

Forest R-Squared value is 0.60, meaning that the model explains 60% of variability in the data. RMSE for Random Forest is 0.11.

## High Impact Variables

Using the Cubist model we found the following variables to have highest impact on PH levels.

Carb.Rel       34.00         Filler.Speed       31.00         Temperature       29.50         Hyd.Pressure3       29.00         Carb.Pressure1       28.00         Bowl.Setpoint       25.50         Hyd.Pressure1       25.00         Usage.cont       24.00         MFR       24.00         Carb.Flow       22.50         Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       11.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00			
Balling       \$3.50         Pressure.Vacuum       49.00         Balling.Lvl       47.50         Alch.Rel       44.00         Oxygen.Filler       42.50         Density       40.50         Carb.Rel       34.00         Filler.Speed       31.00         Temperature       29.50         Hyd.Pressure3       29.00         Carb.Pressure1       28.00         Brand.Code       27.00         Bowl.Setpoint       25.50         Hyd.Pressure1       25.00         Usage.cont       24.00         MFR       24.00         Carb.Flow       22.50         Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       11.50         Pressure.Setpoint       11.50         Fill.Pressure       1.50         PC.Volume       10.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00		Overall	
Pressure.Vacuum         49.00           Balling.Lvl         47.50           Alch.Rel         44.00           Oxygen.Filler         42.50           Density         40.50           Carb.Rel         34.00           Filler.Speed         31.00           Temperature         29.50           Hyd.Pressure3         29.00           Carb.Pressure1         28.00           Brand.Code         27.00           Bowl.Setpoint         25.50           Hyd.Pressure1         25.00           Usage.cont         24.00           MFR         24.00           Carb.Flow         22.50           Filler.Level         21.00           Hyd.Pressure2         20.00           Carb.Volume         12.50           Pressure.Setpoint         11.50           Fill.Pressure         15.00           Hyd.Pressure4         8.50           Carb.Pressure         7.00           PSC.Fill         6.50           Air.Pressurer         6.00           Carb.Temp         6.00           PSC.CO2         3.50           PSC         2.00			_
Balling.Lvl       47.50         Alch.Rel       44.00         Oxygen.Filler       42.50         Density       40.50         Carb.Rel       34.00         Filler.Speed       31.00         Temperature       29.50         Hyd.Pressure3       29.00         Carb.Pressure1       28.00         Brand.Code       27.00         Bowl.Setpoint       25.50         Hyd.Pressure1       25.00         Usage.cont       24.00         MFR       24.00         Carb.Flow       22.50         Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure4       8.50         Carb.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00			=
Alch.Rel       44.00         Oxygen.Filler       42.50         Density       40.50         Carb.Rel       34.00         Filler.Speed       31.00         Temperature       29.50         Hyd.Pressure3       29.00         Carb.Pressure1       28.00         Brand.Code       27.00         Bowl.Setpoint       25.50         Hyd.Pressure1       25.00         Usage.cont       24.00         MFR       24.00         Carb.Flow       22.50         Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       11.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00			
Oxygen.Filler       42.50         Density       40.50         Carb.Rel       34.00         Filler.Speed       31.00         Temperature       29.50         Hyd.Pressure3       29.00         Carb.Pressure1       28.00         Brand.Code       27.00         Bowl.Setpoint       25.50         Hyd.Pressure1       25.00         Usage.cont       24.00         MFR       24.00         Carb.Flow       22.50         Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       11.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00			7
Density       40.50         Carb.Rel       34.00         Filler.Speed       31.00         Temperature       29.50         Hyd.Pressure3       29.00         Carb.Pressure1       28.00         Bowl.Setpoint       25.50         Hyd.Pressure1       25.00         Usage.cont       24.00         MFR       24.00         Carb.Flow       22.50         Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       11.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00			
Carb.Rel       34.00         Filler.Speed       31.00         Temperature       29.50         Hyd.Pressure3       29.00         Carb.Pressure1       28.00         Brand.Code       27.00         Bowl.Setpoint       25.50         Hyd.Pressure1       25.00         Usage.cont       24.00         MFR       24.00         Carb.Flow       22.50         Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       11.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Oxygen.Filler		42.50
Filler.Speed       31.00         Temperature       29.50         Hyd.Pressure3       29.00         Carb.Pressure1       28.00         Brand.Code       27.00         Bowl.Setpoint       25.50         Hyd.Pressure1       25.00         Usage.cont       24.00         MFR       24.00         Carb.Flow       22.50         Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       11.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Density		40.50
Temperature       29.50         Hyd.Pressure3       29.00         Carb.Pressure1       28.00         Brand.Code       27.00         Bowl.Setpoint       25.50         Hyd.Pressure1       25.00         Usage.cont       24.00         MFR       24.00         Carb.Flow       22.50         Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       11.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Carb.Rel		34.00
Hyd.Pressure3       29.00         Carb.Pressure1       28.00         Brand.Code       27.00         Bowl.Setpoint       25.50         Hyd.Pressure1       25.00         Usage.cont       24.00         MFR       24.00         Carb.Flow       22.50         Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       11.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Filler.Speed		31.00
Carb.Pressure1       28.00         Brand.Code       27.00         Bowl.Setpoint       25.50         Hyd.Pressure1       25.00         Usage.cont       24.00         MFR       24.00         Carb.Flow       22.50         Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       11.50         PC.Volume       10.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Temperature		29.50
Brand.Code         27.00           Bowl.Setpoint         25.50           Hyd.Pressure1         25.00           Usage.cont         24.00           MFR         24.00           Carb.Flow         22.50           Filler.Level         21.00           Hyd.Pressure2         20.00           Carb.Volume         12.50           Pressure.Setpoint         11.50           Fill.Pressure         11.50           PC.Volume         10.50           Hyd.Pressure4         8.50           Carb.Pressure         7.00           PSC.Fill         6.50           Air.Pressurer         6.00           Carb.Temp         6.00           PSC.CO2         3.50           PSC         2.00	Hyd.Pressure3		29.00
Bowl.Setpoint       25.50         Hyd.Pressure1       25.00         Usage.cont       24.00         MFR       24.00         Carb.Flow       22.50         Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       10.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Carb.Pressure1		28.00
Hyd.Pressure1       25.00         Usage.cont       24.00         MFR       24.00         Carb.Flow       22.50         Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       11.50         PC.Volume       10.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Brand.Code		27.00
Usage.cont       24.00         MFR       24.00         Carb.Flow       22.50         Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       10.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Bowl.Setpoint		25.50
MFR       24.00         Carb.Flow       22.50         Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       10.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Hyd.Pressure1		25.00
Carb.Flow       22.50         Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       10.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Usage.cont		24.00
Filler.Level       21.00         Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       11.50         PC.Volume       10.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	MFR		24.00
Hyd.Pressure2       20.00         Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       11.50         PC.Volume       10.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Carb.Flow		22.50
Carb.Volume       12.50         Pressure.Setpoint       11.50         Fill.Pressure       11.50         PC.Volume       10.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Filler.Level		21.00
Pressure.Setpoint         11.50           Fill.Pressure         11.50           PC.Volume         10.50           Hyd.Pressure4         8.50           Carb.Pressure         7.00           PSC.Fill         6.50           Air.Pressurer         6.00           Carb.Temp         6.00           PSC.CO2         3.50           PSC         2.00	Hyd.Pressure2		20.00
Fill.Pressure       11.50         PC.Volume       10.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Carb.Volume		12.50
PC.Volume       10.50         Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Pressure.Setpoint		11.50
Hyd.Pressure4       8.50         Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Fill.Pressure		11.50
Carb.Pressure       7.00         PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	PC.Volume		10.50
PSC.Fill       6.50         Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Hyd.Pressure4		8.50
Air.Pressurer       6.00         Carb.Temp       6.00         PSC.CO2       3.50         PSC       2.00	Carb.Pressure		7.00
Carb.Temp         6.00           PSC.CO2         3.50           PSC         2.00	PSC.Fill		6.50
PSC.CO2 3.50 PSC 2.00	Air.Pressurer		6.00
PSC 2.00	Carb.Temp		6.00
	PSC.CO2		3.50
Fill.Ounces 1.50	PSC		2.00
	Fill.Ounces		1.50



Following are the predictions from our analysis.

Bran d	Carb			Carb								Hyd Pres				iller			Usaq				Pres sure		Oxva	Bowl		Air Pres			Balli
Cod e	Volu		Volu	Pres	.Tem		PSC.	PSC	Mnf		Pres		sure		sure l		Filler	Tem		Carb	Dens ity MFR	Balli	Vacu		en	Setp	Setp		Alch	Carb	ng
D	5.48	24	0.27	65.4	135	0.2	0.4	0.04	-100	117	46	0	0	0	96	129	7939411	66	21.7	2950	0.88 264578	1.4	-3.8	8.66	-4	8447	45.2	0.99	6.56	5.34	1.48
Α	5.39	24	0.23	63.2	135	0.04	0.22	0.08	-100	119	46.2	0	0	0	112	120	8043319	65.6	17.6	2916	1.5 270575	2.94	-4.4	8.66	-3.7	7197	46	0.99	7.14	5.58	3.04
В	5.29	23.9	0.3	66.4	140	0.07	0.1	0.02	-100	120	45.8	0	0	0	98	119	8035302	65.6	24.2	3056	0.9 269840	1.45	-4.2	8.68	-3.2	7197	46	0.99	6.52	5.34	1.46
В	5.27	23.9	0.19	64.8	139	0	0.2	0.02	-100	125	40	0	0	0	125	120	6469033	69	18.1	28	0.74 236426	1.06	-4	8.78	-1.9	7197	46	0.99	6.48	5.5	1.48
В	5.41	24.1	0.16	69.4	142	0.04	0.3	0.06	-100	115	51.4	0	0	0	94	116	8067394	66.4	21.3	3214	0.88 282620	1.4	-4	8.59	-2.6	7197	50	0.99	6.5	5.38	1.46
В	5.29	24.1	0.21	73.4	147	0.08	0.22	0.02	-100	119	46.4	0	0	0	94	120	8035302	66.6	18	3064	0.84 267788	1.3	-3.8	8.49	-2.8	7197	46	0.99	6.5	5.42	1.44

## Conclusion

We evaluated many linear, non-linear, tree based models using the historical data and found Cubist to be most effective. This is our initial findings based on the data we had so far. In the process or creating the model we created a system to constantly evaluate and based on the latest data available. This will make this system fine tune and make more accurate recommendations in the future.