RAW-DRIED SALAMI: INFLUENCE OF INITIAL COMPOSITION FOR ACCELERATION OF DRYING

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Abstract: Mathematical Modeling was applied for study of raw-dried salami production process and quality. The influence of entrance factors as meat/lard ratio (X_1), dextrose (X_2) and dietary fiber (X_3) was studied. Dynamics of such indexes of quality as pH, Water Activity, Humidity, Water Binding and Water Retention Capacity (WBC, WRC), Fat Content, Lactic Acid and Total Sugars were studied. Measures for reduction of drying time were proposed.

Key words: raw-dried salami, fractional factorial experiment, meat/lard ratio, dextrose, fiber

Introduction

Fractional Factorial Experiment (FFE) is starting from hypothesis that influential factors do not interact, manifesting an independent action. Accepting this hypothesis allows realizing of such benefits, as reducing the number of expensive experiments, reducing the time, "ease" of system replicas interpretation, "lack" of doubts in interpretation of regression equations and in optimization plans. Also, there are disadvantages of FFE: 1.) Reducing of all general data leads to increasing of error margin. At transition from CFE 22 to FFE 23-1 all data shrinks two times, error is rising. 2.) Low possibility of quantification of factors interaction; mutual influence of input factors, will be invisible in regression equation. 3.) Impossibility of non-influential factor elimination: mutual influence of X1 and X2 factors can be interpreted as "separated" influence of X3 factor, which in reality, does not have any influence. Alternatively, X1 and X3 factors "neutralize" the influence of X2 factor. In such a way, it seems like X2 do not influence the system and X1 do not interact with X3.

Considering all of that, we stopped at Two-Level, Three-Factorial Fractional Experiment, noted as FFE 23-1. Its realization presumes deducing following equation:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

in which: Y – is measured parameter; β_0 – central replica of experiment; β_1, β_2, β_3 – influence coefficients of separated factors X_1, X_2 and X_3.

Planning of two-level three-factorial experiment FFE 2^2

Was studied the influence of factors, determinant for raw-dried salami production technology and for obtaining of quality product according good production practices.

Table 1. Planning of FFE 2^{3-1} in real and encoded coordinates

X_1	*Meat/Lard, kg/kg*	X_2	*Dextrose, kg*	X_3	*Fiber, kg*
+	90/10	+	0.45	+	2
+	90/10	-	0.15	-	0.5
-	70/30	+	0.45	-	0.5
-	70/30	-	0.15	+	2

Studied responses (quality indexes), characterizing raw-dried salami, are following:

- Hydrogen index, pH;
- Water Activity, a_w;
- Relative Humidity, H_R;
- Water Binding Capacity (WBC);
- Water Retention Capacity (WRC);
- Fat Content (FC);
- Lactic acid (LA);
- Total Sugars Content (TSC).

2. Coefficients of regression equations and its interpretation

Table 2. The factors influence on pH

Day	β_0	β_1	β_2	β_3
0	2.83	0.00	-0.01	0.01
1	2.60	0.00	-0.04	0.02
2	2.50	0.00	-0.05	0.00
3	2.47	0.01	-0.06	0.02
4	2.45	0.00	-0.05	0.01
6	2.50	0.01	-0.01	0.01
8	2.62	-0.01	0.00	0.01
11	2.92	0.03	0.08	0.02
15	3.04	0.13	0.03	-0.18
18	2.98	0.15	0.06	-0.04
22	3.13	0.19	-0.02	-0.08
25	3.14	0.15	0.06	-0.10

Meat favors increasing of pH after a week expiration of doing technological process. The pH increasing can mean volatilization or neutralization of some acids; also, can be related with increased humidity of samples, more rich with meat. At beginning sugar contributes to pH decrease, also to acidity rising. Then, after the 8^{th} day, that coefficient changes its sign, becoming positive (the pH is rising, acidity decreases). Dietary fiber influence is inverse. The first 2 weeks that influence is practically null, but at 3th week-the fiber contributes moderately to pH decrease (acidity rising). The observed fiber effect, also can be related with its influence on sample humidity.

Table 3. The factors influence on water activity

Day	β_0	β_1	β_2	β_3
0	0.47300	-0.00050	0.00025	0.00025
1	0.47413	0.00063	0.00038	-0.00013
2	0.47263	0.00038	0.00038	-0.00038
3	0.47213	0.00088	0.00038	-0.00088
4	0.47113	0.00063	0.00063	-0.00088
8	0.46363	0.00263	0.00088	-0.00213
11	0.45675	-0.00150	0.00475	-0.00100
15	0.44413	0.00238	0.00288	-0.00338
18	0.43788	-0.00113	0.00088	-0.00413
22	0.42838	-0.00388	0.00113	-0.00313
25	0.42188	-0.00362	0.00113	-0.00488

No factors exerting significant influence on water activity, demonstrated by the fact that impressive majority of β_1, β_2 and β_3 coefficients do not exceed neither 1% from value of β_0 coefficient. Almost all the influence coefficients of fiber are negative. The negative influence on water activity is rising during the technological process about 10 times, but remaining very little by ponder.

Table 4. The factors influence on relative humidity

Day	β_0	β_1	β_2	β_3	$\beta_{critical}(95)$	$\beta_{critical}(90)$
0	60.57	**5.07**	0.24	-0.86	2.54	1.88
1	62.30	**4.52**	0.16	**-1.42**	1.36	1.01
2	61.65	**5.62**	0.67	**-1.69**	1.19	0.88
3	60.71	**4.69**	0.75	**-1.10**	1.46	1.08
5	58.86	**5.12**	-0.12	-0.62	1.60	1.18
8	54.46	**4.48**	-0.85	**-1.91**	1.98	1.46
11	51.73	**3.67**	0.37	-0.94	2.04	1.51
15	48.00	**6.94**	0.30	**-2.80**	1.60	1.18
18	38.75	**3.20**	1.34	-1.37	2.99	2.21
22	33.99	**3.92**	0.37	-1.70	3.18	2.35
25	30.25	**3.86**	-1.30	**-2.43**	0.88	0.65

Sample humidity depends positively and significantly for high level of significance, P = 95%, on meat ponder rising (lard decreasing). In addition, humidity depends negative significant, especially at statistical ponder P = 90%, on fiber containing rising in recipe. Statistical, humidity not depend on sugar throughout process: value of β_2 coefficients are changing in chaotic way, without any law of value and sign.

Table 5. The factors influence on WBC and WRC

Day	β_0		β_1		β_2		β_3	
	WBC	***WRC***	***WBC***	***WRC***	***WBC***	***WRC***	***WBC***	***WRC***
0	29.56	30.82	2.06	2.72	0.35	-0.60	-0.89	0.39
1	22.28	31.34	-1.69	2.35	-3.01	0.22	0.42	-0.61
2	21.31	30.97	3.59	2.91	-1.07	0.22	-1.87	-0.85
3	21.60	30.53	1.39	2.36	-0.58	0.59	-0.89	-0.65
4	20.05	29.49	4.84	2.83	-0.42	0.13	-1.77	-0.41
8	19.85	27.29	3.48	2.10	0.14	-0.03	-3.29	-0.56
11	23.19	26.26	3.00	2.07	-0.12	-0.04	-0.16	-0.40
15	17.82	24.26	3.97	3.33	5.32	0.33	-1.90	-1.41
18	18.29	19.86	2.01	1.17	0.52	1.05	-0.90	-1.00
22	15.78	17.84	2.34	1.94	0.11	0.03	-0.01	-0.56
25	12.99	15.29	3.49	2.09	-0.38	-0.64	-0.51	-1.16

Concomitant analysis of WBC and WRC leads to the awaited conclusion about influence of meat ponder in recipe. The meat binds and retains water. However, the fiber contributes more moderate with its absolute value and negative in all cases on these indexes. It is a very important result, that correlates with another index values (a_w, H_R). The β_2 coefficients values are smaller and it has different signs, which makes

conclusion that sugar do not have directly influence on these responses. Sugars influence can be latent, or, sugar acts through other factors or in pair with them.

Table 6. The factors influence on Fats

Day	β_0	β_1	β_2	β_3	$\beta_{critical}(95)$	$\beta_{critical}(90)$
0	18.74	**-6.50**	0.45	0.59	5.85	4.32
1	16.15	**-5.57**	-0.28	1.11	1.90	1.41
4	18.70	**-6.70**	-0.16	0.14	1.72	1.27
8	22.12	**-6.01**	1.17	1.13	3.13	2.31
7	21.17	**-5.57**	-0.44	-0.66	1.61	1.19
15	23.02	**-6.78**	-0.06	-0.34	3.10	2.29
18	26.77	**-7.59**	-2.20	2.22	2.00	1.48
22	29.13	**-7.88**	-1.14	2.04	2.10	1.55
25	31.37	**-9.94**	0.64	0.62	1.10	0.82

A fat rise under the influence of fiber is positive in almost cases. Suppose that fiber contribute at fat rising through interaction with other factors. Its sample dehydration action is confirmed by values, obtained from analyzes of several independent data.

Table 7. The factors influence on Lactic Acid

Day	β_0	β_1	β_2	β_3
0	847.5	101.1	-12.9	-113.4
1	868.3	23.9	-168.5	-38.6
2	954.8	58.8	-76.0	-56.4
3	1267.3	-7.4	-11.0	24.5
4	982.9	-14.7	58.8	62.5
8	753.1	-50.9	-86.4	15.3
11	480.4	174.0	14.7	-74.8
15	372.0	-21.4	26.4	-34.9
18	435.7	43.5	50.9	3.1
22	500.0	109.1	74.8	40.4
25	722.0	52.6	66.1	111.6

The factors influence on lactic acid containing is chaotic and hard to interpretation. At the beginning of the drying process (first 2-3 days), the fiber and the sugar contribute to decreasing of lactic acid content, so it decrease the microbiological consumption of sugars. That fact is unexpected especially in case of sugar influence. At the end of process, all of factors contribute on lactic acid rising in the samples.

Conclusion:

The general analyze of all system quality index (responses) demonstrate that for drying process acceleration are necessary such measures:

- It is necessary to raise the amount of fat, so, to decrease meat ratio. That conclusion results from analyze of several independent responses (a_w, H_R, WBC, WRC);
- The recipe must contain more fiber than it is recommended by producers;
- The smaller influence on drying phenomenon has the sugar and its influence is stationary. Therefore, sugar level in recipe must to remain near the center of FFC.