WINE BLENDING ASSISTED BY EXPERT SYSTEM

CUPAJAREA VINURILOR ASISTATĂ DE SISTEM EXPERT

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Abstract. *An expert system has been made in order to assist the process of wines blending, using Monte Carlo methods for searching and selecting of those recipes that meet the requirements for obtaining the desired blending, called standard - an assortment of wine with well-defined characteristics. To verify and validate the system there has been developed an original stochastic model of the blending components properties. It has been allocated the standard unit value for each property. The properties of the recipes selected by the expert system are enclosed between the standard tolerances. Setting these tolerances is done interactively with the expert oenologist, correlated with the actual conditions of blending. Tests have shown the efficiency in selecting the optimum blending recipe both by high-speed search and by using of the optimization criteria adapted to the restrictions inherent to the actual situation of blending with well-defined natural ingredients. These criteria are interactively improved, by means of the oenologist expert..*

Key words: blending, Monte Carlo method, expert system

Rezumat. *S-a realizat un sistem expert de asistare a procesului de cupajare a vinurilor, care utilizează metode Monte Carlo pentru căutarea şi selectarea reţetelor care satisfac cerinţele impuse pentru obţinerea cupajului dorit, numit etalon - un sortiment de vin cu caracteristici bine definite. Pentru a se verifica şi valida sistemul, s-a elaborat un model stochastic original al proprietăţilor componentelor cupajului şi s-a alocat pentru toate proprietăţile etalonului valoarea unitară. Reţetele selectate de sistemul expert au proprietăţile cupajului încadrate între toleranţele aferente etalonului. Stabilirea acestor toleranţe se realizează interactiv cu expertul oenolog degustător în corelaţie cu condiţiile reale de cupajare. Testele efectuate au dovedit eficienţa sistemului în selectarea reţetei optime de cupajare atât prin viteza mare de căutare, cât şi prin utilizarea de criterii de optimizare adaptate restricţiilor inerente situaţiei reale a cupajării cu componente fizice bine definite, criterii perfecţioate interactiv cu expertul oenolog.*

Cuvinte cheie: cupajare, metoda Monte Carlo, sistem expert

INTRODUCTION

Blending means combining several types of wines. Blending is art and innovation; varieties of wine are chosen so as to complement each other in a unique and charming manner. At this time, the most searched in terms of wines is blended wine.

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Blending means - beyond the combination of at least two wines that complement each other leading to obtaining a work of art - uniqueness in taste, color and aroma. It takes artistic sense, talent, inspiration, and courage in combation of the proportions and varieties. What results is a close "friendship" between varieties of wine, unique harmony and personality, because nowhere in the world you will find the same varieties combined in the same way. One have a mystery in every glass of wine. There are two important things one should know about the blending process: what can be done and what can not be done.

MATERIAL AND METHOD

Defining the problem of blending wines

It is determined a prescription dose of a *nv* wines with the characteristics *V[p,s]* in order to obtain a mix similar with the standard, with mass *MR*, defined by the propieties *R[p]* and tolerances *Tr[p]* compared tostandard, where:

$$Tr[p]=100*(R[p] - E[p]) \quad (1)$$

Similar means that the properties of the result are assigned to the tolerances for the standard:

$$R[p] \in E[p] \cdot(1 \pm Te[p]/100) \quad (2)$$

The blending recipe is defined by the dose coefficients *k[s]* through the relation:

$$\sum_{1}^{nv} k[s] = 1 \quad (3)$$

The *MR* mass of the mixture resulted by blending is the sum of the dosed masses *MD[s]* from each component *V[s]*:

$$MR = \sum_{1}^{nv} MD[s] \quad (4)$$

where:

$$MD[v] = k[s] \cdot MR \quad (5)$$

This means that the calculation algorithm should determine an optimum recipe *Ro [p]* with errors *Tro[p]* to meet an optimization criterion that (*CO1*) can be defined as:

$$CO1 = \sum_{1}^{ntp} ABS(Tro[p]) = \min \quad where \;\; ABS(Tro[p]) \le Te[p] \quad (6)$$

or as a quadratic index:

$$CO1^{*} = \sum_{1}^{ntp} (Tro[p])^2 = min \quad (7)$$

Blending algorithm

The result *R[p]* of the blending process can be defined with the relation:

$$R[p] = \sum_{1}^{nv} V[s,p] \cdot k[s] \quad (8)$$

which represents a relationship with *nv* terms. As *ntp* properties there are taken into account, a system of *ntp* linear equations with *nv* variables results, which is characterized by:

$$nv < ntp \quad (9)$$

As a result, the algorithm for determining the optimal values for *k[s]* has to be designed as an overdetermined system.

RESULTS AND DISCUSSIONS

Defining the principles of Monte-Carlo method

In order to check the convergence of procedures for determining the solutions of a system of *ntp* properties with *nv* blending components, it was designed a dimensionless approach of structure of the coefficients of concentration which determines the *E[p]* properties of the standard and those of the blending wines components, *V[p, s]*. For all values of the standard proprieties, the dimensionless value 1 was adopted at this stage:

$$E[p]=1 \tag{10}$$

It was considered that the standard is a average wine obtained in vineyard from a variety of vine in a long period of time, which have a registered trademark. In this acknowledge, because the basis for the blending is the current year's production denoted by index s=1, it will be considered (as an economic condition) that the share of current production in resulted blending mixture (mean value of coefficient *k[1]*) to be maximum in the selected *[v]* variant.

$$k[v,1] \Rightarrow Maxim \tag{11}$$

Another important aspect regarding the management of the blending process is the value for the *Te[p]* accepted tolerances, which decisively influence the real qualities of the product obtained by blending, as well as the algorithm for selecting the optimal blending variant.

The *Te[p]* tolerances required for the standard can be determined from the results of analysis of several batches of wine which were manually blended and which have been successfully marketed, being accepted and bought by customers. So, the limits of *Te[p]* were statisticaly established.

Manual blending is under the direct management of the expert oenologists, the optimal variant for blending being establishing through successive tests. In order to validate the procedures and the inference laws of the expert system, a model of the components entering in the blending process is necessary.

The model is sufficiently accurate, but must have a clear implementation procedure in order to be general and to satisfy a variety of situations that may arise in blending practice. The law who statisticaly governs the living world, and thus the viticulture, is the normal stochastic distribution (Gauss).

Procedures for generating the model

To achive the model, there will be used stochastic methods to generate the tolerances *Te[p]* with a range of values randomly generated, belonging to a uniformly distributed string, called SRU.

As the model to be as general as possible, there were established ranges where tolerances must fit.

The *V[p,s]* property values for the wine patterns entering in the blending process, will be generated from a random allocation, with a random number with normal distribution SRN. This way of modeling covers a very wide field of the possibilities to choose the components for blending.

The following is an example of this new, original method of modeling and simulation of the components of wine blending process. There were selected *ntp*=10 properties for the standard of wines and *nv*=4 wine components in the blending process. In table 1 there are presented the results of the modelling components of a blending dimensionless process.

Table 1

Proprieties and tolerances for the components of blending

p	E[p]	Te[p]	V[p,1]	V[p,2]	V[p,3]	V[p,4]
1	1	0.07	1.002	0.988	0.994	1.080
2	1	0.062	0.930	1.015	1.097	0.925
3	1	0.057	1.083	0.909	0.968	0.929
4	1	0.095	0.923	0.948	0.965	1.004
5	1	0.080	1.042	0.884	0.992	1.019
6	1	0.053	0.965	0.969	1.056	0.966
7	1	0.055	0.816	0.877	1.085	0.917
8	1	0.084	0.957	1.113	1.054	1.038
9	1	0.080	1.120	0.957	1.007	0.918
10	1	0.097	1.008	1.000	1.016	1.061

Principles of random sorting of the determined system *NV* x *NV*

To select a number of *nv* components from the *ntp* or *nv* components, it will be useed a Uniformly Distributed Random Stream (abbreviated UDRS) with values in the range 0 .. 1.

The range 0...1 is divided in *ntp* sectors with $\Delta=1/ntp$ value.

1. j:=0.
2. It generates a random number SRU.
3. It is calculated the *i* index of the equation: $i = Int(SRU/\Delta)+1$.
4. If *i* is repeating, continues from 2.
5. j:=j+1.
6. until j=nv

Results of the random search for the optimal solution of blending

There have been simulated experiments to determine the optimal solutions for blending. There were initiated 170 searches, resulting 16 acceptable solutions from which there were selected the first five with the lowest values for the optimization criterion *CO1*. It was also calculated an optimization criterion *OPT2* to reveal a higher weight given to the contribution for the current harvest.

In table 2.a there are presented the values for the blending coefficients *K[i]*, sorted by the value of the optimization criterion *CO1*. In table 2.b there are

presented the values of the dosing coefficients *Kd[i]* sorted by the value of the optimization criterion *K[1]*.

It can be seen the reduced contribution of (Cristea D., 2002) and (Rubinstein Y. R., Kroese P.D., 2008) components to achieve blending. As a result, there has been allocated the value 0 for *K[2],* where their values are very small. Solutions from the tables 3.a and 3.b have resulted.

Table 2.a

The best solutions of blending

Blending cofficients (Sort CO1)								
poz	**K[1]**	**K[2]**	**K[3]**	**K[4]**	**CO1**	**RAD**	**OPT2**	**∑K[i]**
1	0.3927	0.2946	0.4128	0.1313	0.00658	0	0.0167558	1.2314
2	0.3974	0	0.5784	0.0204	0.00716	1	0.0180171	0.9962
3	0.4127	0	0.5364	0.0407	0.00745	0	0.0180519	0.9898
4	0.4102	0.0073	0.5228	0.0465	0.00784	1	0.0191126	0.9868
5	0.4246	0.0003	0.5036	0.0565	0.00866	1	0.0203957	0.985

Table 2.b.

The best solutions of blending

Dose cofficients (Sort CO1)								
poz	**Kd[1]**	**Kd[2]**	**Kd[3]**	**Kd[4]**	**CO1**	**RAD**	**OPT2**	**∑Kd[i]**
1	0.31891	0.23924	0.3352	0.10663	0.00658	0	0.0206331	1
2	0.39892	0	0.5806	0.02048	0.00716	1	0.0179486	1
3	0.41695	0	0.5419	0.04112	0.00745	0	0.0178677	1
4	0.41569	0.0074	0.5298	0.04712	0.00784	1	0.0188603	1
5	0.43107	0.0003	0.5113	0.05736	0.00866	1	0.0200897	1

Table 3.a

The best solutions of blending

Blending cofficients (Sort K[1])								
poz	**K[1]**	**K[2]**	**K[3]**	**K[4]**	**CO1**	**RAD**	**OPT2**	**∑K[i]**
1	0.4246	0	0.5036	0.0565	0.00866	1	0.0204074	0.9847
2	0.4127	0	0.5364	0.0407	0.00745	0	0.0180519	0.9898
3	0.4102	0	0.5228	0.0465	0.00784	1	0.0191248	0.9795
4	0.3974	0	0.5784	0.0204	0.00716	1	0.0180171	0.9962
5	0.3927	0.2946	0.4128	0.1313	0.00658	0	0.0167558	1.2314

Table 3.b

The best solutions of blending

Dose cofficients (Sort K[1])								
poz	**Kd[1]**	**Kd[2]**	**Kd[3]**	**Kd[4]**	**CO1**	**RAD**	**OPT2**	**∑Kd[i]**
1	0.43120	0	0.5114	0.05738	0.00866	1	0.0200836	1
2	0.41695	0	0.5419	0.04112	0.00716	1	0.0171722	1
3	0.41879	0	0.5337	0.04747	0.00745	0	0.0177896	1
4	0.39892	0	0.5806	0.02048	0.00784	1	0.0196533	1
5	0.31891	0.23924	0.3352	0.10663	0.00658	0	0.0206331	1

No major changes of the hierarchy are noted, being reduced only the time and the complexity of the physical blending process. It must be noted a high percentage of the component (Cristea D., 2002), because it is closest to the properties of the standard, the production of that year being very close to the registered trademark commercial product.

CONCLUSIONS

1. It was developed a stochastic Monte Carlo type modeling and simulation for the wine properties that are used in the blending procedure, starting from the fact that the properties of biological products have laws of a random distribution, Gausian type.

2. In order to determine the optimum recipes of blending, there was developed an optimal random searching algorithm based on the principles of Monte Carlo methods.

3. Experimentation of the developed algorithm have confirmed that assumptions that led to the elaboration of this method are valid, resulting a powerful search convergence, with reduced working time and which provides to the oenologist expert more options that are very close to the required standard.

4. Searching algorithm has been incorporated into the expert system that manges the blending process.

5. Finally we can say that the method and the selection algorithm of the optimal solutions with Monte-Carlo methods offer a great flexibility in the process of improvement of the selection of an optimal variant of blending. It is very fast and can achieve a sufficient number of searches in order to find the best solution depending on the desired optimization criteria and the restrictions inherent in the real situation of phisycal blending.

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