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REGULAR ARTICLE

CASSAVA FORTIFICATION AND QUALITY EVALUATION

PEDHURU RUDO, TUARIRA MTAITA, MUTETWA MOSES*

Horticulture, Department of Agricultural Sciences; College of Health, Agriculture and Natural Sciences, Africa University, Box 1320, Old Mutare, Zimbabwe

ABSTRACT

The broad objective of this work is to improve the nutrient content of cassava flour by inclusion of cowpeas seed flour and cassava leaf powder to assess the effects of the cowpeas flour and cassava leaf powder inclusion on the nutrient quality and acceptability of the flour. Cassava tuber flour was fortified with cowpeas flour and from cassava leaves at 20% and 30% of dry weight. Standard methods were used for the determination of parameter such as protein and carbohydrates. All samples were analysed for potassium, phosphorus, calcium, magnesium, iron, and cyanide. Unfortified cassava had significantly lower ($P<0.05$) values (protein: 0.942%, P: 0.093%, K: 0.749 Mg: 0.052%, Fe: 5.008 ppm) than fortification with both cowpeas flour and cassava leaf flour. Fortification with cowpeas flour did not significantly ($P>0.05$) change the Ca content however they were significant ($P<0.05$) increases cassava leaf flour. Cyanide content increased significantly for Treatment LF_{20} and LF_{30} but remained unchanged for Treatment CW_{20} and CW_{30}. Both cowpeas and cassava leaves had significantly ($P<0.05$) lower carbohydrate content than cassava tuber flour. Both cowpeas and cassava leaves are excellent for fortification but cassava leaves have to be used with additional pre-treatments to reduce the cyanide content in them. Organoleptic qualities analysed indicate high acceptability of fortification of cassava tuber flour with cowpeas flour.

Keywords: Fortification, Cassava flour, Cassava leaves, Cowpeas flour, Nutrient, Organoleptic qualities

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is one among the important cultivated woody shrub in the family Euphorbiaceae and is used for food and feed purpose. Throughout the world, in tropical and subtropical areas, this crop is cultivated as an annual crop. Cassava roots are rich in carbohydrates [1]. Dependence on cassava diets therefore may lead to serious protein deficiency problems. Such malnutrition problem has been reported among consumers that rely primarily on cassava flour and other cassava products as major food source with little or no high protein food sources as complements. Cassava usually not eaten alone most times as a full meal but is rather taken with vegetable stew/soup/sauce that can provide other nutrients like protein.

The animal origin diet like meat, fish and egg are expensive items for people in low-income families in African region. The current exorbitant cost of animal protein especially for low income earners deters the inclusion of such animal protein source in the stew that cassava is eaten with. Improving the protein content of cassava may be an alternative and affordable option. The enriching of the cassava meal with high nutritional way can solve the problems of mal nutrition [2]. This makes the need to improve the protein quality of cassava imperative [3, 4] and to search for cheaper but good quality protein sources that are readily available [5].

In SADC region, the research on cassava crop seems scanty when compared to rice, maize and wheat. Fortification of cassava flour with plant protein is a viable affordable alternative to tackle specifically the problem of protein energy malnutrition in those areas affected by malnutrition. The plant protein can be sourced from unexploited indigenous legumes with high protein content (18.1 to 25.8 %) like cowpeas and cassava leaves, soybeans, and Bambara nuts among others. Cowpeas and cassava leaves unlike other mentioned plant protein sources have not found used in many food formulations as soybean [6].

This study addresses the problem of protein deficiency in cassava, a major staple food, using food-to-food fortification approach with the use of cowpeas and cassava leaves. The broad objective of this work is to improve the nutrient content of cassava flour by inclusion of cowpeas seed flour and cassava leaf powder to assess the effects of the cowpeas flour and cassava leaf powder inclusion on the nutrient quality and acceptability of the flour. It is envisaged that this will enhance the protein content of cassava, decrease the incidence of protein malnutrition among the less privileged cassava consumers in sub-tropical Africa and other developing countries. It is significant that the technology involved can be easily adopted domestically and at cottage level. Utilization of cowpeas and cassava leaves as cassava fortificant will improve its production and accessibility and also diversify the use of cassava.

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*Corresponding Author

Mutetwa Moses

Horticulture, Department of Agricultural Sciences, College of Health, Agriculture and Natural Sciences, Africa University, Box 1320, Old Mutare, Zimbabwe

Email: mosleymute@gmail.com

MATERIALS AND METHODS

Experimental details

Cassava root (*Manihot esculenta* Crantz) (Variety M7) was procured from Chiredzi research station, Chiredzi, Zimbabwe. Cowpea seed (variety CBC 2) was procured from Chiredzi research station, Chiredzi Zimbabwe and cassava leaves will be procured from Africa University Research Block, Mutare Zimbabwe.

***Preparation of Cowpeas into flour (CW_{100})*:** The cowpea seed is winnowed to remove any trash and milled using a hammer mill. The first 5 kg of the milled flour is discarded to make sure there is no contamination of the flour. The flour is put in a polythene bag until used for the study.

***Preparation of cassava flour (Control)*:** Harvested cassava roots are washed to remove all the dirty, the washed roots are peeled care should be taken that all peeled roots are kept under water to avoid discolouration. After peeling the roots are cut into small chips and fermented in water for 60 h. After 60 h the fermented cassava is drained to remove the water and sun dried. When completely dry the cassava is milled using a hammer mill. First 10 kg of the milled cassava is discarded to avoid contamination. The flour is put in polythene bags until used for the study.

***Preparation of cassava leaves flour (LF_{100})*:** Cassava shoots approximately 20 cm in length are harvested, the hard petioles are removed and the leaves are sun dried. When completely dry the leaves are milled using an electric miller. The flour is put in a polythene bag until used for the study.

Preparation of the fortified cassava flour

***20% cowpea concentration (CW_{20})*:** Cassava flour was randomly sampled by scoping the flour to make up a sample of 1500g. Cowpeas flour was also randomly sampled to make up 300g. The cassava flour and cowpea flour were thoroughly mixed together and the mixed flour was divided to make three equal samples.

***30% cowpea concentration (CW_{30})*:** Cassava flour was randomly sampled by scoping the flour to make up a sample of 1500g. Cowpeas flour was also randomly sampled to make up 450g. The cassava flour and cowpea flour were thoroughly mixed together and the mixed flour was divided to make three equal samples.

***20% cassava leaf concentration (LF_{20})*:** Cassava flour was randomly sampled by scoping the flour to make up a sample of 1500g. Cowpeas flour was also randomly sampled to make up 300g. The cassava flour and cowpea flour were thoroughly mixed together and the mixed flour was divided to make three equal samples.

***30% cassava leaf concentration (LF_{30})*:** Cassava flour was randomly sampled by scoping the flour to make up a sample of 1500g. Cowpeas flour was also randomly sampled to make up 450g. The cassava flour and cowpea flour were thoroughly mixed together and the mixed flour was divided to make three equal samples.

Chemical analysis

Protein and Carbohydrate were determined according to AOAC [7]. The micronutrients including magnesium, potassium, cyanide, calcium and iron were evaluated using an Atomic Absorption Spectrophotometer (Buck 210VGP) Germany according to AOAC [7].

Sensory analysis

The organoleptic evaluation of the biscuits samples was carried out for consumer acceptance and preference. Samples of the biscuits prepared from the cassava tuber flour and the different cowpeas and cassava leaf composite flour. Consumers evaluated the treatments on overall appreciation, taste, color and odour of the flour. Scores were given against the choice and preferences of the respondents.

Statistical analysis

All data collected to be statistically analyzed using the GenSTAT Analysis of Variance (ANOVA) software. Differences between means were determined using the Least Significant Difference (LSD) test at 0.05 level.

RESULTS

Nutrient content from fortified cassava tuber flour

Nitrogen (N)

Data regarding the fortification of cassava tuber flour (CTF) with cowpeas flour (CWF) and cassava leaf flour (CLF) showed significant ($P<0.05$) differences for the nitrogen content. Results show that CTF (Control) has the least amount of nitrogen (0.151%) in comparison to CLF (Treatment LF_{100}) and when fortified with either CLF or CWF.

Results show that CLF (Treatment LF_{100}) have has higher nitrogen (4.780%) content than CWF (Treatment CW_{100}) (3.445%). After fortifying the CTF, Treatment LF_{30} produced the highest amount of nitrogen (1.220%) while treatment CW_{20} had the least (0.727%). Treatment CW_{30} and Treatment LF_{20} produced result which were not significantly ($P>0.05$) different from each other (table 1).

Table 1: Chemical composition of flours

Treatment	N %	Protein %	P %	K %	Mg %
Control	0.151^{a}	0.942^{a}	0.093^{a}	0.749^{a}	0.052^{a}
CW_{100}	3.445^{e}	21.529^{e}	0.366^{d}	1.304^{f}	0.150^{e}
LF_{100}	4.780^{f}	29.877^{f}	0.365^{d}	1.873^{g}	0.302^{f}
CowPea $^{(CW)}$					
CW_{20}	0.727^{b}	4.542^{b}	0.136^{bc}	0.847^{b}	0.067^{b}
CW_{30}	0.910^{c}	5.687^{c}	0.143^{bc}	0.867^{c}	0.070^{b}
Cassava Leaf $^{(LW)}$					
LF_{20}	0.917^{c}	5.729^{c}	0.130^{b}	0.943^{d}	0.090^{c}
LF_{30}	1.220^{d}	7.628^{d}	0.161^{c}	0.990^{e}	0.107^{d}
$LSD_{0.05}$	0.0497	0.3106	0.025	0.015	0.0064
Significance	***	***	***	***	***
CV%	1.6	1.6	7.1	0.8	3.0

***denotes significance at $P<0.001$

Protein

Table 1 shows that the fortification of CTF with different proportions of CLF and CWF was significant ($P<0.05$). CTF was had the least protein content (0.942%) in comparison to CLF and CWF which had 21.529% and 29.877% respectively.

After fortifying CTF, Treatment LF_{30} had highest protein content (7.628%) while Treatment CW_{20} had the least protein content (4.542%). Results for Treatment LF_{20} and CW_{30} were not significantly ($P>0.05$) different from each other, with 5.729% and 5.687% respectively.

Phosphorus (P)

Data pertaining to fortification of cassava tuber flour with varying proportions of cassava leaf flour and cowpea four is shown in table 1. Results from the investigation of the study show that fortifying CTF was significant ($P<0.05$) at all levels for the CWF and CLF used. The P content in both CWF and CTF was significantly ($P<0.05$) higher than CTF but not significantly ($P>0.05$) different from each other.

Treatment LF30 produced the highest P content (0.161%) and it was not significantly different from Treatment CW20 and CW30 which produced 0.136% and 0.143% respectively.

Potassium (K)

The Control treatment had the least (0.749%)) potassium (K) content with respect to CW_{100} and LF_{100} which had 1.304% and 1.873% respectively (table 1). Results from this investigation show that treatments from fortification of CTF with CLF produced significantly ($P<0.05$) higher K content than treatments from fortification with CWF. Treatment LF_{30} produced the highest K content (0.990%) followed by Treatment LF_{20} (0.943%) while Treatment CW_{20} and CW_{30} had 0.847 and 0.867% respectively.

Magnesium (Mg)

The Mg content from the Control treatment, Treatment CW_{100} and Treatment LF_{100} was significantly ($P<0.05$) differently from each other with treatment LF_{100} having the highest Mg content (0.302%). Similarly, fortification of CTF with CLF produced significantly more Mg content as observed in Treatment LF_{20} (0.090%) and LF_{30} (0.107%) compared to Treatment CW_{20} and CW_{30} with Mg content; 0.067% and 0.070% respectively (table 1).

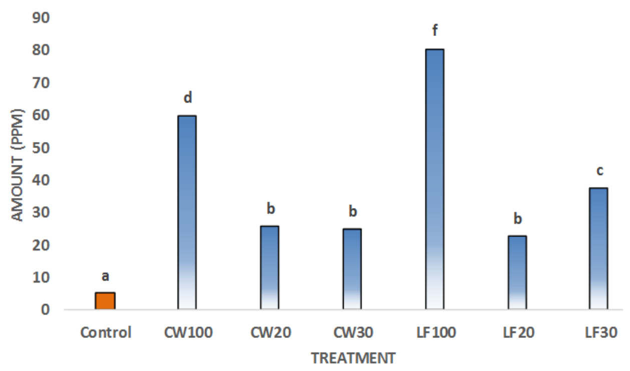

Fig. 1: Shows the influence of fortification on Fe content

Iron (Fe)

Results pertaining to Fe content show that the Control treatment has significantly the lowest (5.008 ppm) Fe content in comparison to CW_{100} and LF_{100} with 60.034 ppm and 80.517 ppm respectively (fig. 1). Fortification of CTF with CWF from level treatment CW_{20} to level treatment CW_{30} did not significantly ($P>0.05$) increase the Fe content. However, Fe content increased significantly ($P<0.05$) from level treatment LF_{20} to level Treatment LF_{30}.

Calcium (Ca)

Results from the investigation reveal that the calcium (Ca) content in the Control treatment and CW100 was not significantly ($P>0.05$) different from each other (fig. 2). Similarly, fortification of CTF with CWF was not significant ($P>0.05$) at all levels. However, Ca in CLF was 8 times more than that in CTF such that the Treatments LF_{20} and LF_{30} produced Ca content which was significantly ($P<0.05$) more than Treatment CW_{20} and CW_{30}. The more the proportion of CLF used in the fortification of the CTF the more the Ca content that was obtained and this is true for Treatment LF_{20} and LF_{30}.

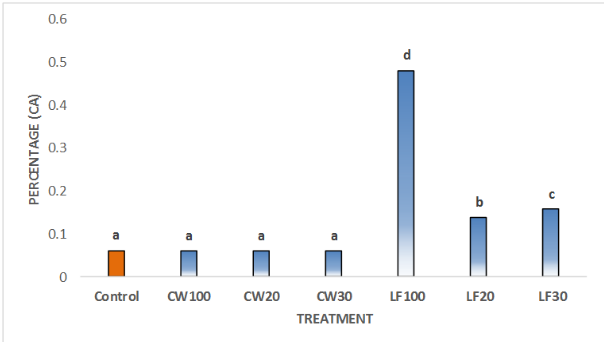

Fig. 2: Shows the influence of different fortifying agents on Ca content

Cyanide (CN)

Data pertaining to the CN content in the Control treatment, CW_{100}, LF_{100} and fortified CTF at different levels is shown in fig. 3. The CN content in the Control treatment and CW_{100} was not significantly ($P>0.05$) differently from each other. Similarly, the fortified CTF with both levels of CWF (CW20 and CW30) did not significantly influence any change to the CN content. However, fortification of CTF with CLF increased the CN content significantly ($P<0.05$) as observed from Treatment LF_{20} and LF_{30} (fig. 3).

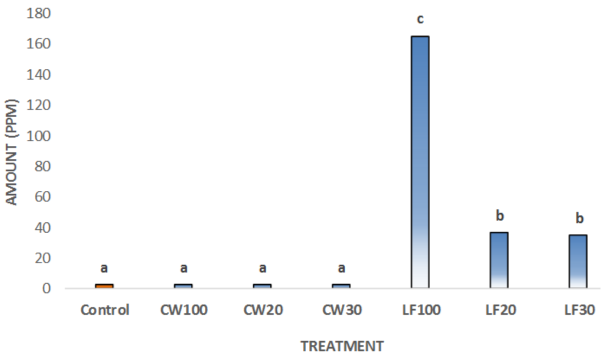

Fig. 3: Shows the influence of different fortifying agents on CN content

Carbohydrate

Results from the investigation reveal that LF_{100} has significantly (P<0.05) lower carbohydrates compared to CW_{100} (36.044%) and CTF (73.225%). Similarly, fortification of CTF with CWF and CLF at different levels significantly (P<0.05) reduced the carbohydrate content (fig. 4).

Organoleptic tests

Overall appreciation

Results for the overall appreciation of the unfortified cassava and fortified cassava with either cowpeas or cassava leaves are shown in table 2. The fig. show that 36 out of the 50 respondents scored very good to the overall appreciation of the Treatment CW_{20} and 18 respondents also scored very good to Treatment CW_{30}. Treatment CW_{30}, LF_{20} and LF_{30} had each 2 respondents who scored excellent on the overall appreciation of the levels of cassava fortification. Treatment LF_{20} and LF_{30} had 4 respondents each who scored poor on the overall appreciation.

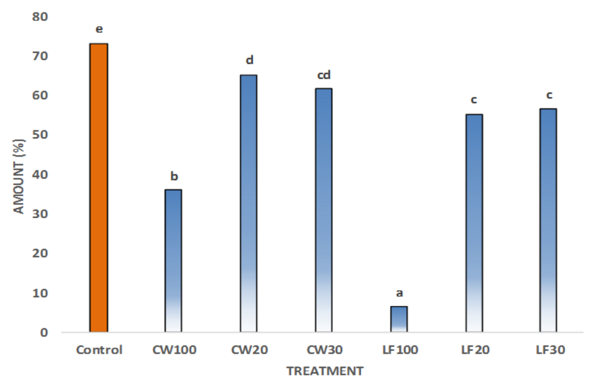

Fig. 4: Shows the influence of different fortifying agents on carbohydrate content

Overall taste

Data pertaining to the overall taste preferences recorded from the survey is shown in table 3. Out of the 50 respondents 6respondnents scored excellent for the overall taste of cassava. Twenty-eight respondents scored very good for the overall taste of the Control treatment while only 2 respondents did not like the taste of cassava. After fortification of cassava, Treatment CW_{20} and Treatment CW_{30} recorded 12 and 4 respondents respectively who scored excellent for the overall taste. The preference for Treatment LF_{20} and LF_{30} was somewhat lower as there were more respondents who scored poor and fair compared to the fortification of cassava with cowpeas.

Appearance of the flour

Data regarding the opinions of the respondents towards the appearance of the treatments is shown in table 4. For the Control treatment, CW20 and CW30 all the respondents scored good, very good and excellent. However, for Treatment LF20 and LF30 the preferences of the respondents were showing that the fortification of cassava with different levels of cassava leaves was unpopular as the color of the flour became more colored than being white. There were fewer respondents who score very good and excellent than those who scored fair to poor preferences of appearance. Fortification with cowpeas were the most preferred treatments.

Odour of the flour

Data from the respondents regarding their preferences towards the odour of the flours under study is shown in table 5. The Control treatment, Treatment CW_{20} and Treatment CW_{30} reveal that they have a got moderate to no odour which is most preferred by the respondents. However, fortification of cassava tuber flour with flour from cassava leaves, as in Treatment LF_{20} and LF_{30} was relatively unpopular since the treatments somewhat produced a more moderate to strong odour.

Table 1: Responses for overall appreciation

Treatment	Poor	Fair	Good	Very Good	Excellent
Control	4	-	4	26	12
CW_{20}	-	44	12	36	-
CW_{30}	-	4	42	18	2
LF_{20}	4	20	8	14	2
LF_{30}	4	12	10	14	2

Table 2: Responses for overall taste

Treatment	Poor	Fair	Good	Very good	Excellent
Control	2	-	8	28	6
CW_{20}	-	2	4	26	12
CW_{30}	-	-	6	30	4
LF_{20}	4	18	16	4	-
LF_{30}	2	10	20	10	-

Table 3: Responses for appearance of the flour

Treatment	Poor	Fair	Good	Very Good	Excellent
Control	-	-	10	24	10
CW_{20}	-	-	10	18	14
CW_{30}	-	-	14	20	8
LF_{20}	6	12	16	2	4
LF_{30}	4	16	14	2	4

Table 4: Responses for flour odour

Treatment	No odour	Questionable odour	Moderate odour	Strong odour	Severe odour
Control	28	12	2	-	-
CW_{20}	24	16	2	-	-
CW_{30}	18	24	2	-	-
LF_{20}	6	8	26	4	-
LF_{30}	4	8	28	4	-

DISCUSSION

Traditionally, the roots of cassava are harvested and processed by many methods and produce different food products for diverse purposes. Cassava which is an important staple in the Sub-Tropics is low in protein and deficient in essential amino acids. However, the protein content of all composite flours with different levels of both CWF and CLF increased as a result of the significantly more nitrogen that is in cowpeas and cassava leaves than cassava tubers. Therefore, the more the proportion of cowpea or cassava leaf flour is added the more the protein content is obtained in the composite flour. It has been reported that fortification of cassava with soybean or cowpea extract increased the protein content of cassava [6, 8]. In a similar study using soya bean by Collins and Falasinnu, they observed that legumes are generally high in their protein content and proposed that they make an ideal source for protein supplementation [9]. This observation agrees with previous findings of several researchers [10-12].

The results of the P content of CTF, CWF and CLF are shown in table 1. Significantly ($P<0.05$) unfortified cassava tuber flour has got less phosphorus than CWF and CLF. The increase in the P content of the CTF was as a result of adding either CWF or CLF. These results agree with the work by Anuonye *et al.* [13] on fortifying cassava with yams.

There was also a corresponding increase in most of the other elements with increase in either CWF or CLF. The K content increased significantly ($P<0.05$) with fortification of the cassava tuber flour, similarly Mg and Fe content from CWF and CLF is significantly ($P<0.05$) superior to CTF. The Ca content of cassava tuber flour and cowpea flour does not differ significantly ($P>0.05$) from each. As a result, fortification of CTF will not benefit in increased Ca content of the product. Similar results were observed in the work of Anuonye *et al.* [14]. However, the Ca content in cassava leaves is significantly more than that in the tubers [15]. Therefore, as expected, to improve the Ca content in CTF fortification with the flour from its leaves will benefit as expressively observed for Treatment LF_{20} and LF_{30}. This is attributed to the replacement of the cassava tuber flour with calcium-rich flour from cassava leaves.

Fig. 1 shows that cassava tubers have significantly much less Fe content than cowpeas and cassava leaves. The increase in the Fe content of the fortified CTF is as a result of adding the flour of cowpeas and/or cassava leaves. Treatment LF_{20} produced the same effect with Treatment CW_{30} revealing that cassava leaves are very rich in Fe content.

Results obtained in this study show that CTF has significantly ($P<0.05$) more CHO content that the products from the fortification with cowpea flour or flour from cassava leaves. Correspondingly, there was a significant ($P<0.05$) decrease in the CHO content of the CTF with addition of flour from cowpeas and cassava leaves. This is attributed to the fact that there is poor CHO content in both cowpeas like any other legume and cassava leaves. As a result, there was no significant difference in the CHO content by increasing the level of either CWF or CLF. These results are similar to those obtained in the work of Obadina *et al.* [16] with soya beans.

The total CN content of the simple cassava tuber-flour is very low and statistical not significantly different with the CN content in cowpeas flour (fig. 3). Fortification of CTF with CWF at all levels did not result in any change of the CN content. However, fortification of CTF with CLF increased the CN content in the composite flour significantly ($P<0.05$). This is attributed to the very high CN content in CLF and the replacement of the low CN content flour with high CN content flour in the composite flour.

The organoleptic Test investigated the overall consumers' appreciation as well as taste preferences, preferences in terms of color appearance and odour of the flour. Unlike those countries in central Africa were cassava is a staple and there are many dishes that have been developed from cassava, in Zimbabwe our staple is maize. An appreciable number of Zimbabweans do eat cassava and the numbers are increasing as more and more people are being to eat a wide range food. So, it was expected that the results from this investigation was likewise influenced by the fact that cassava is not a very popular dish in the region. For the overall appreciation however, the product from fortifying with cowpeas flour was rated better from good to excellent. Similarly, with regards to taste preferences and appearance fortified cassava tuber flour with cowpeas flour scored more from good to excellent as well. With regards to the odour of the composite flours, more respondents said that the composite flour with cowpeas had no odour to questionable odour. However, for the composite flour with cassava leaves more respondents said that it had a moderate to strong odour. These results are attributed to the fact that cowpeas are already an acceptable food unlike cassava leaves.

CONCLUSION

The results of this study have shown that substitution of both cowpeas flour and cassava leaves in cassava tuber flour is possible. Both cowpeas flour-fortified cassava tuber flour and cassava leaf flour-fortified cassava tuber flour could be used to fight macronutrient and micronutrient deficiencies. The mineral composition of the cassava tuber flour was enhanced as a result of the flour substitution. The composite flour could help in reducing protein energy and micronutrient deficiency prevalent in developing countries such as Zimbabwe. Cassava tuber flour can be fortified by adding flour from cassava leaves however, these results shows that the fortification with cassava leaf flour leads to increase in cyanide content and organoleptic challenges. It is concluded that protein, phosphorus, potassium, magnesium and iron content in cassava tuber flour could be enriched with up to 30% cowpeas flour without organoleptic challenges.

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AUTHORS CONTRIBUTORS

All authors contributed equally in the development of this paper

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