

Final report

for the CORE Organic Plus funded project

“Drying, Juices and Jams of Organic Fruit and Vegetables: what happens to Desired and Non-Desired compounds? FaVOR-DeNonDe”

Period covered: 30 March 2015 - 29 March 2018

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1. Consortium

Project acronym:	FaVOR-DeNonDe	Project ID:	849
Project title:	Drying, Juices and Jams of Organic Fruit and Vegetables: what happens to Desired and Non-Desired compounds?		
Project website:	http://coreorganicplus.org/research-projects/favor-denonde/		
Start of project:	30/03/2015	End of project:	29/03/2018
Duration in months:	36		
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1) University, Public research centre, Private research centre, Company, Other

2) PC = Project coordinator, WPL = Work package leader, WPCL = Work package co-leader, P = Participant

2. Summary

2.1 Post-term project summary suitable for web publication

The main activity was related to quantitative data on commonly consumed fruit (strawberry, plum, apple) and vegetables (tomato and sweet bell pepper) along some processing chains (jam, juices and dried products), pointing out the role of different sources of variability, such as the type of cultivation (Conventional, CONV or Organic, ORG), the different cultivars, the sampling year, and the type of processing and how these processing chains affect the quality of the products. A particular attention has been paid on the type of processing, where the use of innovative processing machines was performed, in comparison with traditional or home-made processing technologies. This for the need, especially for local and small farmers, of small and simple plants to process agricultural products, in order to add value for their productions, for achieving high quality and safe products.

For this scope three types of approaches for processing were used:

- a miniaturized multifunctional processing line (MT), already validated in previous Projects, in comparison with home-made technique (HM) for jam strawberry production;
- a pneumatic press, a rack-press and a belt-press compared for the production of apple juices;
- an innovative drier, completely supplied by solar energy (SUN) compared with a traditional forced air oven-drier (OVEN) was used for the production of prunes, dried tomatoes and sweet bell peppers.

The list of analyzed samples is shown below:

SCHEME OF ANALYZED SAMPLES (ORG is Organic, CONV is Conventional)

Species	Variety	Country	Sampling	Processing	Year	Analyses
Apple	Sügisjooknik	Estonia	ORG	juice	2015	1, 3, 4, 5
	Krameri tuviõun	Estonia	ORG + CONV	juice	2015	
	Krista	Estonia	ORG + CONV	juice	2015	
	Talvenauding	Estonia	ORG + CONV	juice	2015	
	Cortland	Estonia	ORG	juice	2015	
	Aroma	Denmark	ORG	juice	2015	
	Ahrista	Denmark	ORG	juice	2015	
	Rubinstep	Denmark	ORG	juice	2015	
	Discovery	Norway	ORG	juice	2015	
	Karen Schneider	Norway	ORG	juice	2015	
Aroma	Norway	ORG + CONV	juice	2015		
Apple	Liivi kuldrenett	Estonia	ORG + CONV	juice	2016	1, 3, 4, 5
	Krameri tuviõun	Estonia	ORG + CONV	juice	2016	
	Talvenauding	Estonia	ORG + CONV	juice	2016	
	Cortland	Estonia	ORG + CONV	juice	2016	
	Tellissaare	Estonia	ORG + CONV	juice	2016	
	Sputnik	Estonia	ORG + CONV	juice	2016	
	Ahrista	Denmark	ORG unsprayed	juice	2016	
	Ahrista	Denmark	ORG sprayed	juice	2016	
	Aroma	Denmark	ORG	juice	2016	
	Aroma	Norway	ORG + CONV	juice	2016	
	Bramleys Seedlings	Norway	CONV	juice	2016	
	Discovery	Norway	ORG + CONV	juice	2016	
	Santana	Norway	ORG + CONV	juice	2016, 2017	
	Apple	Liivika	Estonia	ORG	juice	
Alesja		Estonia	ORG	juice	2017	
Katre		Estonia	ORG	juice	2017	
Antonovka		Estonia	ORG	juice	2017	
Antei		Estonia	CONV, BITTER PIT	juice	2017	
Krameri tuviõun		Estonia	CONV, BITTER PIT	juice	2017	
Talvenauding		Estonia	ORG + CONV, SCALD	juice	2017	
Plum	Jubileum	Denmark	ORG + CONV	raw	2015 + 2016	1, 5
	Tophit	Denmark	ORG + CONV	raw	2015 + 2016	
	Opal-Valor	Denmark	ORG + CONV	raw	2015 + 2016	
	Jubileum	Norway	ORG + CONV	drying	2015 + 2016	
	Reeves	Norway	ORG + CONV	drying	2015 + 2016	
	Victoria	Norway	ORG + CONV	drying	2015 + 2016	
Strawberry	Asia	Italy	ORG + CONV	puree + drying	2015 + 2016 + 2017*	1, 3, 5
Tomato	Perbruzzo F1	Italy	ORG + CONV	drying	2015 + 2016 + 2017*	1, 2, 3, 5
	SAAB	Italy	ORG + CONV	drying	2015 + 2016 + 2017*	
Sweet pepper	Alceste F1	Italy	ORG + CONV	drying	2015 + 2016 + 2017*	1, 2
	RTV	Italy	ORG + CONV	drying	2015 + 2016 + 2017*	

1: phytochemicals. 2: taste active compounds. 3: sensory analyses. 4. patulin. 5: allergens.

* samples analyzed in raw or freeze-dried state

The processed samples were produced in open field on two consecutive sampling years (2015 and 2016), on experimental fields. A third year of sampling was added, considering the evaluation made on raw products.

Moreover, for tomato and sweet bell pepper, the production made from open fields of private organic growers, was considered, so obtaining samples in two consecutive years (2016 and 2017).

Hence, a further comparison of the quality indexes was made on raw products in three consecutive years (2015, 2016 and 2017).

The control samples were represented by the lyophilized material, generally referred as “raw” or “not treated” sample.

The considered quantitative data regarded "Desired" and "Non Desired" compounds, being the desired ones those potentially healthy and tasty for humans, such as phytochemicals, antioxidants and volatiles, and the non desired some anti-nutritional traits, such as the mycotoxin patulin and the presence of allergens. The samples were also evaluated by their sensory properties using a trained panel.

As for the allergen analysis, they were analyzed by indirect competitive ELISA for determination of Bet v 1-related protein, or pathogenesis-related proteins (PR-10), causing birch pollen related fruit allergies.

A big amount of data was collected, with a consequent variability among them. The general consideration about desired compounds that can be made is that, if a well detectable difference in composition has been found in raw product, this difference was also retained in the processed one, with the processing technique strongly influencing the qualitative parameters of the final products. In this context, better results in terms of antioxidant presence were found for:

- apple juices obtained from belt-press;
- strawberry jams obtained with miniaturized small-scale plant;
- prunes, tomatoes and sweet bell pepper obtained with oven drying.

On the other hand, it has to be pointed out that processing methods causing a lower retention on the phytochemical contents often show a better response in term of sensory properties, as found in apple juices and in solar-dried samples of strawberries, plums and tomatoes.

Some differences were found among the assayed cultivars, and, finally, among the comparison of the system of cultivation (ORG vs CONV).

Specifically, the system of cultivation mainly influenced the antioxidant content in apples of traditional cultivars of Estonia obtained from aged plants; as for strawberry, it was found an higher amount of antioxidants in organic samples in one year of three, and a significant increase in ascorbic acid was found in the assayed local variety of organic bell pepper, in all three years, but not in the corresponding commercial hybrid. On the other hand, the plum cultivar Jubileum, assayed from Denmark and Norway in two years, resulted not adapted for organic cultivation for the content in ascorbic acid, constantly giving lower indexes in all samples in comparison with fruits from conventional cultivation.

As regards the influence of the sampling years, in samples of apples, plums, tomatoes and sweet bell pepper, a tendency to an increase in phytochemicals and antioxidant indexes was detected in 2016 compared to 2015 samples, due to the very different climate conditions of these two years.

Interestingly, for the non desired traits, no clear relationship was found between the presence of patulin and allergens for the systems of cultivations, but significant variations were found regarding processing techniques, sampling years and the assayed cultivars. Interestingly, for some apple cultivars from Estonia low levels of the allergen Mald1 were detected.

Concluding, the sources of variability among the analyzed samples gave, in order of influence, the following ranking:

- 1. Processing techniques;
- 2. Years of sampling;
- 3. Cultivars;
- 4. Growing methods.

2.2 Short process update of the whole project

The Project achieved its objectives, with the main one represented by the determination of compositional changes in differently processed samples of organic fruit and vegetables. The main change in quality

indexes regarded the different sustainable and small-scale processing techniques, compared with traditional and home-made ones. Another source of variability has been given by the different genotypes used for the experiments: this means that an important factor for quality assessment during the processing chain is the correct choice of the genotype, or cultivated variety. A deep work on the compositional profile for "desired" and "non-desired" compounds of the raw and the processed products were performed and the resulting data were correlated to the sensory data.

A relatively unexpected aspect was the big variation within different sampling years, but this can be justified by the deep climatic changes over the two main years of sampling, especially in Northern Europe. Just as an example, plums from Norway were harvested on 22 September in 2015, and on 6 September in 2016. Generally, little variations were seen from the ORG-CONV comparison, some changes were detected in raw, untreated samples whereas these differences disappeared in processed products.

3. Main results, discussion, conclusions and fulfilment of objectives

3.1 WP1

WP1	Relationship between sensory quality, secondary metabolite profile and antioxidant capacity in raw and processed products from organic agriculture (apple, plum, strawberry, tomato, sweet pepper)
WP leader: Prof. Ulla Kidmose, Partner 4 (Denmark) Responsible partners: Partner 1, 6 and 7 (Italy), Partner 3 (Norway) and Partner 2 (Estonia).	
<p>Overall summary of main results, discussion and conclusions of WP1</p> <p>The processed samples were analyzed over two consequent sampling years (2015 and 2016), with same assayed genotypes in CONV and in ORG conditions. Raw samples of plums were compared over two consequent sampling years (2015 and 2016), for three diffused genotypes from experimental fields located in Denmark and Norway. The raw products of strawberry were compared over three consequent sampling years (2015, 2016 and 2017), on the cv Asia, noted for its suitability to ORG conditions of cultivation. However, sensory evaluation was only carried out on the 2016 samples due to mould in the other samples. The raw products of tomato and sweet bell pepper were compared over three consequent sampling years (2015, 2016 and 2017), both on experimental fields located in CREA-ORA, Monsampolo del Tronto (Partner 6) and from private organic growers on 2016 and 2017. Sensory evaluation was carried out on the 2015 and 2016 samples.</p> <p>The metabolite profile was obtained by chromatographic and spectrophotometric analyses both in raw and in processed samples: soluble solid content, pH and titratable acidity, ascorbic acid content, total phenol content, total carotenoid content and volatile production. In tomato samples, known for their "Umami" and "Kokumi" taste, the presence and concentration of taste active compounds (mainly glutamic acid and glutathione) was assessed. The antioxidant capacity was measured by an EPR approach on extracts of apple juices and plums, by evaluating the scavenging activity against DPPH radical and superoxide anion in some samples. The volatile production was assessed by gas-chromatography-mass spectrometry, coupled with an Olfactometric analysis to evaluate the odour impact of volatile components of the analyzed samples.</p> <p>The main differences in quality indexes were found among different processing techniques, sampling years, assayed genotypes and systems of cultivations, in this order of importance.</p> <p>Interestingly, for sweet bell pepper, the difference found for the type of cultivation was also related to the type of used genotypes, where the local variety, well adapted to the territory of cultivation (Central-East Italy), showed a good response in ORG conditions with respect to CONV one, whereas the used commercial hybrid did not show the same response. A similar situation, where the response ORG-CONV - was very differentiated among assayed cultivars was in raw plum, assayed from Denmark and Norway on 2015 and 2016.</p> <p>One of the main clear results about the impact of processing on the quality was detected in dried strawberries: SUN dried ones resulted much more tasty than OVEN ones, a full accordance was found between volatiles detection and quantification and sensory evaluation.</p>	

Report on the results obtained (A), and fulfilment of objectives (B)

A- results obtained:

A more detailed view of the results obtained in WP1 have been reported in Deliverables 5 and 6 (D5 and D6), where the D5 have reported the data on processed samples, while in D6 the main quality indexes and their changes were reported for raw and starting products.

Apple

Samples of apple juices, used for the experiments described in WP3 were obtained by waterpress, analyzed in 2015 and 2016, showed some differences in the phenol content associated with the antioxidant capacity, measured by the DPPH method with an EPR approach. These differences were mainly due to the assayed cultivars, to the year of sampling, and to the type of growing. The general trend in the values was that in 2016 (average 13.3 ± 4.0 mg Trolox eq. /100 mL) higher antioxidant values than 2015 (average 9.6 ± 2.4 mg Trolox eq. /100 mL) were found, and that ORG cultivars from Estonia generally showed higher indexes than the corresponding in CONV conditions. This difference was not found for apple juice samples from Denmark and Norway.

In 2015, raw fruits have been analyzed and the corresponding antioxidant indexes were higher in the raw fruits than in the juices, as expected. Interesting variations in the retention of the antioxidants due to the processing were found among the assayed cultivars. In 2016, the juices were also analyzed at the unpasteurized status, in order to check the additional effect of thermal treatments. Also in this case, differentiated effects of retention or great loss of antioxidants was found among the assayed cultivars.

Plum

Plums were obtained from Denmark (Jubileum, Tophit, Opal, Valor) and Norway (Jubileum, Reeves, Victoria), with different cultivars over two sampling years (2015 and 2016), cultivated in ORG (defined as "not sprayed") and CONV, assayed for the main quality indexes and for the presence of phytochemicals with antioxidant action, such as ascorbic acid and phenols. The plums from Norway were also subjected to drying, by comparing two methods, one traditional by forced-air oven, and another by an innovative solar drying.

The most interesting differences were in the type of drying, performed in 2015 and in 2016, with a better retention of caffeic acid derivatives, the most correlated one with Folin-Ciocalteu index, in oven-drying, while anthocyanins were better retained in solar-dried samples.

The raw fruits showed differences among the assayed cultivars, the sampling years, while the type of cultivation showed variability within the samples, with no general relevant changes between ORG and CONV. The only cultivar that showed a clear variation between ORG and CONV was Jubileum for the ascorbic acid, with a constant lower content in ORG than CONV: this in all assayed samples. On the other hand, the levels of neo-chlorogenic acid, the most important phenol compound in plum, was subjected to significant changes only among assayed cultivars (high values in Valor 2016, Denmark, and in Victoria 2016, Norway).

Strawberry

The quality of strawberries, both processed and raw, was strongly influenced by the year of production, and secondarily, to the effect of the system of cultivation.

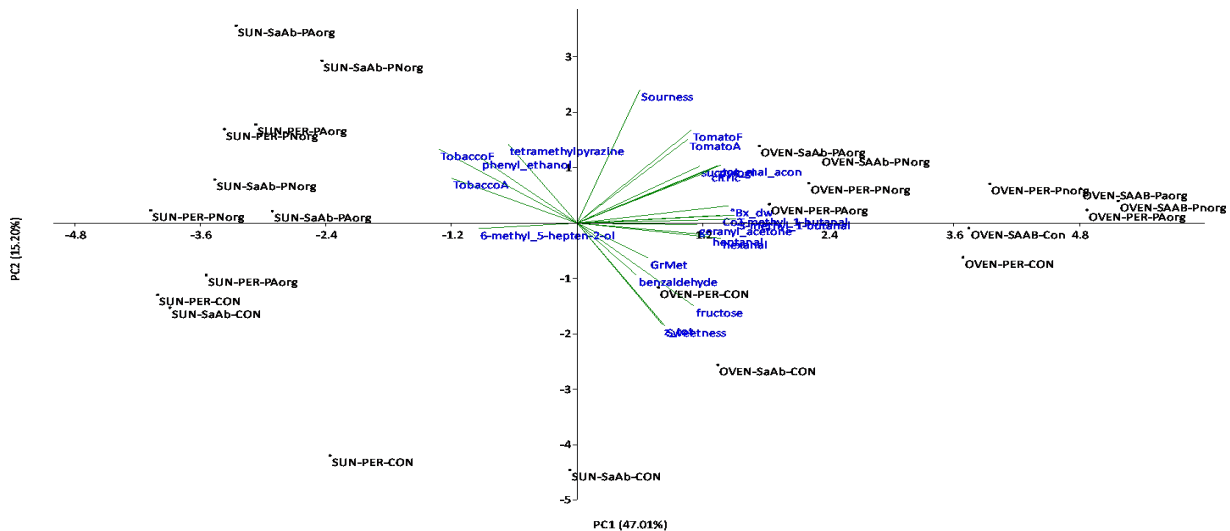
As for jam production, a big loss in phytonutrients (AsA and ATH) has been detected, and this was expected, but the ORG samples, produced by an innovative mild-technology, resulted in a higher retention (see D5). The volatiles analyzed from jams accounted for significant differences between MT and HM samples, with some compounds, such as ethyl esters better retained in HM, while others, important for strawberry flavour, such as mesifurane, were better retained in MT jams. Minor differences were found between ORG and CONV samples.

As for drying, this process induced a higher loss in AsA in SUN samples than OVEN, while, as for plums, the SUN drying induced a better retention of anthocyanins, responsible for the colour of fruits. Noticeably, the volatile profile analyzed on 2016 dried samples, was in a full accordance with the evaluation made by sensory analysis, where SUN samples better retained the strawberry flavour than OVEN ones: the main

compounds responsible for strawberry flavour, analyzed by GC-MS, were mostly present in SUN samples than OVEN ones (see D5).

Tomato

In tomato a deep work was performed by trying to evaluate the role of single chemical components, both volatiles and non volatiles, in the taste evaluation, also by trying to distinguish samples by type of drying, system of cultivation, and assayed genotypes. For the detailed description of compositional changes in dried tomato, see D5. A special item of this study for tomato samples was performed by partner nr.7, UNIMI, with studies aiming at identifying taste active compound with "umami" and "kokumi" role, see details on D5.



A multivariate analysis, taking into account the most relevant correlated chemical parameters with sensory data indexes in two years of sampling allow to discriminate the type of drying (left and right of PCA plot, see above), as well as the ORG and CONV samples (up and down of PCA plot).

Sweet bell pepper

The sweet bell pepper was the only product where the compositional changes induced by the variables resulted relevant both for the assayed genotypes and for the systems of cultivation. An higher presence of desired phytochemicals, such as AsA in RTV than HF1 Alceste (see D5) was found in dried samples. This was evident also by the analysis on the raw peppers, where the antioxidant capacity was increased in RTV ORG samples with respect to CONV ones, whereas in Alceste HF1, the trend was opposite (see D6).

Sensory analyses

The biggest differences in the sensory quality for apple juice was found between the different pressing methods whereas smaller differences were seen between the cultivars.

The biggest differences in the sensory profile of plums were found between the cultivar whereas no differences in the sensory quality was found between ORG and CONV grown plums. Mallard and Reeves are sweet cultivars, Victoria has high intensity of caramel flavor.

Strawberry samples were only evaluated in 2016 due to mould attack in 2015 samples. The biggest differences in all the sensory attributes are seen between solar and oven drying and to a minor degree between organic and conventional growing conditions. The SUN dried samples have high intensity of sweetness and strawberry flavor and the OVEN dried samples have highest intensity of dried fruit flavor and stored flavor.

The results of the sensory evaluation of tomato showed significant difference between the two varieties and differences between drying method. Solar dried Perbruzzo is intense in tobacco aroma and – flavor whereas SAAB solar is intense in dried fruit aroma and flavor.

Significant differences in the attributes between the drying methods were also found for bell pepper. Solar dried samples are more intense in bitter, burnt- and dried fruit flavour whereas conventional dried samples are more intense in sweetness and baked bell pepper/green bell pepper flavor. Similar results were found between 2015 and 2016. For both tomato and bell pepper the cultivation practice (ORG vs CONV growing) had a minor influence on the sensory quality.

B- fulfilment of objectives:

The main objective of the Project, synthesized in the sentence "An home-made food processing, made in small quantities and with high quality food material, ensures a better taste and nutritional quality than "industrially" processed food"?, was to assess a possible relationship between Organic fruit and vegetables with sustainable and small-scale processing plants. This was fulfilled by the performed comparison between these typology of plants and traditional ones, also considering home-made processing. The most relevant differences found in the quality indexes monitored along these processing chains were for the different system of processing. The responses were differentiated, with the adding of other significant variables, that was the sampling years and the assayed genotypes. A minor amount of variability was obtained from the evaluation of differently cultivated starting products, i.e. conventional vs organic productions.

WP2	Allergenicity of fruit and processed fruit products (apple, plum and strawberry) and of different organic and conventional raw and processed vegetables (tomato).
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WP leader: Prof. Dr. Wilfried Schwab, Partner 5 (Germany)
 Responsible partners: Partner 3 (Norway), Partner 2 (Estonia) and Partner 1 (Italy)

Overall summary of main results, discussion and conclusions of WP2

Bet v 1-homologous proteins were extracted from fresh fruit samples as well as from processed food material and the allergen content was quantified with an indirect competitive ELISA.

- The level of allergens (Bet v 1 homologue) was analyzed in fruits and processed products:
- Mal d 1 from apple *Malus domestica*
 - Pru d 1 from plum *Prunus domestica*
 - Fra a 1 from strawberry *Fragaria × ananassa*
 - Sola l 4 from tomato *Solanum lycopersicum*.

The main factor regarding the variability in the content of allergen resulted the type of processing (especially in apple and tomato) but also the assayed genotype (plum and strawberry) showed a significant role, together with the year of sampling. A minor role was assessed by the systems of cultivation.

Report on the results obtained (A), and fulfilment of objectives (B)

A- results obtained:

A more detailed view of the results obtained in WP2 have been reported in Deliverable 7 (D7). The tomato allergen Sola l 4 and the Fra a 1 allergen from strawberry fruits displayed different thermal stability. In the dried tomatoes the allergen content was significantly lower compared to fresh fruits, in contrast to dried strawberries, whereby the Fra a 1 content of fresh and processed fruits is similar. The higher sugar content in strawberry fruits as well as in jam compared to tomatoes might influence the protein stability in a positive way, leading to a minor decrease of allergen degradation due to thermal treatment.

For tomatoes and strawberries, the cultivation method showed no significant effect on the allergen content. In contrast to this, organic apples showed a tendency of lower Mal d 1 contents compared to conventional apples although not all cultivars showed this effect. However, changing seasonal effect from year to year including variations in temperature, rainfall, humidity and pathogens influenced the allergen level in all fruits to a greater extent. All fruits investigated in this study showed a remarkably dependency on the genetic background as there was a significant relationship between the amount of the respective Bet v 1-homolog and the genotype.



B- fulfilment of objectives:

The main objectives of WP2 were the development of analytical methods to measure the content of some allergen in fruit and vegetables, enlarging this study to some related processed products, and this objective can be considered fulfilled.

Moreover, the study on the factors influencing the variation in these products, such as type of processing, genotype used, sampling years and system of cultivation have been intensively stressed and established within the period of the Project. Further studies are needed, especially on the behaviour of more genotypes and cultivars to better evaluate this influence in the expression of allergen content.

WP3	Presence of health-beneficial and health-threatening compounds in organic apple juice.
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WP leader: Ass. Prof. Ulvi Moor, Partner 2 (Estonia)

Responsible partners: Partner 3 (Norway), Partner 4 (Denmark), and Partner 1 (Italy)

Overall summary of main results, discussion and conclusions of WP3

Sample of apples and apple juices, cultivated in ORG and in CONV, coming from three different countries (Estonia, Norway and Denmark) were analyzed along three years of production for their qualitative aspects "desired" and "non-desired". According to the results, it can be concluded that content of health-beneficial polyphenols and the consequent antioxidant capacity are significantly influenced by cultivar, cultivation technology, apple storage temperature before processing and by juice pressing technology. Old organic apple orchards are valuable sources of apples with high polyphenol content. Small-scale juice producers can be advised to implement waterpress instead of traditional rack-and-frame press in order to produce healthier and tastier juice.

Patulin occurrence in juice was first of all affected by apple cultivar and yearly different weather conditions, and also by the onset of some physiological post-harvest disorders, such as bitter pit and superficial scald.

Report on the results obtained (A), and fulfilment of objectives (B)**A- results obtained:**

A detailed report of the results on apples is given on Deliverable 5 (D5).

The presence of beneficial compounds has been evaluated by an accurate screening of Estonian, Norway and Denmark cultivars of apples: both in raw products and in juices, the varietal influence and the system of cultivation significantly influenced the presence of antioxidants, with the old cultivated Estonian ORG varieties having the highest indexes in beneficial compounds, such as phenols and, generally, compounds with antioxidant capacity against DPPH.

The presence of patulin, one of the most important mycotoxin in apple and apple juice monitored with different experiments in three subsequent years, resulted mainly influenced by a varietal factor, with less influence by growing systems of cultivation. Interestingly, fruit with physiological disorders, such as bitter pit and superficial scald, seem more susceptible to increase the patulin in the resulting juices.

B- fulfilment of objectives:

WP 3 had initially three objectives and all of them were fulfilled. During the project, additional hypothesis was developed about possible reasons for occurrence of patulin in some juices and this hypothesis was also confirmed.

The first objective was to find out if apple cultivars with higher fruit polyphenol content might have more efficient natural defence system and therefore lower risk for blue mould development and patulin contamination in juice. It was found out that juice pressed from apples with higher than average polyphenol content may also contain patulin above legal limit.

The second objective was to find out if warmer than optimal apple storage temperature before processing affects patulin formation in apples and juice. Higher temperature ($9\pm 2^{\circ}\text{C}$) did not increase the risk for patulin occurrence in all cultivars, but both juices pressed from organic and conventional 'Talvenauding' stored at $9\pm 2^{\circ}\text{C}$ had patulin contamination in juice.

The third hypothesis was that different processing methods might have impact on sensory and health-beneficial quality of the juice, but would not influence patulin content. The hypothesis was confirmed.

The additional hypothesis was developed during the project that apples with physiological disorders

might be more susceptible to patulin-producing fungi and therefore juice pressed from such apples is more likely to contain patulin. The hypothesis was confirmed.

WP4 Proposed dissemination activities.
Partner 1 (Italy, WP Leader) and all other Partners.

WP leader: Roberto Lo Scalzo (Partner 1, Italy)
Responsible partners: Partner 2 (Estonia), Partner 3 (Norway), Partner 4 (Denmark), Partner 5 (Germany), Partner 6 (Italy) and Partner 7 (Italy)

Overall summary of main results, discussion and conclusions of WP4

The Project consisted by several Meetings, where the advancement of work, the mid-term report and its related evaluation were already been achieved.

The list of all Meetings and reports is reported on the following Table:

Drying, Juices and Jams of Organic Fruit and Vegetables: what happens to Desired and Non-Desired compounds?		FAVORDENONDE	
Date	Location	Type	Notes
10/04/2015	CRA-IAA (now CREA-IT), Milano	kick-off meeting	Preliminary plan of work
16/11/2015		web-meeting	Advancement of works
09/05/2016		web-meeting	Advancement of works
18/10/2016	Bucuresti	mid-term meeting	Detailed report from each Partner
03/02/2017		mid-term report, web meeting	Mid-term evaluation
23/10/2017		web meeting	Advancement of works
05/03/2018		web final meeting	Detailed Final report from each Partner
29/03/2018		end of the Project	
29/06/2018		final report	Delivered by the Coordinator

Just after the kick-off meeting of the Project, April 2015, the City of Milano hosted the Universal Exposition "EXPO 2015", starting from 1st May 2015. The Project FavorDenonDe was presented in an Outdoor Event (MI.D.I. Milan Demonstrative Initiatives), held on 8th September 2015 at CREA-IAA, Milano, entitled "Innovative solutions for Food Processes, Preservation, Safety, and Control"; the presentation is available at the following link: http://iaa.entecra.it/pdf/MiDI-8Sept2015-CREA%20IAA/2-Expo_meeting_LoScalzo_8sett2015.pdf.

In the months of June 2015 and 2016, two events were held at CREA-ORA, Research Unit of Horticulture, where the experimental fields of tomato and bell pepper are located. The links related to the two events are available at:

- http://sito.entecra.it/portale/public/documenti/cra-ora_giornata_divulgativa_per_il_bio_23062015.pdf
- <http://www.sinab.it/bionovita/giornata-di-studio-su-orticoltura-biologica-e-risorse-genetiche>.

Moreover, during 2016 the Project activities were also presented at two national events, that are:

- the Italian Conference organized by the Ministry of Agriculture, entitled "Research in organic and biodynamic farming: an overview", Rome, 20-21 January 2016, available at:

http://sito.entecra.it/portale/cra_avviso.php?id=16444&tipo=convegno&lingua=IT

- the International Exhibition of Organic and Natural Products "SANA", which was held from 8 to 12 September in Bologna. The FavorDenonDe Project was presented in the Workshop about the trans-national research on organic agriculture, specifically dedicated to CORE Organic Projects, on 12 September 2016, available at: <http://www.crea.gov.it/wpcontent/uploads/2016/09/Brochure-SANA.pdf>.

Report on the results obtained (A), and fulfilment of objectives (B)

A- results obtained:

Dissemination of the results

Oral and poster presentations:

- April 2016, oral presentation in Avignon, France, at the 2nd Euro-Mediterranean Symposium on Fruit and Vegetable Processing: E. Vangdal et al., Effects of the drying technique on the retention of phytochemicals in conventional and organic plums (*Prunus domestica* L.). <http://orgprints.org/30810/>
- April 2016, poster presentation in Avignon, France, at the 2nd Euro-Mediterranean Symposium on Fruit and Vegetable Processing: M. Fibiani et al., Fate of the main quality, nutraceutical and taste active compounds in conventional and organic tomatoes (*Solanum lycopersicum* L.) subjected to different drying techniques. <http://orgprints.org/30811/>
- April 2016, poster presentation in Avignon, France, at the 2nd Euro-Mediterranean Symposium on Fruit and Vegetable Processing: V. Picchi et al., Effects of the processing technique on the retention of bioactive compounds and volatiles in organic and conventional strawberry jams. <http://orgprints.org/30813/>
- April 2016, oral presentation in Avignon, France, at the 2nd Euro-Mediterranean Symposium on Fruit and Vegetable Processing: Heinmaa et al., "Health-beneficial and health-threatening compounds in organic apple juice depending on processing technology". <http://orgprints.org/30809/>
- September 2016, Abstract and poster for the Eurosense conference in Dijon, France, 11 - 14 September 2016: Eggers et al., Effect of pressing methods on the sensory quality of organic apple juice.. <http://orgprints.org/33130/>
- October 2016, poster presentation in Chania, Crete, at the III International Symposium on Horticulture in Europe - SHE2016: Heinmaa et al., "The effect of organic and conventional fruit production method on mineral composition and sensory properties of cloudy apple juice". <http://orgprints.org/33136/>

Publications:

- Heinmaa, L., Moor, U., Pöldma, P., Raudsepp, P., Kidmose, U., Lo Scalzo, R. Content of health-beneficial compounds and sensory properties of organic apple juice as affected by processing technology" *Accepted for publication in LWT - Food Science and Technology*. <http://orgprints.org/33137/>
- Vangdal, E., Picchi, V., Fibiani, M., Lo Scalzo, R. Effects of the drying technique on the retention of phytochemicals in conventional and organic plums (*Prunus domestica* L.). *Accepted for publication in LWT - Food Science and Technology*. <http://orgprints.org/33138/>
- Picchi V., Lo Scalzo R., Kurze E., Fibiani M., Vangdal E., Schwab W.. Inter-annual variations are more important than the system of cultivation in determining the nutritional quality of three Norwegian plum (*Prunus domestica* L.) cultivars. *Submitted to JSFA - Journal of the Science of Food and Agriculture*.
- Kurze E., Lo Scalzo R., Campanelli G., Schwab W.. Effect of tomato variety, cultivation, climate and processing on Sola I 4, an allergen from *Solanum lycopersicum*. *PLoS ONE*, 13(6): e0197971. <https://doi.org/10.1371/journal.pone.0197971>.
- Kurze E., Kock V., Lo Scalzo R., Olbricht K., Schwab W. Effect of the strawberry genotype, cultivation and processing on the Fra a 1 allergen content. *Submitted to Nutrients MDPI*.
- Paolo D., Bianchi G., Lo Scalzo R., Morelli C.F., Rabuffetti M. and Speranza G. The Chemistry behind Tomato Quality. NPC. Natural Products Communications. 2018, vol. 13, *in press*.

Dissemination of the results with regards to thesis compilation:

- Rigamonti, Andrea (2017), Master Thesis. Studio sui costituenti di varietà locali di pomodoro (Sapore antico Abruzzo e Perbruzzo) sottoposte a diverse tecniche di essiccamento. [Investigation on the constituents of local cultivars of tomatoes subjected to different drying technologies]. University of Milano, Faculty of Science and Technologies. Tutor Prof. G. Speranza, Co-tutor Dr. Carlo Morelli, Dr. Giulia Bianchi.
- Vignati, Marta (2016), Master Thesis. Secondary metabolites and antioxidant capacity in raw and dried organic sweet bell pepper. University of Milano, Faculty of Science and Technologies. Tutor Prof. G. Speranza, Co-tutor Dr. Roberto Lo Scalzo.
- Lund, Søren E. Spanner (2016). Sensory evaluation of drying methods on bell pepper (*Capsicum annum* L.) considering cultivar and agricultural methods. 15 ECTS Master Thesis
- Melotti, Edoardo (2016). Studies on the constituents of sweet pepper (Senise pepper pgi) subjected to

different drying techniques. Master Thesis, University of Milano, Faculty of Sciences and Technologies. Tutor Prof. G. Speranza.

- Corno, Fabio (2015). Indagini sui costituenti di pomodori sottoposti ad essiccamento. [Investigation on the constituents of tomatoes subjected to drying.] Master Thesis, University of Milano, Faculty of Science and Technologies. Tutor Prof. G. Speranza.

- Puusta, Rachel (2018). Master thesis. Mõnede eestis kasvatatud õunte (*Malus domestica* Borkh.) allergeensuse ja antioksüdantide sisaldus sõltuvalt sordist ja viljelusviisist. [Allergenecity and content of antioxidants in some Estonian apples (*Malus domestica* Borkh.) depending on cultivar and cultivation system]. Estonian University of Life Sciences, Institute of Agricultural and Environmental Sciences, Department of Horticulture. Supervisors: Ulvi Moor, Tõnu Tõnutare.

- Kilki, Kaarel (2018). Master thesis. Eesti, Norra ja Taani päritolu õunte erinevatest sortidest pressitud mahla kvaliteet ja meeldivus Eesti tarbijale – pilootuuring. [The quality of apple juice pressed from different cultivars originating from Estonia, Norway and Denmark and product liking in Estonia – a pilot study]. Estonian University of Life Sciences, Institute of Agricultural and Environmental Sciences, Department of Horticulture. Supervisors: Ulvi Moor, Lagle Heinmaa.

Other disseminations specific for each Country Partners:

Italy

- Video of FavorDenonDe Project made within BioFach 2018, Nuremberg (Germany) by Dr. Dario Paolo, Collaborator of the Project as speaker, made by Thomas Alföldi, FIBL, visible on YouTube, <https://www.youtube.com/watch?v=XknDTevoois>

- The small-scale miniaturized plant for producing high safe and quality fruit jams was shown in a public demonstration in Amatrice, Lazio region, Italy, where a terrible earthquake mainly on 24/08/2016 and 18/01/2017, magnitudo 5,5-6,0, destroyed the city and the surroundings. Some projects of social and working regeneration in agriculture are ongoing on the territory, also with the contribution of Government, Private and Non-Profit Associations. In this context, CREA-IT Milano personnel went to Amatrice and practically demonstrated the use of the small-scale plant for producing an high quality jam of local varieties of apples in a day of work on 9 November 2017. The event is documented on "<http://www.crea.gov.it/laboratori-mobili-per-la-piccola-e-media-impresa/save-the-date-laboratori-mobili-ad-amatrice/>".

- The FavorDenonDe project was present also at the event "Seeds and Chips", held in Milano on 12 May 2016, where the solar drier was presented with its potential for developing food sustainability strategies in developing countries (<http://iaa.entecra.it/index2.php>).

Estonia

– March, 2016: oral presentation in Polli, Estonia, at the Horticultural Forum 2016: "The quality of apple juice depending on production method, apple storage conditions and pressing method" Presentation available at: http://epkk.ee/wp-content/uploads/2016/03/Aiandusfoorum-Ounamahla-kvaliteet-_Ulvi-Moor_2016.pdf

– August 2016: oral presentations in the field-day for organic fruit and berry growers in Estonia: "The effect of cultivar and pressing method on the quality of organic apple juice "Mycotoxins in apple juice".

– 01. December 2017 Saku, Estonia. Seminar for farmers and juice producers: "The quality and safety of apple products". 21 participants.

Norway

For further activities towards industry and growers, the list from the Norway side is as follows:

- Organic producers (meetings in November 2016, March 2017 in Telemark and Hardanger), attending 45 persons;

– Juice and cider producers (September 2017 in Lofthus) 52 persons;

– Fruit innovators (meeting February 2018 in Voss), 130 persons.

- Norske Fruktdagar 2018, Park Hotel Vossevangen 8-9 February 2018, Title of contribution:

Vidareforedling av frukt, inspirasjon frå verda rundt. Available at:
<https://vest.nlr.no/nyheter/2017/norske-fruktdagar-2018/>.

Denmark

- Oral presentation about organic apple juice production at a Danish symposium for growers and smaller juice producers. December 6th 2016

Germany

- Presentation: 14. Wissenschaftstagung Ökologischer Landbau 2017, 7 -10 March 2017, Freising, Germany
- Poster presentation: 12. Deutscher Allergiekongress 2017, 5 – 7 October 2017, Wiesbaden, Germany; winner of the poster prize (second place).
- CORE organic Newsletter "Allergens in tomatoes, strawberries and apples: Influence of production systems and processing methods" 6 December 2017. Available at: <http://projects.au.dk/coreorganicplus/currently/nyhed/artikel/allergens-in-tomatoes-strawberries-and-apples-influence-of-production-systems-and-processing-metho/>
- Konfitüren, Säfte und Trocknung biologisch angebauter Lebensmittel: Was geschieht mit Allergenen während der Verarbeitung? <http://orgprints.org/31827/>

B- fulfilment of objectives:

The discussion about the quality indexes of organic fruit and vegetables products with the associated correct choice of processing techniques is actually open and surely of scientific relevance at multidisciplinary level. This has been demonstrated by the numerous disseminating events, pointing out the role of the city of Milano, where the EXPO 2015 (Feed the Planet, Energy for Life) was hosted. In the final part of the Project, a wide discussion and dissemination of the aspects related to the possibility of innovative and sustainable processing of food, better if Organic, has been made during "BioFach 2018" at Nuremberg, Germany, the most important exhibition in Europe within the activities and research related to Organic Agriculture. Hence, the preliminary objectives of a wider dissemination as possible to non-scientific public, as well as organic farmers, can be considered fulfilled. The successive steps, with more traditional instruments of dissemination, such as Conference Participation, Workshops with Agro-Industry stakeholders and, finally, preparation of scientific manuscripts has also been performed during the Project and will not be finished within the official date of ending of it.

4. Milestones and deliverables status

Deliverable No.	Deliverable name	Link to the document	Planned delivery month ¹⁾	Actual delivery month ¹⁾	Reasons for changes/delay and explanation of consequences
D1	Kick-off Meeting		1	1	
D2	Consortium Agreement signature		2-3	2-3	
D3	Metabolite profiling and sensory evaluation in raw and processed organic		18	18	

	fruit and vegetables				
D4	Presence of allergens in organic samples of fruit and vegetables		18	18	
D5	Metabolite profiling and sensory evaluation in processed organic fruit and vegetables of the second half of the Project		36	36	
D6	Metabolite profiling in raw products along different sampling years (2015, 2016, 2017)		36	36	
D7	Influence of processing on allergens presence in organic fruit and vegetables		36	36	

Milestone No.	Milestone name	Planned delivery month ¹⁾	Actual delivery month ¹⁾	Reasons for changes/delay and explanation of consequences
M3.1	Production of conventional and organic fruit and vegetable samples	3	3	
M3.2	Organic Apple juice Processing	2	2	
M3.3	Processing by jam of strawberries	1	1	
M3.4	Processing by drying of tomatoes, sweet peppers and plums	3	3	
M3.5	Sensory analyses of 2015 samples	12	12	
M3.6	Metabolite profiling of 2015 samples	12	12	
M4.1	Cloning, expression and protein purification of recombinant allergens finished	5	5	
M3.2	Organic Apple juice Processing	2	2	
M3.3	Processing by jam of strawberries	1	1	
M4.1	Cloning, expression and protein purification of recombinant allergens finished	5	5	
M4.2.	Polyclonal antibodies (Davids Biotechnologie GmbH Regensburg) is available	8	8	
M4.3.	Indirect competitive ELISA for Mal d 1, Pru d 1 and Sola l 4 is	12	12	

	developed			
M4.4	Protein extraction method from fruit samples optimized	14	14	
M5.1	Production of conventional and organic fruit and vegetable samples in 2016	14-19	14-19	
M5.2	Processing by jam of strawberries 2016	15	15	
M5.3	Processing by drying of tomatoes, sweet peppers and plums 2016	15-20	15-20	
M5.4	Sensory analyses of 2016 samples	20-24	20-24	
M5.5	Metabolite profiling of 2016 samples	20-36	20-36	
M6.1	Production of conventional and organic fruit and vegetable samples in 2017	26-30	26-30	
M6.2	Metabolite profiling of 2017 samples	31-36	31-36	
M7.1.	Cloning, expression and protein purification of recombinant PR-10 allergens	1-5	1-5	
M7.2.	Production of polyclonal antibodies (Davids Biotechnologie GmbH Regensburg)	6-8	6-8	
M7.3.	Development of indirect competitive ELISA for Mal d 1, Pru d 1 and Sola l 4	9-12	9-12	
M7.4	Optimize protein extraction method from fruit samples	13-15	13-15	
M7.5	Measure Mal d 1 allergen content in apple fruits and apple juice	16-18	16-18	
M7.6	Measure Fra a 1 allergen content in strawberries and jam	19-21	19-21	
M7.7	Measure Sola l 4 allergen content in tomatoes	22-24	22-24	

¹⁾ Measured in months from the project start date (month 1)

Additional comments on deviations from the original project implementation plan in case there is an impact on fulfilment of the overall project objectives.

5. Publications and dissemination activities

5.1 List extracted from Organic Eprints

The following list represents the items present in Organic Eprints, extracted on 3-10 May 2018. Where cited, all the described arguments or publications or reports have been indicated in the overall text of the manuscript:

<http://orgprints.org/28935/>

<http://orgprints.org/30781/>

<http://orgprints.org/30782/>
<http://orgprints.org/30784/>
<http://orgprints.org/30786/>
<http://orgprints.org/30791/>
<http://orgprints.org/30809/>
<http://orgprints.org/30810/>
<http://orgprints.org/30811/>
<http://orgprints.org/30813/>
<http://orgprints.org/31827/>
<http://orgprints.org/32703/>
<http://orgprints.org/33130/>
<http://orgprints.org/33136/>
<http://orgprints.org/33137/>
<http://orgprints.org/33138/>

5.2 Additional dissemination activities

The dissemination activities have been fully described in WP4 report, specifically dedicated to this item.

5.3 Further possible actions for dissemination

- *List publication/deliverables/activities arising from your project that you are still planning in the future*
- Paolo D., Bianchi G., Morelli C.F., Speranza G., Campanelli G., Kidmose U., Lo Scalzo R. Impact of drying techniques, seasonal variation and organic growing on flavour in two Italian tomato varieties. Publication in course of compilation
- Lo Scalzo R., Bianchi G., Paolo D., Vignati M., Campanelli G., Kidmose U. Organic sweet bell pepper dried products: quality evaluation by taste-active and sensory indexes. Publication in course of compilation
- *List publications/deliverables arising from your project that Funding Bodies could consider disseminating.* FavorDeNonDe has a specific WP for the disseminating activities (WP4), where all relevant publications and reports have been reported. Moreover, some part of FavorDeNonDe results have been disseminated as Master Thesis. Where possible, the items have been also made available for their tracking into the web.
- *Indicate publications/deliverables that could usefully be translated (if this has not been done, and indicate target language).* Some reports, given in WP4, are in Italian and in Norwegian, and should be translated into English. At last, the Abstract of the Master Thesis of Fabio Corno (2015), Marta Vignati (2016) and Andrea Rigamonti (2017) are in Italian and should be translated into English.

5.4 Specific questions regarding dissemination and publications

- *Is the project website up-to-date?*

In a preliminary step, the Project was downloaded on OrgEprints. Afterwards, the results of the first year Project activities were presented in a report which is visible in the CORE Organic website, section "News": <http://coreorganicplus.org/currently/nyhed/artikel/effects-of-processing-on-phytochemicals-in-fruits-and-vegetables/>. Moreover, some results on the allergen content have

been presented in another report, visible at <http://projects.au.dk/coreorganicplus/currently/nyhed/artikel/allergens-in-tomatoes-strawberries-and-apples-influence-of-production-systems-and-processing-metho/>.

A video related to the main results of the Project has been prepared by Dr. Dario Paolo and Dr. Thomas Alföldi during the BioFach 2018 Exhibition:

<https://www.youtube.com/watch?v=XknDTevoois>.

All the main reports and publication made within the Project were downloaded in OrgEPrints, and the most of all other events dissemination have been online documented, on the website of CREA (<http://iaa.entecra.it/index2.php>).

- *List the categories of end-users/main users of the research results and how they have been addressed/will be addressed by dissemination activities.*

During the whole period of the Project, a special attention has been paid to the dissemination results aimed to *non-researcher persons*, mainly *stakeholders* of fruit and vegetables producers and, even, directly to the *producers and farmers*. In this case, a special effort was made to adequate the technical language to this context of ideas exchanges.

Moreover, a synergy was developed with private companies, that resulted very interested in some items of the Project. Hence, an example of cooperation was achieved with a small enterprise, G-Tek (www.gtek.it), Ing. Giovanni Marino, who build the solar driers, essential instruments within a part of the Project. Ing. Giovanni Marino won a Bronze Medal Prize for innovation in processing of fruit and vegetables at MacFrut 2017, Cesena, Italy, and has been invited at BioFach 2018, Nuremberg, at the Event of the Science Day held on 16 February 2018 (http://icrofs.dk/fileadmin/user_upload/TPOrganics_Biofach_Science_Day_agenda.pdf, <http://orgprints.org/32703/>).

6. Project impact

The most important impact of FavorDenonDe activities was assessed at the Workshop at BioFach 2018, Nuremberg, during the Science Day Event (http://icrofs.dk/fileadmin/user_upload/TPOrganics_Biofach_Science_Day_agenda.pdf), where the title of the workshop was "The contribution of organics to sustainable food systems". In this session, an active discussion was performed between researchers and representatives of Private Companies, in the field of Food Processing. In this context, it has been pointed out the need of the availability of smaller and effective plants for processing food, in order to obtain an higher degree of sustainability, especially for the Organic Sector. The emerged keyword was "downsizing of food processing plants". The suggestion that can be made is that these discussion should be enlarged and made more publicly available, especially within the Organic Farmers and Organizations, that resulted very interested to this item.

Up to now, at least at national Italian levels, for several discussions regarding future proposals in the field of quality of food from Organic Agriculture, the participation to the FavorDenonDe has been and will be a significant positive facilitation in the participation of other Projects. This has been already happened with an H2020 Project, called BRESOV (UE Call SFS-07-2016-2017), where the group of CREA-IT of Milano was invited to participate. This Project started on 1 May 2018 and will have the Kick-Off Meeting on next June, 2018.

7. Added value of the transnational cooperation in relation to the subject

As for the transnational research cooperation, this was the first experience in the Coordinating a Project, and, obviously, it resulted extremely positive, although with an initial high degree of difficulties and the added value was especially given from the point of view of the multidisciplinary features of the participating Partners.

The aspect of the characterization of the genotypical diversity regarding the quality aspects of fruit and vegetables and the possible relationship with the type of cultivation, highlighting the potential of adaptation in organic conditions by selected genotypes, has been acquired in some informal meetings with researchers operating in the field of vegetable breeding. In this context, the same research group of CREA-IT working in FavorDenonDe was selected as participant in the H2020 Project entitled Breeding for Resilient Efficient and Sustainable Organic Vegetable Production, acronym BRESOV, UE Call SFS-07-2016-2017, coordinated by Prof. Branca, University of Catania. The main aim of this Project is the genetic selection in vegetables (tomato, snap bean, and Brassica species) under organic conditions.

Moreover, on the side of the food processing, some international collaborations are ongoing by Dr. Tiziana Cattaneo, a Colleague of CREA-IT of Milano. These collaborations regard the use of solar driers for processing food in developing countries of Africa, where the environmental conditions are very adapted for this type of processing, especially sustained by an energy-saving apparatus. Two operative conventions have been formalized with local Institutions and Organizations of producers of Senegal, Tanzania and Kenia, with exchange of expertise and an initial purchase of experimental solar driers: this within a Project called "Malanda" (http://iaa.entecra.it/pdf/Convegno_GMA_28novembre2017_Palermo.pdf; <http://www.malanda-agrocentre.com/>) for the collaboration in Senegal; and within the signing on 9 Novembre 2017 of a Memorandum of Understanding by the President of CREA with University of Rome, campus Bio-medico, Strathmore University (Kenya), St. Joseph University (Tanzania) and the non governative organization "Golfini Rossi" (see <http://iaa.entecra.it/index2.php>; <https://www.golfinirossionlus.com/copia-di-cosa-facciamo-1>) for the collaboration with Tanzania and Kenia.

8. Suggestions for future research

As it can be expected, several questions have remained opened after the end of the Project: some of them can deserve some attention for future researches:

- a wider sight on varietal panorama for organic cultivation, can give some more possibility to farmers to choice the well adapted genotype;
- a more punctual study on the influence of climatic changes on the quality aspects of the agricultural products: often, in FavorDenonDe, the most variability was given by the different sampling years;
- the previous approach can be joined with studies regarding the influence of different territories on the quality indexes of the products: in this context an essential component can be given directly by the farmers, with a "participatory" contribution to the research;
- the study on new tasty compounds from fruit and vegetables, as well as their processed products, should be better implemented by deeper studies on the relationship between processing changes and volatile composition. This aspect can give further information about the changes in quality indexes with the various factors of variability, starting from field conditions to final processed product;

Annex 1: Cost overview and deviations from budget

Partner no.	Total person months	Spent person months	Total budget	Spent budget
P1	36	36	88110	78095
P2	16	16	72000	72000
P3	8	8	81000	81000
P4	15	21	191600	191600
P5	36	32	132391	110474
P6	27	18	41000	40069
P7	36	19	44000	44000
TOTAL	174	150	650101	617238

Reasons for deviations from the budget and explanation of consequences (in case there is an impact on fulfilment of the overall project objectives).

Annex 2: Recommendations to the CORE Organic consortium in relation to launching and monitoring of future transnationally funded research projects

Two future transnationally research projects can be proposed:

- Participatory breeding activities and their impact on the quality of the organic productions for fruit and vegetables;
- Besides "Quantity" also the "Quality" of organic productions deserves the attention to be monitored along different years and locations, to evaluate the influence of climatic changes.

Milano, 29 June 2018

**The Coordinator
Roberto Lo Scalzo**

